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TITLE: The Assessment of Military Multitasking Performance: Validation of a Dual-Task and Multitask Protocol

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1. **14. ABSTRACT** The Assessment of Military Multitasking Performance (AMMP) is a battery of functional dual-tasks and multitasks based on military activities that target known sensorimotor, cognitive, and physical/exertional vulnerabilities after concussion/mild traumatic brain injury (mTBI). The AMMP was developed to help address known limitations in post concussive return to duty (RTD) assessment and decision making. Using an iterative process using data from both healthy controls (HC) and subjects with mTBI residual symptoms, task refinement has resulted in task metrics with overall excellent interrater reliability. Dual-task metrics in the AMMP battery were most sensitive to between group differences when cognitive loads were added to military relevant motor tasks including the loading of rounds into magazines, walking, or running an agility course. Multiask metrics were sensitive to performance differences in reaction time during a simulated combat patrol and organization and planning during a complex Charge of Quarters duty scenario. Inertial sensor measures of peak velocities during 180 degree turns in normal walking, and exploratory analyses using time series analysis methodologies is demonstrating the potential to correctly categorize healthy control and subjects with mTBI. Once validated, the AMMP, either as a battery or as individual tasks, is intended for use in combination with other metrics to inform duty-readiness decisions in Active Duty Service Members following concussion. There is likely an optimal balance of symptom report, impairment and AMMP functional metrics that can be modeled to optimally discriminate between ready and non-duty ready personnel.					
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EXECUTIVE SUMMARY
The Assessment of Military Multitasking Performance:
Validation of a Dual-task and Multitask Protocol
Award number W81XWH-12-2-0070; 10November 2015

Background

Concussed personnel commonly experience persistent cognitive, postural, and vestibular deficits as well as disabling headaches, hearing or visual impairments, dizziness, and sleep dysfunction. These symptoms can impair duty performance and disrupt a SM's ability to safely reintegrate with the unit. Drawing from the sports concussion literature, military clinicians often base return to duty (RTD) determinations on results from clinical measures of cognition, balance testing, and symptom self-report measures during exertional testing. These existing RTD measures are problematic because they collectively lack valid norms, have poor face validity, or have not yet been validated among Warfighters. Research aims were designed to begin validation of a functional, performance-based assessment protocol to address gaps identified by the Gray Team II Report of the Chairman of the Joint Chiefs (April 2011) and the DTM 09-033, by developing a functional assessment to guide RTD decisions following mTBI that can be administered both in the deployed and garrison based environments. Initial 1-year (Sept 2009-Oct 2010) MRMC funding allowed collection of stakeholder and expert specifications and literature review to specify an assessment concept and develop a preliminary set of 9 tasks based on dual-task and multitask assessment methods. .

Using the previously developed set of nine performance-based assessment tasks called the Assessment of Military Multitasking Performance (AMMP), funds were awarded by the Army Medical Research Materiel Command for preliminary validation of this assessment battery using service members with residual symptoms following concussion/mild traumatic brain injury (mTBI) and healthy control (HC) subjects. The four specified aims of this project included: 1) Further specify and refine a set of dual-tasks and multitasks with procedures for test administration, 2) Evaluate interrater reliability for each of the dual-task and multitask metrics using healthy control and service members with diagnosed mTBI undergoing rehabilitation for residual symptoms (known groups), 3) Evaluate and interpret hypothesized correlations between scores on neurobehavioral and sensorimotor domain tests and scores on AMMP dual-tasks and multitasks in healthy control SMs and SM with mTBI to determine convergent validity, and 4) Evaluate the ability of dual-task and multitask test items to discriminate between healthy control SM and SM with mTBI residual symptoms undergoing rehabilitation.

This report describes the methods and outcomes of this validation protocol.

Methods

Using healthy control subjects from the US Army Research Institute of Environmental Medicine (Natick, MA) and both healthy control and subjects with mTBI residual symptoms from Fort Bragg, NC, three phases of data collection were conducted involving an iterative task refinement process for the AMMP including feasibility considerations and the use of repeated inter-rater reliability testing to improve task metrics, administration and scoring instructions. The six tasks that remained in the AMMP battery after this refinement process were then used to evaluate convergent and discriminate validity.

Key Accomplishments and Findings

1. Achieved clinically acceptable inter-rater reliability; all test metrics for each of the six tasks remaining in the AMMP battery have interrater reliability above 0.90 for dual-tasks and above 0.88 for multitasks except for several metrics on errors and cues which were then not used to evaluate between group differences.
2. Based on a minimum correlation of 0.3 for evaluation of hypothesized relationships between standard neurocognitive measures and AMMP task metrics; these hypotheses were supported. Although small (almost all below 0.4), expected correlations were demonstrated for most tasks with the exception of the Patrol-exertion task.
    a. Small correlations may be due to complexity of the tasks with multiple factors affecting performance. In addition, the mTBI group was not tested at the time of evaluating AMMP tasks for several assessments including Neurobehavioral Assessment Battery and Comprehensive Trail Making Test tests, which may have been a confounder given lag times between neurocognitive testing (obtained from Womack TBI Clinic chart) and AMMP battery testing.
    b. Dynamic Visual Acuity Testing (http://www.micromedical.com/Products/) was administered as a behavioral measure of gaze stability and a proxy for vestibular function testing. The DVAT identified only 3 subjects with mTBI who demonstrated clinically significant impairments in gaze stability (> 2 lines lost) during rapid head impulses (≥ 120 degrees/sec) relative to static visual acuity during a head stationary condition. This clinical reference point was consequently insufficient for use as a correlational measure for AMMP metrics intended to target vestibular vulnerabilities.
3. Subjects with mTBI appear to have more difficulty than HC with cognitive tasks ***especially*** when overlaid on physical challenge:
    a. Dual-task interference for the cognitive task when tested during the motor task was able to distinguish HC from mTBI groups in the Load Magazine-Radio Chatter and Instrumented Stand and Walk-Grid Coordinates Dual Task.
    b. Metrics focusing on executive function (cognitive) vulnerabilities demonstrated the ability to distinguish groups in the Charge of Quarters Duty task. A combination of exertional, cognitive and reaction time requirements in the Patrol-exertion task resulted in symptom report of reduced visual clarity and slower reaction time metrics which distinguished mTBI compared to HC.
4. Other than reduced peak velocities during 180 degree turns during normal walking as measured by inertial sensors, and reaction times during the mulitask, Patrol-exertion, AMMP physical performance metrics alone were insufficient to distinguish groups, leading to speculation that for the most part subtle differences may require inertial sensors or other laboratory equipment to identify physical performance dissimilarities in elite Warfighters that are healthy versus concussed.
5. Using 1) the AMMP task metrics that discriminate groups, 2) PCL-C scores (PTSD screen), and 3) self-assessment for readiness to return to combat duty, predictive modeling through logistic regression, discriminant analysis and decision tree analysis (CHAID) yielded successful classifications of HC and mTBI between 80.8% and 91.7% of cases. Accepting a number of limitations such as an inability to use cases with missing data, these methods show promise in identifying specific factors and AMMP metrics that provide the most information and that may be further investigated for RTD decision-making.
6. Exploratory analyses using time series analysis methodologies (principal component analysis (PCA)) is demonstrating the potential to correctly categorize healthy control and subjects with mTBI. These

exploratory findings require further investigation with the current data set to develop a theoretical framework for their interpretation and association with known mTBI related vulnerabilities. .

7. There is likely an optimal balance of symptom report, impairment and functional metrics that can be modeled to optimally discriminate between ready and non-duty ready personnel.
8. An AMMP Training Manual and Training Modules (PowerPoint and Video) are included in appendices and under separate files. For each of the six AMMP tasks, these materials provide 1) Task Description and Set Up, 2) Examiner Instructions and Script, 3) Score Sheet, 4) Scoring Guide, 5) Task specific testing materials. The AMMP Training Manual and Modules are designed to enable prospective AMMP examiners to understand, visualize, and practice the administration of the 6 AMMP tasks.

Future Research Recommendations and Next Lines of Inquiry

Next steps in research include both general "gap area" themes as well as specific research question to promote development and validation of individual tasks. Both are presented in this section however next steps in research will admittedly be informed by DoD/ stakeholder needs, availability of test subjects within FORSCOM or in medical readiness platforms in the MEDCOM. Research prioritization may also be a function of specific interests and expertise among clinical researchers in study design and administration related to the AMMP tasks.

AMMP BATTERY

We recommend creation of an AMMP Steering Committee during the bridge period following this current initial validation effort and next steps, to assist with monitoring and potentially coordinating further validation studies. Some focus areas include:

- **Gap 1: Tailoring AMMP Tasks to address different types of RTD decision making (Acute vs. Chronic Injury); Time since injury: Short (days) vs. Long (months**). The current AMMP battery includes performance tests that could be used to screen SM in austere, far forward settings (to inform early RTD decision making after acute injury) and other AMMP tasks likely better suited to measure performance in established practice environments (Hospital Settings). Follow on research should be pursued to identify optimal administration points in the continuum of care and to validate their use in appropriate practice environments. Considerations may include practical constraints to administration (space or maximal time requirements to set up and administer) or equipment factors (durability of instrumented systems (e.g., computers or accelerometers) to reliably function in austere environments).

- **Gap 2: Standardized Scoring**: In current form, each individual AMMP test-task is assessed based on participant performance on a series of task specific component metrics (e.g., time to perform, number of errors, number of items correctly identified, etc.). Thus, overall task performance is based on calculating performance on a series of sub-component metrics which have not been normalized to a standardized scoring system within the battery. Investigators see significant value in the development of a scoring system based on percentages or on a Likert based system that specifies: a) better than average, b) average, or c) worse than average, will contribute to the clinical utility of these assessment tasks. This approach would allow relative distinctions between performances on individual AMMP tasks and provide more specific feedback on a participant's relative strengths and challenges.

- **Gap 3: Phase II Discriminant Validity:** To meet with the primary RTD gap area of characterizing readiness to RTD, the research team would propose testing in a cohort consisting entirely of SM with history of concussion to discriminate between those who are duty ready (despite recent history of concussion) from non-duty ready personnel who may appear functional but are for some reason, non-duty ready (e.g.,: still symptomatic, subtly impaired in one or more physiologic systems; or unable to perform Warrior Tasks or Battle Drills to standard).

- Responsiveness to Change: If individual AMMP tasks are to be used to measure progress toward RTD readiness as a result of rehabilitation (intervention), research to evaluate metric responsiveness to change is essential. This will dictate the need for alternate forms of several of the AMMP tasks.

- Predictive modeling using AMMP task metrics should focus on predicting 'Successful Return to Duty'. Success for different RTD roles must be defined and studies that follow the Service Member's RTD experience must occur to generate the ultimate objective of the AMMP, to develop a predictive model for successful RTD. Factors which may be evaluated might include retention and promotion, annual evaluations, and use of health care resources for continuing mTBI symptoms.

<u>AMMP SPECIFIC TASK DEVELOPMENT</u>

- Specific AMMP tasks may have greater sensitivity in certain patient groups (e.g. ISAW Grid in acutely concussed personnel, rolling component of Run Roll Aim for those reporting post traumatic dizziness as a clinical complaint). Studies to identify AMMP task use based on patient complaint profile are needed.
- Using an up tempo video (this may be a ready-made video that provides a busier and more challenging cognitive load), evaluate the Patrol-Exertion task at point of RTD in established concussion care programs following rehabilitation (given exertion component and high face validity) (Candidate sites: WOMACK, NC; Fort Campbell KY). Additionally, develop, test, and validate alternate version Patrol-exertion videos to include more complicated scenarios requiring greater cognitive focus to allow use of the Patrol-exertion task in testing for responsiveness to change and response to treatment interventions.
- Two of the AMMP dual-tasks (ISAW-Grid and Load Magazine-Radio Chatter) may be considered for use in their current state on a limited basis in military rehabilitation settings to provide further information from military clinicians on their utility and relationship to RTD success/failure. Data from this clinical use should be evaluated to provide further validation of these dual-task metrics to provide useful clinical information on patient performance and progress.
- Develop, test, and validate alternate version(s) of the CQ Duty task to allow testing for responsiveness to change and response to treatment interventions focused on mTBI vulnerabilities including executive dysfunction and impaired attention and memory.
- Using the ISAW-Grid and a modification of the Illinois Agility-Word List task: Obtain serial measures of dual task cognitive load-dynamic stability performance in a cohort of SMs (Active Duty Cadets or acutely concussed Special Forces SM) pre- and post-concussion from boxing or other sports injury to establish recovery curves of static postural stability, dynamic stability, agility, attention and working memory in highly functional and highly motivated personnel (USMA)

    - ISAW-Grid task at baseline, 24 hours, 72 hours, 96 hours, 1 week, 9 and 14 days to follow recovery from acute concussion and once normal recovery curves are determined, to evaluate responsiveness to interventions such as the graded return to activity protocol.

    - Illinois Agility-cognitive task (like Grid-coordinates) at baseline, assuming asymptomatic (headache and dizziness resolved) and again at 5, 7, 9 and 14 days)
    - Validate similar dual-task performance study in civilian athlete cohorts (e.g., academia, NCAA, NFL).
- Use Load Magazine- Radio Chatter test to measure performance in AD Soldiers under stressed temperature conditions (extreme hot/ extreme cold)- Cross validate other military functional tasks requiring bi-manual dexterity (USARIEM)
- Based on findings from the current inertial sensor data of the Illinois Agility-Packing List and Run Roll Aim tasks, consider further studies with inertial sensor instrumentation to evaluate the high level mobility and subtle mobility deficits of Warrior athletes potentially with a combination of motor tasks (floor to stand transitions and combat rolls) that challenge vestibular vulnerabilities.
- Encourage additional studies to translate the use of Dual-task and Multitask assessments with face validity to civilian tests.

Conclusions

The successful completion and key findings of this study provides ample reason to support on-going research to refine and apply the AMMP battery for evaluating the SM with mTBI with regard to readiness for successful return to duty. Defining parameters that identify what successful RTD looks like is a key next step for successful prediction. We believe that AMMP tasks may be used as well in the civilian setting with minimal modification.

ABBREVIATIONS

AMMP: Assessment of Military Multitasking Performance
BI: Brain Injury (Mild Traumatic Brain Injury)
COG = Cognitive Priority
CQ Duty: Charge of Quarters Duty
CTMT: Comprehensive Trail making Test
DNI: Do Not Instruct
DoD: Department of Defense
DVAT: Dynamic Visual Acuity Test
DVBIC: Defense and Veterans Brain Injury Center
FDD: Front Desk Duty
FFT: Fast Fourier Transform
FORSCOM: US Army Forces Command
HC: Healthy Control
HR: Heart Rate
HRV: Human Research Volunteer
ICC: Intraclass Correlation Coefficient
IED: Improvised Explosive Device
IQR: Interquartile Range
IRR: Interrater Reliability
ISAW-Grid: Instrumented Stand and Walk -Grid Coordinates
MEDCOM: US Army Medical Command
MET: Multiple Errands Test
MOB: Mobility Priority
MOS: Military Occupational Specialty
mTBI: Mild Traumatic Brain Injury
NAB: Neurobehavioral Assessment Battery
NAB_DB: Neurobehavioral Assessment Battery: Digits Backward
NAB-D: Neurobehavioral Assessment Battery: Number-Letters Part D
NSI: Neurobehavioral Symptom Inventory
PCL-C: PTSD Checklist-Civilian Version
PLS-DA: Partial Least Squares – Discriminative Analysis
RTD: Return to Duty
Rx: Reaction
SM: Service man/men or woman/women
SRT: Simple Reaction Time
SVM: Support Vector Machine
TOH: Tower of Hanoi
USARIEM: U.S. Army Research Institute of Environmental Medicine
USAARL: US Army Aeromedical Research Laboratory
WAMC: Womack Army Medical Center
WRAT: Wide Range Achievement Test Reading

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INTRODUCTION

The Assessment of Military Multitasking Performance (AMMP) is a battery of functional dual-tasks and multitasks based on military activities that target known sensorimotor, cognitive, and exertional vulnerabilities after concussion/mild traumatic brain injury (mTBI). The AMMP was developed to help address known limitations in post concussive return to duty (RTD) assessment and decision making. The purpose of this research was to validate the AMMP battery. The scope of research included: 1) finalizing a set of tasks that met feasibility standards, 2) insuring inter-rater reliability for scoring of final task metrics, 3) evaluate convergent and discriminate validity using correlation of AMMP task metrics to standard neurocognitive tests and 4) test known group validity by comparing performance of tasks for healthy controls (HC) and soldiers with mTBI. AMMP is intended for use in combination with other metrics to inform duty-readiness decisions in Active Duty Service Members following concussion.

BODY
RESEARCH ACCOMPISHMENTS BY STUDY AIMS

Introduction

This section first describes the design and study populations from both the U.S. Army Research Institute of Environmental Medicine (USARIEM) and from Fort Bragg for the validation studies on the Assessment of Military Multitasking Performance (AMMP). Extensive demographic information is provided, particularly for the subject pool from Fort Bragg. A brief summary of subject characteristics, a discussion of findings on test order bias and on our measure of fatigue is included at the end of this initial section, as is a brief description of the AMMP battery of tasks. Following this, the findings are presented for each of the four project aims. The final section of this report includes findings that result from exploratory analysis of the data on AMMP task metrics that can distinguish the two study populations.

Study design

This study involved a convenience sample case-control measurement study involving test construction and evaluation using a target population of concussion/mild traumatic brain injury (mTBI) subjects and healthy controls (HCs). This measurement development study involved three sequential phases which used interrater reliability (IRR) findings, informal and qualitative feedback from raters and subjects, as well as logistical and practical properties evaluation by the test developers to drive task revision. The first phase of this study involved HC subjects at USARIEM and focused on iterative IRR testing to drive task refinement. The final phase 2 phases of this study, which were conducted with both HC and subjects with mTBI residual symptoms at Fort Bragg, included several project aims. The studies at Fort Bragg included a study to address IRR for a subset of individuals with mTBI, followed by IRR for both HC and mTBI subjects; correlational analyses to relate AMMP components to impairment based neurobehavioral tests (convergent validity); and known groups comparison of AMMP ability to differentiate participants with mTBI from HC participants (known groups to support construct validity).

Participants

The following inclusion/exclusion criteria were used to evaluate potential subjects for all phases of this study.

<u>Inclusion Criteria</u>
Healthy Controls

- Service men or women (SM), active duty that remain with their unit and are eligible for deployment, age 18 to 42 years of age.

Subjects with mTBI

- Service men or women (active duty) receiving care for mTBI-related symptoms within the Department of Defense (DoD) system. For the current protocol, this reflects subjects being seen via Womack Army Medical Center (WAMC) TBI Pipeline as a proxy for ongoing or persistent mTBI symptoms that require intervention.
- Ages 18 to 42 years of age.
- mTBI documented in medical record by subject's physician or TBI trained clinician at time of study enrollment based on a positive mechanism of injury and altered or lost consciousness at time of injury.
- Clinical presentation > 2 weeks and not > 2 years after documented date of injury (mTBI producing).
- Vision (corrected or uncorrected) sufficient for unassisted reading and performance of everyday personal tasks and independent community ambulation.
- SM presents with hearing (without amplification) adequate for engaging in close-range personal or telephone conversation.
- SM must be able to perform functional activities at moderate (12 to 14 on Borg Rating of Perceived Exertion) levels for up to 10 minute testing sessions with intermittent breaks as needed and tolerate a total test time of 120 to 180 minutes with frequent breaks.

<u>Exclusion Criteria (both groups)</u>

- SM diagnosed with severe brain injury or who has a sustained penetrating head injury.
- SM has documented activity restrictions incompatible with safe performance of AMMP test demands.
- SM presents with any medical or behavioral health condition that render him/her unable to perform moderate exertion for up to 10 minutes, quickly changing positions including getting up from the floor, sitting for up to 30 minutes, lifting up to 20 pounds. During screening, the physical requirements of the study will be summarized and SM will be asked if they wish to continue. (Personnel with physical profile scores reflecting PUL scores (Army Profile System) of other than "1" will be reviewed for eligibility. If the SM agrees to participate and has difficulty, any task not tolerated will be discontinued.
- SM has hearing deficits that render him/her unable to communicate effectively in a clinical or community setting.
- SM has functional deficits in visual integrity, acuity, efficiency or processing that render him or her unable to perform one or more of the tasks described to him/her in the AMMP testing battery.

<u>Relative Exclusion Criteria</u>

- Following informed consent, as part of screening, the Study Coordinator will describe the AMMP tasks and then ask the SM if he/she would like to continue. Given the activities of the AMMP battery, we anticipate an individual with significant pain complaints might self-select to discontinue study participation. Likewise, the Patrol-Exertion task includes viewing a virtual scene that was created by the developers of Virtual Afghanistan, so individuals with significant PTSD could decide to discontinue study participation.

Once enrolled, the PTSD Checklist-Civilian Version (PCL-C) and the Visual Analog Pain Scale was completed by all participants to allow for consideration of baseline stress and/or pain as a co-variate, but scores on these measures were not used to exclude participation in data collection.

<u>Recruitment and Subject Characteristics</u>

The subjects from USARIEM were recruited by briefings and recruitment materials and included both permanent party and human research volunteers (HRVs) who were stationed at USARIEM. Demographics for the 20 HC volunteers are found in Table A. The 2nd round of testing on 12 HC subjects conducted at USARIEM (for 2 revised tasks) used a subset of the original 20 volunteers and specific demographic information was not repeated from this subject pool.

The subjects from Fort Bragg were recruited in several ways. HC subjects were recruited by convenience sampling of volunteers from Fort Bragg Special Operations and the 528 Sustainment Brigade, subjects who responded to recruitment postings placed at fitness centers and cafeterias around the base, as well as volunteers from the Defense and Veterans Brain Injury Center (DVBIC) in-processing briefings. These DVBIC briefings occurred on an almost daily basis as part of the standard informational training provided to all soldiers in-processing to Fort Bragg after transfer from other duty stations. Subjects with mTBI were recruited from the clinical population receiving rehabilitation services at the WAMC TBI Clinic using inclusion/exclusion criteria as described in above. A total of 54 HC and 54 subjects with mTBI were recruited from Fort Bragg, not all subjects answered all intake questions and not all subjects were able to complete all AMMP tasks. Subjects filled in an extensive intake form including the PCL-C and a Neurobehavioral Symptom Inventory (NSI) symptom checklist. Our study team made an error in transferring the PCL-C checklist to the intake form and only 19 of the 22 questions were asked of most subjects. Summary tables to describe our study population at Fort Bragg are seen below (Tables B1-B6).

Table A. USARIEM Subjects: Demographics \ Service \ Symptoms

VARIABLE	HEALTHY CONTROLS (N=20)*
Age: median(range)	25 (19-32)
Sex	
Female	9 (45%)
Male	11 (55%)
Ethnic Background	
Black / African American	8 (40%)
Caucasian	7 (35%)
Hispanic / Latino	3 (15%)
Other	2 (10%)
First Language English	15 (75%)
Education	
High School	7 (35%)
Some college or Associate Degree	6 (54.5%)
Bachelor's Degree	4 (20%)
Graduate or Professional Degree	3 (15%)
WRAT Reading level	
Percentile: median(range)	53 (0-99)
Grade	
5-8	3 (15%)
9-12	4 (20%)
>12	13 (65%)
Months of Service: median (range)	19 (4-106)
Total Symptom Score: median (range)	2 (0-16)
*Version 2 of 2 AMMP tasks were evaluated on a HC Subset, N=12 WRAT = Wide Range Achievement Test Reading	

Table B1. Fort Bragg Subjects: Demographics \ Service \ Symptoms

Data Item (#HC,#mTBI)	HC	mTBI	p-value, method
Age (years) (mean(SD), median(range) (54,54)	30.4 (6.0) 30 (19-42)	27.7 (5.9) 25.5 (19-42)	0.007, Mann-Whitney U

Data Item (#HC,#mTBI)	HC	mTBI	p-value, method
Sex (54,54)		3 (5.6%)	0.073, Fisher Exact
Female	10 (18.4%)	51 (94.4%)	
Male	44 (81.5%)		
Ethnicity(54,54)			
Asian/Pacific	3 (5.6%)	5 (9.3%)	0.023, Chi-Square Exact
Biracial	0 (0%)	1 (1.9%)	
Black/African American	16 (29.6%)	4 (7.4%)	
Hispanic/Latino	6 (11.1%)	9 (16.7%)	
Native American	0 (0%)	2 (3.7%)	
White	28 (51.9%)	33 (61.1%)	
Other	1 (1.9%)	0 (0%)	
Education(54,54)			
Bachelor's Degree	19 (35.2%)	9 (16.7%)	0.008, Chi-Square Exact
Graduate/Professional Degree	7 (13.0%)	1 (1.9%)	
High School graduate/GED	7 (13.0%)	10 (18.5%)	
Some college or Associate Degree	21 (38.9%)	34 (63.0%)	
English 1st Language(54,54)	45 (83.3%)	44 (81.5%)	1, Chi-Square Exact
Handedness (54,54)			
Both	3 (5.6%)	2 (3.7%)	1,Chi-Square Exact
Left	5 (19.3%)	6 (11.1%)	
Right	46 (85.2%)	46 (85.2%)	
Pain now (YES) (54,54)	6 (11.1%)	32 (59.3%)	<0.001, Fisher Exact
For those with pain now: Pain level now (Mean(SD), median(range)), (6,32)	3.3 (1.8), 3.5 (1-6)	3.0 (1.6), 2 (1-8)	0.549, Mann-Whitney U-Exact
Pain last week (YES) (54,54)	16 (29.6%)	43 (79.6%)	<0.001, Monte-Carlo Exact
For those with pain last week: Pain level last week (Mean(SD), median(range), (16,43)	3 (1.8) 2 (1-7)	3 (1-8) 2 (1-9)	<0.001, Mann- Whitney U
Energy level (mean (SD), range)(53,54)	6.7 (1.2) 7 (5-10)	6.5 (1.1) 7 (3-10)	0.512, Mann Whitney U
ADHD (54,54)	1 (1.9%)	11 (20.4%)	0.004, Fisher Exact
Learning Disability (54,54)	1 (1.9%)	4 (7.4%)	0.363, Fisher Exact

Table B2. Fort Bragg Subjects: Military History

Data Item	HC	mTBI	p-value, method
Service Time (yrs) (54,54) Mean (SD), median (range)	8.9 (5.6), 8.2 (0.3-23.3)	6.1 (5.2), 3.6 (0.8-23.0)	0.004, Mann-Whitney U
Branch (54,54)			
Army	52 (96.3%)	53 (98.1%)	1, Exact Chi-square
Air Force	1 (1.9%)	1 (1.9%)	
Navy	1 (1.9%)	0 (0%)	
Active Duty (54,54)	52 (96.3%)	54 (100%)	0.495, Fisher Exact
Pay Grade (54,54)			
E1-E6	26 (48.1%)	44 (81.5%)	0.002, Exact chi-square
E7-E9	9 (16.7%)	1 (1.9%)	
WO-1-WO-5	2 (3.7%)	2 (3.7)	
O1-O3	15 (27.8%)	6 (11.1%)	
O4-O10	2 (3.7%)	1 (1.9%)	
Primary MOS Category (54,54)			
Force Sustainment	27 (50.0%)	21 (38.9%)	0.012, Exact Chi-square
Operation	9 (16.7%)	2 (3.7%)	

Operations Support	18 (33.3%)	31 (57.4%)	
Deployed to Iraq/Afghanistan (54,54)	39 (72.2%)	38 (70.4%)	0.832
Total Deployments Iraq (26,15)			
1	9 (34.6%)	8 (53.3%)	0.265, Exact chi-square
2	13 (50.0%)	4 (26.7%)	
3	2 (7.7%)	3 (20.0%)	
4	2 (4.9%)	0 (0%)	
Total Deployments Afghanistan (27,31)			
1	17 (63.0%)	25 (80.6%)	0.170, Exact chi-square
2	8 (29.6%)	3 (9.7%)	
3	2 (7.4%)	1 (3.2%)	
5	0 (0.0%)	1 (3.2%)	
7	0 (0.0%)	1 (3.2%)	
MOS = Military Occupational Specialty			

Table B3. Fort Bragg Subjects: Injury history

Data Item	HC	mTBI	p-value, method
Sustained an injury that prevented duty > 24 hours during past 12 months (54,54)	4 (7.4%)	39 (72.2%)	<0.001, Fisher Exact
If injury "yes"- number of injuries (4,39)			
1-2	3 (75.0%)	27 (69.2%)	0.601, Exact chi-square
3-5	0 (0%)	8 (20.5%)	
6 or more	1 (25.0%)	4 (10.3%)	
Symptoms past week (54,54)			Fisher Exact
Memory problems/lapses	4 (7.4%)	37 (68.5%)	<0.001
Balance	1 (1.9%)	19 (35.2%)	<0.001
Bright light	2 (3.7%)	26 (48.1%)	<0.001
Irritability	4 (7.4%)	33 (61.1%)	<0.001
Headache	5 (9.3%)	43 (79.6%)	<0.001
Sleep Problems	6 (11.1%)	39 (72.2%)	<0.001
Sustained a concussion ever? (1 or more) (54,54)	14 of 54 (26.0%)	53 of 54 (98.1%)*	<0.001, Fisher Exact
Number of head injuries/concussions (14,53)			
1-2	7 of 13 (53.8%)	27 (50.0%)	
3-5	5 of 13 (38.5%)	16 (29.6%)	0.603, Exact chi-square
>5	1 of 13 (7.7%)	11 (20.4%)	
*One subject in the mTBI group did not answer this question on the intake form.			

Table B4. Fort Bragg Subjects: Other reported health issues

Data Item	HC	mTBI	p-value, method
Seen health care provider	Percent of 54	Percent of 54	Based on responders
Combat stress (53,50)	3 (5.6%)	5 (9.3%)	0.480, Fisher Exact
PTSD (53,50)	3 (5.6%)	9 (16.7%)	0.067, Fisher Exact
Anxiety (53,50)	7 (13.0%)	13 (24.1%)	0.139, Fisher Exact
Depression (53,50)	7 (13.0%)	13 (24.1%)	0.136, Fisher Exact
Average sleep / day (mean (SD), median (range)) (53,54)	6.2 (1.4), 6 (4-10)	5.4 (1.4), 5 (3-8)	0.008, Mann Whitney U

Case 138 excluded from HC due to value of 18			
Hours sleep past 24 hours (mean (SD), median (range)) (54,54)	6.5 (1.4), 6.5 (4-9)	5.9 (2.1),6 (0-15)	0.023, Mann Whitney U
Number of caffeinated drinks (54,54)			
0	21 (38.9%)	26 (48.1%)	0.124, Exact chi-square
1	18 (33.3%)	14 (25.9%)	
2	7 (13.0%)	12 (22.2%)	
3	5 (9.3%)	1 (1.9%)	
>3	3 (5.6%)	1 (1.9%)	
Sleep aid (54,54)	3 (5.6%)	16 (29.6%)	0.002, Fisher Exact
Hearing loss since enlisted (54,54)	17 (31.5%)	30 (55.6%)	0.019, Fisher Exact
Increased sensitivity to sound (54,54)	7 (13.0%)	26 (48.1%)	<0.001, Fisher Exact
Ringing in ears (54,54)	15 (27.8%)	37 (68.5%)	<0.001, Fisher Exact
Difficulty hearing in a noisy room (54,54)	14 (25.9%)	37 (68.5%)	<0.001, Fisher Exact

Table B5. Fort Bragg Subjects: Standardized tests-patient reported on intake form

Data Item	HC	mTBI	p-value, method
NSI total (mean (SD), median (range))			Mann-Whitney
Incomplete NSI (45,42)	5.3 (9.2), 2 (0-53)	21.1 (12.1), 17.5 (2-52)	<0.001
Complete NSI (9,12)	2.4 (2.6), 3 (0-6)	29.6 (17.0), 29 (4-57)	<0.001
NSI Domain Vestibular (54,54)	0.5 (1.2), 0 (0-7)	3.1 (2.4), 3 (0-9)	<0.001, Mann-Whitney
NSI Domain Somatosensory (54,54)	1.7 (3.5), 0.5 (0-19)	6.6 (4.3), 5 (0-17)	<0.001, Mann-Whitney
PCL-C (mean (SD), median (range) (54,54)	22.1 (8.0), 19 (17-63)	31.8 (14.4), 30 (0-73)	<0.001, Mann-Whitney
PCL-C Checklist>45 (54,54)	1 (1.9%)	7 (13.0%)	0.060, Exact chi-square
Ready to return to duty (54,54)	49 (90.7%)	27 (50.0%)	<0.001,Exact chi-square
Note: NSI = Neurobehavioral Symptom Inventory-22 NSI scores will be presented separately for those with and without missing items 16-18. The two domain scores include all subjects since they do not include the missing items.			

Table B6. Fort Bragg Subjects: Neurocognitive and Dynamic Visual Acuity Results

Test (#HC,#mTBI)	HC	mTBI	p-value, method
Tower of Hanoi (#HC, #mTBI) (Mean (SD), median (range)			
# moves (53,34)	10.0 (2.1), 9.8 (7.2-15.4)	10.5 (2.5), 10 (7.2-19.6)	0.223, Mann-Whitney
Error percentile (53,34)	0.04 (0.03), 0.04 (0-.13)	0.05 (.04), 0.04 (0-0.18)	0.479, Mann-Whitney
Total Errors (53,34)	1.8 (1.6), 2 (0-7)	2.6 (3.2), 2 (0-18)	0.315, Mann-Whitney
Test of Memory (54,54)			
Insufficient effort (%)	1 (1.9%)	8 (14.8%)	0.002, Exact chi-square
NAB Numbers and letters (Mean (SD), median (range)			
Part A, percentile (54,44)	28.8 (28.2), 21 (9-96)	23.8 (28.4), 13 (9-99.9)	0.131, Mann-Whitney
Part B, percentile (54,44)	46.2 (28.2), 46 (9-96)	27.8 (23.7), 19.5 (9-96)	0.001, Mann-Whitney
Part C, percentile (54,44)	31.3 (21.2), 24 (1-84)	29.4 (25.5), 19.5 (1-99)	0.210, Mann-Whitney
Part D, percentile (54,44)	34.8 (27.8), 29 (9-96)	27.4 (27.6), 21 (9-92)	0.060, Mann-Whitney
NAB Digits (Mean (SD), median (range)			
Forward, percentile (54,44)	36.0 (29.3), 24 (9-95)	29.4 (29.5), 19.5 (9-95)	0.247, Mann-Whitney
Backward, percentile (54,44)	50.7 (28.6), 46 (9-92)	36.0 (27.2), 31 (9-90)	0.010, Mann-Whitney
Trail Making (percentile) (54,43)	46.2 (9.6), 46.5 (29-68)	40.2 (9.0), 41 (17-62)	0.005, Mann-Whitney
Composite Percentile	39.7 (29.5), 37.5 (1-96)	22.9 (22.1), 18 (9-89)	0.006, Mann-Whitney
WRAT Reading (mean (SD), median (range) (>12.9 converted to 13)	102.1 (12.5), 101 (76-134)	95.7 (10.7),95.5 (70-119)	0.007, Mann-Whitney
Standardized (53,54) Grade level(53,54)	11.9 (1.7), 12.7 (5.1-13)	10.8 (2.4),11.6 (3.8-13)	0.004, Mann-Whitney
DVAT			
Right line lost (52,46)	Missing=2	Missing=8	
0	31 (59.6%)	14 (30.4%)	
1	10 (19.2%)	18 (39.1%)	0.010, Exact chi-square
2	11 (21.2%)	11 (23.9%)	
3	0 (0%)	2 (4.3%)	
4	0 (0%)	1 (2.2%)	
Left line lost(52,46)			0.010, Exact chi-square
0	32 (61.5%)	14 (30.4%)	
1	11 (21.2%)	17 (37.0%)	
2	9 (17.3%)	12 (26.1%)	
3	0 (0%)	2 (4.3%)	
5	0 (0%)	1 (2.2%)	
NAB = Neurobehavioral Assessment Battery WRAT = Wide Range Achievement Test Reading DVAT = Dynamic Visual Acuity Test using Micromedical Instrumentation, > 2 lines lost considered abnormal with this instrumentation			

General Findings

Test Populations

A review of the extensive demographic tables above shows that the HC and mTBI groups are dissimilar in a number of characteristics. The HC subjects are older, more educated, have higher ranks and more years of military service. Qualitatively, to the AMMP research team, this difference appeared to be the result of recruitment and testing issues; HC subjects with higher ranks were more likely to have control of their schedules, thus allowing them to agree to study participation and to be able to present themselves for testing. Interested potential HC subjects of lower rank often were called away by Command requirements and could not be tested when scheduled. The pool of subjects with mTBI commonly had multiple required medical appointments in a given week and thus their Command officers were more likely to be accustomed to having potential subjects be away from their duty station for appointments. This appeared to result in a greater likelihood that Command for mTBI subject's would allow participation in AMMP testing, thus resulting in testing inclusive of a younger pool of subjects. The subject group with mTBI report more symptoms, more issues with PTSD and more hearing issues all of which are common in a pool of active duty military personnel with a history of concussion/mTBI. Both HC and mTBI groups had equivalent numbers of deployment experiences. Interpretation of findings should take in to account these differences in subject demographics.

Test Order Bias

During testing at Fort Bragg, an attempt was made to rotate the order of task administration to avoid having test results regularly affected by fatigue or by testing proximity to another task that might evoke distressing symptoms. A consistent order of AMMP task administration was not found. A simple evaluation of the distribution of administration time was done to look at whether a task was administered in the first half (1-3) or second half (4-6) of tasks. No evidence of bias was found for any of the 6 tasks being administered in any specific order.

Measure of Fatigue using Simple Reaction Time (SRT)

Using SRT as a measure of fatigue, our findings indicate that the HC and mTBI were similar in SRT at baseline, and subjects with mTBI are significantly slower than HC at the end of AMMP testing (Table C). This may be indicative of a greater level of fatigue compared to HC after completion of the AMMP task set. The contribution of fatigue to task scores cannot be determined although attempts were made to rotate the order of testing (see Test order bias above) to avoid having fatigue affect any one AMMP task score more than another.

Table C. Comparison of Pre- and Post-testing SRT as Fatigue Measure.

Metric (#HC, #mTBI)	**HC Mean(SD) Median(Range)**	**mTBI Mean(SD) Median(Range)**	**p-value, method**
Baseline (msec) (51,33)	279.4(38.6) 275.3(223.7-453.5)	301.8(77.5) 282.2(208.3-555.4)	0.664, Mann-Whitney
End of AMMP(msec)(51,34)	258.0(41.3) 254.4(214.2-509.5)	324.2(116.8) 314.2(213.2-620.8)	0.006, Mann-Whitney
Change in reaction time(end-baseline)	-21.4(31.4) -17.7(-113.5-55.9)	22.4(85.5) -4.0(-95.8-293.7)	0.017, Mann Whitney

Brief Descriptions of AMMP Tasks

The six tasks that compose the AMMP were developed using either a dual-task or multitasking paradigm. All tasks employ observational metrics and some tasks also utilize inertial sensor data to characterize SM performance.

AMMP Multitasks

Charge of Quarter Duty

The SM is challenged to develop and execute a work plan for completing an array of interleaving tasks (supply inventory, PVC foot stool assembly, providing information to superiors, prospective memory tasks) associated with his/her hypothetical assignment to Charge of Quarters Duty.

Run-Roll-Aim

The SM completes a high level mobility task with multiple maneuvers while carrying a simulated weapon. Maneuvers are cued by a computer screen with a handheld remote controlled slide advancer. The task requires a rapid start, avoiding a "trip wire" obstacle, performing a 3-5 second rush, combat rolling, searching for visual targets through simulated weapon scope, rapid lateral dodging and back pedaling.

Patrol-Exertion

The SM is challenged to gather intelligence in a recorded video depicting a virtual Afghanistan patrol environment while reporting observed IED markers based on a briefing provided at the beginning of the video. The SM then uses the information to answer specific questions from memory at the end of the patrol video. The SM will perform continuous step-ups on an exercise step at an intensity of 65-85% of HR maximum throughout the activity while being monitored for effort level via a Polar HR monitor and performance observation. The SM will be wearing a combat helmet, eye protection, and be carrying a simulated M16 weapon equipped with a trigger switch connected via Bluetooth to a computer configured to record reaction time (RT). The SM is required to press the switch each time a beep tone stimulus is heard throughout the video as a measure of RT during a divided attention multitask.

<u>AMMP Dual-tasks</u>

Illinois Agility Test – Packing List

The Illinois Agility Test requires running distances of 30' with rapid direction changes and navigation of obstacles in a serpentine pattern during the middle part of the obstacle course. A memory task is also completed. Then both the agility task and the memory task are performed at the same time. Accuracy of memory recall and time to complete the agility task are measured in single and dual-task conditions.

Instrumented Stand and Walk – Grid Coordinates

The SM is challenged to perform the Instrumented Stand and Walk (ISAW) test (developed by APDM) which includes instrumented and timed assessment of quiet standing for 30 seconds, assessment of dynamic stability during walking for two 7 m (23 foot) lengths with a 180 degree turn at midpoint. The SM will next memorize an 8 digit alphanumeric grid coordinate provided within the context of a simulated patrol mission brief and report the exact sequence back to the examiner after 45 seconds. Finally, both the ISAW and the grid memorization tasks will be performed simultaneously. Accuracy of grid coordinate recall, postural sway area, gait path variability, and time to complete the ISAW (i.e. gait speed) will be measured in single and dual-task conditions.

Load Magazine – Radio Chatter

SM completes a relatively automatic manual task choosing from a bin of mixed size dummy rounds (5.56 and 7.62 caliber) and loading 5.56 caliber training rounds into magazines as fast as possible both in a single and a dual-task condition. The dual-task condition requires monitoring radio communication and verbally announcing when radio chatter is relevant to scenario instructions.

AIM 1: FURTHER SPECIFY AND REFINE A SET OF DUAL AND MULTITASKS WITH PROCEDURES FOR TEST ADMINISTRATION

Description of Iterative Process

This measurement development study involved three sequential phases which used IRR findings, informal and qualitative feedback from raters and subjects, as well as logistical evaluation by the test developers of practical task factors to drive task revision. Specifically, the team integrated lessons learned during testing in an iterative manner over successive phases of testing to improve face validity of the tasks and the quality of subject performance data. Investigators also worked to decrease test burden on participants by decreasing test administration time. Other considerations during task development and refinement included consideration of the cost and durability of equipment, and testing space requirements. Revisions included dropping or modifying tasks with poor IRR or poor face validity, refinement of task administration and scoring instructions, and improving operational definitions and scoring metrics.

Phase I involved HC volunteers tested at USARIEM in Natick, MA. During Phase Ia, we evaluated the feasibility and IRR of the original 9 tasks comprising the original version of the AMMP[1,2]. Three of the original [3] 5 multitasks were eliminated and salient components were refined and consolidated into one multitask called the Charge of Quarters (CQ) Duty Task (see Figure 1). The 3 original multitasks demonstrated poor IRR due to unclear operational definitions of success and failure on task components (Figure 1), and difficulty observing all components of each task. One of the 4 original dual-tasks, the Step initiation-Stroop task was dropped after this phase of testing in favor of dual-task assessments with greater face validity[1,2] and due to concerns about durability of instrumentation. For Phase Ib, feasibility and IRR of 2 tasks were evaluated on 12 HC subjects, the new multitask, CQ Duty and a revised SALUTE multitask was modified to incorporate improvised explosive device (IED) marker reporting. In a later phase of this study, the SALUTE multitask was modified to incorporate the reaction (Rx) time dimension of the eliminated Step initiation-Stroop task.

Phase II involved subjects with mTBI tested at Fort Bragg, NC. The goal of Phase II was to evaluate the IRR and feasibility of the revised AMMP tasks named in the middle section of the Figure in subjects with mTBI residual symptoms. This phase of testing took place at Fort Bragg, NC with subjects primarily in military occupation specialties related to combat and combat support. This phase was another iteration of reliability and feasibility evaluation in subjects on an active Army base.

The goal of Phase III was to evaluate the IRR and feasibility of the AMMP tasks after the final revisions to all tasks were completed. A total of 26 both HCs and subjects with mTBI were evaluated in this phase which was completed over a several month time period.

The final result of this iterative development process is a set of 6 tasks, 3 dual-tasks and 3 multitasks which were evaluated for their ability to discriminate known groups (HCs and subjects with mTBI symptom complex) and for correlation to standard neurocognitive tests as a means to evaluate convergent and discriminate validity.

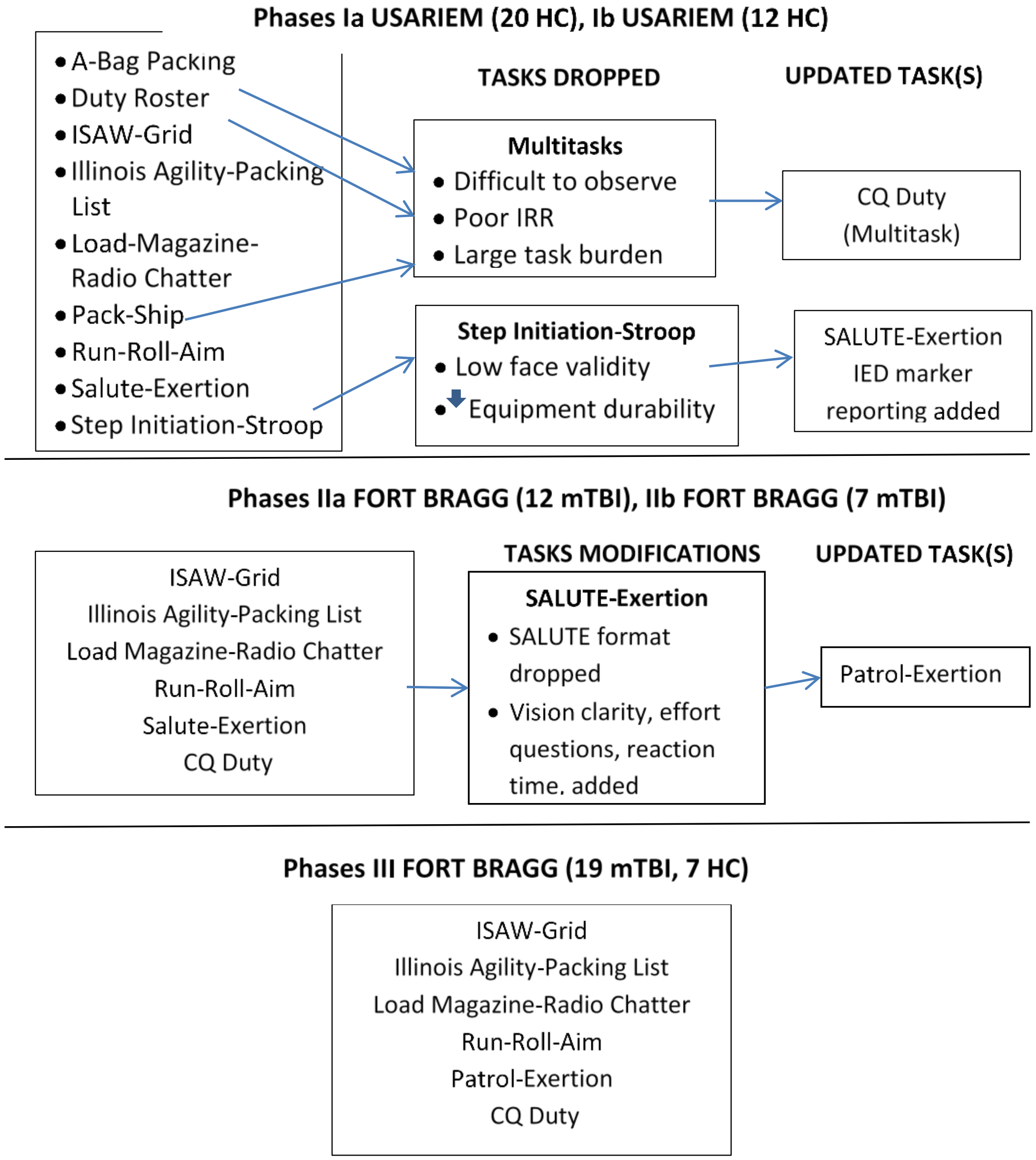


Figure 1. AMMP Refinement Phases using Interrater Reliability and Feasibility Evaluation

Evaluation of AMMP tasks based on Task Evaluation Criteria: Logistical and Practical Considerations

The ultimate goal of the AMMP development effort is to provide military clinicians with a reliable and valid test battery that is clinically implementable. Therefore, logistical and practical considerations of the individual tasks were evaluated (see Tables IA & IB).

<u>Test Administration Time</u>

Background

Team members administering the AMMP protocol were asked to time the total administration time for each of the tasks. Total administration time included instruction time and time to complete the task. They began recording this data at subject ID 71. In total, for each of the AMMP tasks, 40 to 47 HC and 23 to 30 mTBI participants were included in the analysis.

Method

Subjects were excluded if they had not completed the task, since their task times are not reflective of the true total time. Mean and median times are reported for HC and mTBI groups. Tests for significant differences between HC and mTBI included the t-Test for independent groups to test for difference of means if the data met the criteria for a normal distribution; otherwise, the non-parametric Mann-Whitney U test for independent groups was used to test the difference in medians. A two-sided p-value <0.05 was required for significance.

Results

AMMP task administration time for HCs was between 12.3 – 26.6 minutes across each of the 6 tasks and between 12.1 – 30.1 minutes to administer the same to SM with mTBI. For CQ Duty, there was a statistically significant difference in administration time between HC and SM with mTBI ($p = 0.033$). Time estimates for set up and take down were quite similar across tasks (approximately 10 minutes to set up and between 5-10 minutes to take down).

<u>Cost</u>

There was a fairly wide range of supplies and equipment costs across tasks, ranging from $175 (CQ Duty) to $8,920 (Instrumented Stand and Walk – Grid Coordinates, or ISAW-Grid). The tasks that included use of inertial sensor systems incurred the largest equipment costs (Illinois Agility Test-Packing List, Run Roll Aim, ISAW-Grid). Inertial sensor systems are becoming more readily available in clinical settings and may not be considered cost prohibitive.

Table IA. Logistical and practical characteristics for AMMP multitasks

Parameter	Description	Charge of Quarters Duty		Run-Roll-Aim		Patrol-Exertion	
		HC Mean (SD) N=44	mTBI Mean (SD) N=30	HC Mean (SD) N=40	mTBI Mean (SD) N=27	HC Mean (SD) N=47	mTBI Mean (SD) N=28
Total time	Time (minutes) from beginning of task instructions to end of task performance	26.6 (6.3)	30.1 (7.2)	13.4 (4.1)	14.0 (5.7)	23.2 (3.2)	24.5 (4.7)
Set up and take down time	Total time	Approximately 10 minutes up and 10 minutes down		Approximately 10 minutes and 5 minutes down		Approximately 10 minutes and 10 minutes down	
Storage space	Estimated space needed to store materials, supplies when the task is not set up	All supplies fit the 5-drawer storage unit, 24"(H) x 13"(W) x 12" (D)		All supplies fit in a small closet.		All supplies fit in a small closet.	
Cost	Estimated dollar amount of materials and equipment	$180[1]		$6,127[2]		$1,360[3]	

[1] PVC pieces ($50), walkie talkies ($60), office supplies ($15), plastic, 5-drawer storage unit ($10), stopwatch ($15), wall clock ($30). Does not include tables and chairs that would be available in a clinic setting.
[2] Laptop with Microsoft Office Powerpoint ($400), 2 traffic cones ($12), slide advancer ($40), simulated weapon ($300), stopwatch ($15), NexGen inertial sensor system (http://www.nexgenergo.com/ergonomics/ergoprods.html) (2 sensors) ($5,300), short focal point scope (such as insect or bird watching scope ($60) mounted on simulated weapon. Does not include therapy mats that would be available in a clinic setting.
[3] Laptop (to play Patrol video) ($400), audio-speakers ($50), large video monitor ($350), audio-recorder ($50), sports type heart rate monitor with chest strap ($50), helmet ($100), eye-protection ($20), aerobics step ($40), simulated weapon ($300). Does not include engineering costs and components for creating reaction time device affixed to simulated weapon.

Table IB. Logistical and practical characteristics of AMMP dual-tasks

Parameter	**Description**	**Illinois Agility Test-Packing List**		**ISAW – Grid Coordinates**		**Load Magazine – Radio Chatter**	
		HC Mean (SD) N = 46	**mTBI Mean (SD) N = 23**	**HC Mean (SD) N = 47**	**mTBI Mean (SD) N = 29**	**HC Mean (SD) N = 43**	**mTBI Mean (SD) N = 29**
Total time	Time (minutes) from beginning of task instructions to end of task performance	12.3 (2.8)	12.1 (2.7)	16.2 (5.3)	17.8 (3.9)	21.9 (4.0)	22.1 (3.8)
Set up and take down time	Total time	10 minutes set up, 5 minutes take down		10 minutes set up, 5 minutes take down		5 minutes set up, 5 minutes take down	
Storage space	Estimated space needed to store materials and supplies when the task is not set up	All supplies fit into a small closet		All supplies fit into a small cupboard		All supplies fit into a small cupboard	
Cost	Estimated dollar amount of materials and equipment	$5,440[4]		$8,920[5]		$407[6]	

[4] Orange traffic cones x 8 ($120), tape ($5), stopwatch ($15), NextGen sensor system (2 sensors) ($5,300).

[5] Laptop ($400), stopwatch ($15), tape ($5), APDM Inertial Sensors (Opal) system ($8,500) (www.apdm.com/wearable-sensors)

[6] M-16 dummy rounds ($250), M-16 magazines ($50), plastic workshop bins ($12), stopwatch ($15), iPod (or other audio player) ($50), iPod speaker ($40)

AIM 2: EVALUATE INTER-RATER RELIABILITY FOR EACH OF THE DUAL-TASK AND MULTITASKS USING HEALTHY CONTROLS AND SM WITH DIAGNOSED MTBI

Introduction

The AMMP team focused on development of a performance based assessment that targeted known mTBI vulnerabilities to be used to help inform return to duty (RTD) decision-making following military concussion. The AMMP had to meet ecological validity standards of military personnel, including commanders, who value the real-world use of the assessment[1]. Given the consequences of using AMMP metrics to contribute to duty readiness decisions, a vital first step in the AMMP validation process was to determine if the AMMP tasks could be scored reliably. The focus of Aim 2 of this protocol was to evaluate the IRR for each of the dual-tasks and multitasks using HC and SM with diagnosed mTBI.

Method

This study aim involved three sequential phases which used IRR findings, informal and qualitative feedback from raters and subjects, as well as logistical evaluation by the test developers of practical properties to drive task revision. Specifically, the team integrated lessons learned during testing in an iterative manner over successive phases of testing to improve face validity of the tasks and the quality of subject performance data.

<u>Research design</u>

This was a measurement development study involving test construction and test evaluation.

<u>Participants</u>

Phase I

Healthy subjects between the ages of 18 and 42 were recruited by convenience sampling from both HRV and permanent party active duty service members from the USARIEM in Natick, Massachusetts. Inclusion and exclusion criteria are described above. In Phase Ia, the initial 9 AMMP tasks were evaluated on 20 HC volunteers (11 males, 9 females, mean age 25.8 (+/-3.5) with revisions made that required re-evaluation of IRR on 2 of the tasks. In Phase Ib, these two revised tasks (CQ Duty and SALUTE-Exertion task) were tested on 12 USARIEM subjects who were a subset of the subjects tested in Phase Ia.

Phase II

A total of 12 SM (11 male, median age 31, range 21-42) with mTBI were recruited from the clinical population receiving rehabilitation services at the WAMC TBI Clinic for persistent symptoms from a concussion occurring from 2 weeks to 2 years (median days (range): 306 (71-470) prior to the AMMP test date. Physical and occupational therapists from the WAMC TBI Clinic identified potential participants who met the eligibility criteria and provided an information and study contact form. Participants were excluded as described in Phase I. A second set of 7 SM (6 male) were recruited from this same population for additional reliability testing that was focused primarily on revisions to the SALUTE-exertion task scoring and instructions to subjects.

Phase III

As described above, HC subjects were recruited by convenience sampling of volunteers from Fort Bragg Special Operations and the 528 Sustainment Brigade, subjects who responded to recruitment postings placed at fitness centers and cafeterias around the base, as well as volunteers from the DVBIC in-processing briefings. These DVBIC briefings occurred on an almost daily basis as part of the standard informational training provided to all soldiers in-processing to Fort Bragg after transfer from other duty stations. Subjects with mTBI were recruited from the clinical population receiving rehabilitation services at the WAMC TBI Clinic using inclusion criteria as described in Phase II above. A total of 26 subjects were involved in this final phase of IRR evaluation, 7 HC (5 male, median (range) age 34(20-42) and 19 subjects with residual mTBI symptoms (all male, median (range) age 24 (19-40). Median days since most recent concussion was 147 (range 63-632).

Analysis

The Krippendorf Alpha [4] was used to evaluate IRR. This general measure can be used regardless of the number of observers, sample size, missing data and type of measurement (nominal, ordinal, interval, or ratio). For both interval and ratio data the analysis is equivalent to the intraclass correlation coefficient (ICC) for two observers and is extended for many observers. For nominal data, analysis for two observers is equivalent to Scott's Pi. Parallel analyses using both the Krippendorf and Kappa (2 observers) have produced identical results. The code was integrated into both SPSS V18.0. Bootstrapping with an n=2000 was used to produce 95% confidence intervals. In some cases where the scorers were not constant the SPSS V18.0 ICC analysis assuming a one way random model was used to confirm the Krippendorff result.

Results

IRR findings are provided in Tables IIA-IIF with the dual-tasks presented first, followed by the multitasks. All test metrics for each of the 6 tasks remaining in the AMMP battery have interrater reliability above 0.90 for dual-tasks and above 0.88 for multitasks except for metrics on errors and cues which were then not used to evaluate between group differences.

Table IIA. Illinois Agility-Packing List Interrater Reliability

Scoring item (Metrics)	USARIEM* n=20, Healthy Controls (HC)	Fort Bragg/WAMC* n=12 SM with mTBI	Fort Bragg/WAMC# n= 23 (18 mTBI, 5 HC)
	Reliability, ICC 95% CI (lower, upper)	Reliability, ICC 95% CI (lower, upper)	Reliability, ICC 95% CI (lower, upper)
Single Task Time	0.98 (0.96-0.99)	.82 (0.58-0.98)	0.99 (0.98-0.99)
Single Task Words Correct	0.89 (0.73-0.99)	0.80 (0.69-0.90)	1.0 (1-1)
Single Task Word Errors	NA	0.54 (0.12-0.83)	1.0 (1-1)
Dual-Task No Instruction: Time	0.96 (0.94-0.98)	0.96 (0.93-0.98)	0.99 (0.987-0.995)
Dual-Task NI: Words Correct	0.93 (0.88-0.97)	0.93 (0.86-0.99)	0.99 (0.97-1)
Dual-Task NI: Word Errors	0.07 (0-0.30)	0.93 (0.87-0.97)	0.99 (0.96-1)
Dual-Task NI: Course Errors	NA	NA	1.0 (1-1)
Dual-Task COG: Time	0.90 (0.85-0.95)	0.98 (0.97-0.99)	0.99 (0.989-.997)
Dual-Task COG: Words Correct	1.0 (1.0-1.0)	0.97 (0.92-1)	1.0 (1-1)
Dual-Task COG: Word Errors	0.10 (0.0-0.36)	0.74 (0.37-0.99)	0.996 (0.987-1)
Dual-Task COG: Course Errors	NA	NA	0.77 (0-1)
Dual-Task MOB: Time	0.96 (0.91-0.98)	0.88 (0.80-0.95)	0.98 (0.97-0.99)
Dual-Task MOB: Words Correct	1.0 (1-1)	1.0 (1-1)	1.0 (1-1)
Dual-Task MOB: Word Errors	0.09 (0-0.35)	0.85 (0.64-1)	0.86 (0.58-1)
Dual-Task MOB: Course Errors	NA	NA	1.0 (1-1)

COG: Cognitive priority; "concentrate on remembering the words", NI: no instruction given, MOB: Mobility priority; "concentrate on going as fast as you can" NA: not applicable or not evaluated
*** = 3 raters; # = 2 raters**

Table IIB. Load Magazine-Radio Chatter Interrater Reliability

Scoring item (Metrics)	USARIEM* n=20 Healthy Controls (HC)	Fort Bragg/WAMC* n=12 SM with mTBI	Fort Bragg/WAMC# n= 24 (18 mTBI, 6 HC)
	ICC (95% CI)	ICC (95% CI)	ICC (95% CI)
Rounds loaded single & dual@	Not evaluated	Not evaluated	Not evaluated
Correct Key Word Single	0.99 (0.98-1)	0.94 (0.88-0.99)	0.997 (0.993-1)
Distractor Key Word Single	0.93 (0.83-1)	0.69 (0.38-0.92)	0.995 (0.986-1)
Correct Key Word Dual	0.98 (0.96-1)	0.99 (0.97-1.0)	0.978 (0.949-0.999)
Distractor Key Word Dual	0.97 (0.95-0.99)	0.50 (0.11-0.82)	0.947 (0.869-1)

*** = 3 raters; # = 2 raters; @ = for practical reasons, all dummy rounds were counted one time, not by individual rater**

Table IIC. Instrumented Stand and Walk-Grid Coordinates (ISAW-grid) Interrater Reliability

Scoring item (Metrics)	USARIEM* n=20, Healthy Controls (HC)	Fort Bragg/WAMC* n=10 SM with mTBI	Fort Bragg/WAMC # n= 26 (19 mTBI, 7 HC)
	ICC (95% CI)	ICC 95% CI	ICC (95% CI)
Walk Time 1 Single	0.99 (0.98-1),	0.77 (0.64-0.86)	0.97 (0.96-0.99)
Walk Time 2 Single	0.97 (0.96-0.98)	0.95 (0.92-0.98)	0.95 (0.90-0.98)
Walk Time 3 Single	0.98 (0.97-0.99)	0.91 (0.85-0.96)	0.98 (0.97-0.99)
Walk Time 1 Dual	0.92 (0.85,0.97)	0.89 (0.78-0.98)	0.92 (0.86-0.97)
Walk Time 2 Dual	0.98 (0.97,0.99)	0.94 (0.89-0.96)	0.95 (0.90-0.98)
Walk Time 3 Dual	0.97 (0.95-0.98)	0.81 (0.72-0.88)	0.98 (0.97-0.99)
Grid Coord Single	0.56 (0.14-0.90)	0.88 (0.78-0.97)	0.97 (0.92-1)
Grid Coord 1 Dual	0.94 (0.90-0.97)	0.94 (0.85-1)	0.98 (0.93-1)
Grid Coord 2 Dual	0.99 (0.97-1)	0.99 (0.99-1)	0.999 (0.998-1)
Grid Coord 3 Dual	0.92 (0.84-0.99)	1.0 (1-1)	0.997 (0.990-1)

*** = 3 raters; # = 2 raters; Coord = coordinates**

Table IID. Patrol-Exertion Interrater Reliability

SALUTE-EXERTION Version 1 (V1)		SALUTE-EXERTION Version 2 (V2)		PATROL-EXERTION	
Scoring item (Metrics)	**USARIEM* n=20 (V1)**	**USARIEM* n=12 (V2)**	**Fort Bragg/WAMC* n=7 SM with mTBI (V2)**	**Scoring item (Metrics)**	**Fort Bragg/WAMC[#] n= 26 (19 mTBI, 7 HC)**
			Reliability, ICC 95% CI (lower, upper)		**Reliability ICC 95% CI (lower, upper)**
Size	0.85 (0.76-0.93)	0.72 (0.53-0.87)	3 triplets disagreed[1]	X. Sum of IED markers	0.95 (0.91-0.98)
Activity	0.29 (0.0-0.60)	0.77 (0.58-0.94)	5 triplets disagreed[1]	Y. Sum of post-test patrol questions	0.97 (0.94-1)
Location	0.80 (0.64-0.93)	0.78 (0.56-0.95)	1 triplet disagreed[1]	Z. Sum of X and Y	0.97 (0.95-0.99)
Unit	NA[@]	0.14 (0-0.57)	3 triplets disagreed[1]	Vision clarity initial	0.99 (0.97-1)
Time	0.57 (0.22-0.86)	0.73 (0.44-0.96)	1 triplet disagreed[1]	Vision clarity end	0.99 (0.98-1)
Equipment	0.89 (0.79-0.92)	0.81 (0.62-0.95)	3 triplets disagreed[1]	RPE initial	0.98 (0.95-1)
Scan IED Markers	NA	0.90 (0.76-0.98)	0.97 (0.94-0.99)	RPE end	1.0 (1-1)
Total Score	0.80 (0.66-0.91)	0.79 (0.66-0.90)	0.91 (0.84-0.96)		

[@] = In the initial version, the report was described as a SALTE report as the "Uniform or Unit" component of the report was not consistently used, based on advice from one military advisor per local reporting format.
[1] Due to insufficient n to calculate ICC, the number of rater disagreements is reported
RPE = Rate of Perceived Exertion; NA=not applicable or not evaluated
*** = 3 raters; # = 2 raters; V1=Version 1, V2=Version 2**

Table IIE. Charge of Quarters (CQ) Duty Interrater Reliability

Scoring item (Metrics)	USARIEM * n=12 Healthy Control (HC)	Fort Bragg/WAMC* n=12 SM with mTBI	Fort Bragg/WAMC# n= 25 (19 mTBI, 6 HC)
	ICC (95% CI)	ICC (95% CI)	ICC (95% CI)
Task performance	0.94 (0.86-0.99)	0.90 (0.84-0.95)	0.88 (0.76-0.97)
# of Rule breaks	0.64 (0.32-0.90)	0.46 (0.0-0.79)	0.91 (0.75-1)
# of Visits	0.98 (0.96-0.99)	0.92 (0.80-0.99)	0.98 (0.97-0.99)
Total time	0.98 (0.96-0.99)	0.99 (0.99-1.0)	0.998 (0.994-1)

*** = 3 raters; # = 2 raters**

Table IIF. Run-Roll-Aim Interrater Reliability

USARIEM* n=20 Healthy Controls (HC)		Scoring item (Metrics)	Fort Bragg/WAMC* n=11 SM mTBI[@]	Fort Bragg/WAMC [#] n= 26 (19 mTBI, 7 HC)
Scoring item	**ICC (95% CI)**		**Reliability, ICC 95% CI (lower, upper)**	**Reliability, ICC 95% CI (lower, upper)**
Trial 1 incongruent numbers correct	0.996 (0.99-1)	Trial 1-Time(secs)	0.91 (0.80-0.99)	0.999 (0.997-1)
Trial 1 incongruent number errors	2 of 20 triplets disagreed	Trial 1-numbers correct	0.54 (0.08-0.89)	0.96 (0.91-1)
Trial 2 congruent numbers correct	0.86 (0.65-1)	Trial 2-Time (secs)	0.80 (0.57-0.97)	0.999 (0.993-0.999)
Trial 2 congruent number errors	2 of 20 disagreed	Trial 2-numbers correct	0.55 (0.0-0.93)	0.93 (0.70-1)
Trial 3 congruent numbers correct	0.57 (0.15-0.89)	Trial 3-Time(secs)	0.86 (0.67-0.98)	0.995 (0.991-1)
Trial 3 congruent number errors	2 of 20 disagreed	Trial 3-numbers correct	0.72 (0.40-0.95)	0.996 (0-1)
Trial 4 incongruent numbers correct	0.50 (0.23-0.74)	Trial 4-Time(secs)	0.89 (0.75-0.98)	0.999 (0.998-1)
Trial 4 incongruent number errors	1 of 20 disagreed	Trial 4-numbers correct	0.99 (0.97-1.0)	0.98 (0.96-1)
		Total errors (all trials)	ICC's for individual trials calculated, T1: 0.54, T2: 0.13, T3: 0.18, T4: 0.85	0.64 (0.13-0.92)
		Total cues (all trials)	ICC's for individual trials calculated, T1: 0.71, T2: 0.56, T3: 0.37, T4: NA[&]	0.87 (0.66-1)

Time to complete the Run-Roll-Aim was not scored by all raters during initial testing.
Errors for HC were recorded as #triplets disagreed as the range of errors was low, ie., 0-3 total;
Prior to testing mTBI, revisions were made to score sheets and instructions; -Congruent directional Stroop cue= roll direction arrow and R/L letter match, incongruent directional Stroop cue = roll direction arrow and R/L letter do not match:
Correct / Errors = odd or even numbers viewed through scope and called out: [&] No cues required—all zeros.
***=3 raters; #=2 raters; @ = not all subjects were able to tolerate completion of all trials;**

Limitations

No subjects with residual symptoms of mTBI were less than 2 months post most recent concussion in this study due to recruitment issues. Scoring of and responses from subjects with more acute symptoms and from populations at additional installations or deployment environments may result in a requirement for further refinement of operational definitions of task metrics including expansion of acceptable and unacceptable answers. All raters for this study were physical and occupational therapists with a minimum of 6 years of experience and a knowledge of the background and development process of the AMMP battery. This may have contributed to a bias in scoring some or all of the AMMP tasks. Further reliability testing with novice raters who did not participate in the development of this assessment will contribute to clarity on the amount of training required to achieve adequate IRR for a clinical metric.

Conclusions

Acceptable levels of IRR were achieved for the AMMP dual-task and multitask metrics with the application of a deliberate refinement process that recognized the importance of measure reliability and feasibility. In this early stage of the AMMP validation process, we have chosen to deal with the complexity of the multifaceted metrics that are used in dual-task and in multitask measures, by evaluating IRR for each separate task metric. As the AMMP validation process proceeds, we aim to normalize performance across AMMP tasks, combining individual component metrics to generate a composite score for each task and potentially for the complete AMMP battery. Composite scores should ease interpretation and facilitate decision making as demonstrated with other batteries described in the rehabilitation literature [5,6].

The AMMP is intended for use in combination with other metrics to inform RTD decision-making in SM with mTBI. To make RTD recommendations, the importance of IRR in a metric cannot be overstated [7,8]. Kottner et. al., suggests that when important decisions on individuals are being made on the basis of an assessment score, IRR values should be 0.90 or 0.95 [8]. Not all metrics for the AMMP tasks met this stringent standard; however, following the iterative process in the AMMP battery development, the majority of the ICC's were above 0.90 (Tables IIA-IIF), supporting the continuation of the validation process for the component tasks in this assessment battery. Those metrics that did not meet this standard were typically characterized by restricted value ranges which can significantly reduce ICC values.

The consistency of scores across raters is fundamental to the ability to use the findings of the AMMP to make substantive recommendations regarding readiness to RTD following concussion/mTBI. This research demonstrated that following an iterative development process, individual AMMP tasks appear feasible, and have metrics that can be reliably scored by experienced rehabilitation professionals. Before the AMMP is used clinically to inform RTD decision-making, further evaluation of intra-rater, novice rater, test-retest reliability, and additional validation studies should be carried out.

AIM 3: DETERMINE CORRELATION BETWEEN SCORES ON THE NEUROBEHAVIORAL AND SENSORIMOTOR DOMAIN TESTS AND SCORES ON AMMP DUAL- AND MULTITASKS IN HEALTHY CONTROL SM AND SM WITH MTBI.

Introduction

Design of the AMMP tasks focused on attempting to test known vulnerabilities associated with neurobehavioral and sensorimotor domains affected by mTBI. Table IIIA provides hypothesized correlations of task scores and these vulnerabilities. Correlation of tasks with neurobehavioral tests are described in this section. Correlations were not hypothesized for the physical domains thought to be susceptible to concussion, however, in order to ensure AMMP task inclusion of all vulnerabilities, the physical domains are included in the task development matrix.

Table IIIA. Hypothesized correlations AMMP Components (gray) and Tests of Neurobehavioral Domains (yellow)

mTBI-related task challenges: Primary ● Secondary ○	**mTBI Susceptible Domains**										
	Cognitive				**Sensorimotor**				**Physical**		
	Executive function[1]	**Memory**	**Attention**	**Reaction time**	**Eye gaze tracking**	**Scanning**	**Vestibular**	**Balance**	**Exertion**	**Bend-lift**	**Manual Speed**
AMMP MULTITASKS											
CQ Duty	●	○				○				○	○
Run-Roll-Aim			○	○	●		●	●	○	○	
Patrol-Exertion	○	○	●	●		●	○	○	●		
AMMP DUAL TASKS											
Illinois Agility Test-Packing List		●	○				○	●	○		
Load Magazine-Radio Chatter	○		●								●
Instrumented Stand & Walk-Grid coordinates		●	○				○	○			
NEUROBEHAVIORAL TESTS – to evaluate validity of AMMP components[2]											
Simple Rx Time: Key press, decision-rule[3]				●							
Neuropsychological Assessment Battery (NAB) attention module 1) fwd/bkwd digit span 2) numbers and letters	●	●	●								
Dynamic Visual Acuity: Vertical and Horizontal - head still vs. head moving at 2Hz					○		●				
Tower of Hanoi Planning *(ANAM4)*	●										
Comprehensive Trail Making Test: Connect numbers/letters in sequence with distractors	●		●			●					○
WRAT (Wide Range Achievement Test) Reading	Reading skills and IQ estimate										
Test of Memory Malingering	Test-taking effort										

[1]Planning, decision-making, response inhibition, processing speed
[2]Neurobehavioral tests will support AMMP construct validity but **not** included in the final AMMP battery
[3]Simple Reaction time (*ANAM4)* administered at the beginning and end of test session as a marker of test related fatigue. (Bleiberg et al, 2007).

Methods

Research Design

Data source

All neurobehavioral tests were administered to HC at the time they were tested on the AMMP. The mTBI participants were tested on the Tower of Hanoi (TOH), Wide Range Achievement Test (WRAT) and SRT at the time they were tested. All other test results for this group were extracted from their medical record.

Analysis

Pearson Product-Moment Correlation Coefficient was used to evaluate the relationship between AMMP task scores and neurobehavioral test performance. Sensorimotor measures are related to task performance and are not specifically evaluated here. Task scores may provide insight into the possible effects of these measures. Dynamic Visual Acuity Test (DVAT) results did not provide evidence of deficiency for most participants where a minimum of 3 lines loss indicates a problem. Only three HC and three mTBI met this criteria. Therefore, correlation analysis was not carried out.

Tables of results

The tables of results for each of the tasks includes the following rows: SRT (number of moves, error percentile, total errors), Neurobehavioral Assessment Battery Numbers-Letters Part D (NAB-D) (raw and T-score), Neurobehavioral Assessment Battery Digit Backward (NAB_DB) (raw and T-score), TOH, Comprehensive Trailmaking Test (CTMT) Composite Index, and WRAT Reading (raw and standardized score). Columns for each of tasks are the specific task scores.

Correlation coefficients include 95% confidence intervals and a p-value as a measure of difference from zero. R Statistics (https://www.r-project.org/) was used for analysis.

Participants

Study participants included all persons recruited at Fort Bragg for the evaluation of known groups. In addition, subjects recruited at Fort Bragg for evaluation of IRR were included in tasks that did not change and exhibited high reliability. This included Load Magazine-Radio Chatter, ISAW-Grid and number of visits and total time scores of the CQ Duty. Participants not completing a task were excluded.

Results

Refer to Tables IIIB through IIIG for specific results. Most significant correlations were small at less than 0.4. This was expected given the complexity of the tasks and likelihood of multiple influences on performance. A minimum correlation of 0.3 was selected for evaluation of hypothesized relationships with task metrics. Highlighted items exhibit absolute correlation values $\geq$ 0.3.

CQ Duty (Table IIIB)

- Demonstrated a small correlation with TOH as a measure of executive function, as hypothesized, for task metrics of Total Performance Score and # visits.
- Demonstrated a small correlation with NAB Numbers-Letters, as hypothesized, as a measure of executive function and memory/attention for task metric # visits.
- Demonstrated a small correlation with CTMT as a measure of executive function and attention, as hypothesized for task metrics of total time.
- Demonstrated a small correlation with SRT (baseline and end of testing), not hypothesized, for task metric task performance. This may be related to level of fatigue.

Run-Roll-Aim (Table IIIC)

- Demonstrated a small correlation with NAB Numbers-Letters as a measure of memory/attention, as hypothesized, for task metrics total time for each of the trials 1 to 4 as well as aggregate time (sum of trials 1 to 4).
- Demonstrated a small correlation with NAB_DB as a measure of memory/attention, as hypothesized for task metrics total time on trial 4.
- Demonstrated a small correlation with CTMT as a measure of executive function and attention, as hypothesized, for task metrics total time trials 2 and 4 and aggregate time.
- Did not correlate with SRT as hypothesized.

Patrol-Exertion (Table IIID)

- Did not demonstrate correlation of $\geq$0.3 with any of the neurocognitive measures.
- Demonstrated a small correlation with SRT at baseline and moderate correlation with SRT at end of testing, as hypothesized, for task metrics related to vision clarity and reaction time at both the beginning and end of testing.

Illinois Agility-Packing List (Table IIIE)

- Demonstrated a small correlation with TOH as a measure of executive function, not hypothesized, for task metrics dual test time with emphasis on remembering the words and dual-task time with emphasis on mobility as well as aggregate time.
- Demonstrated a small correlation with NAB_DB as a measure of memory/attention, as hypothesized, for task metrics # words correct under no instruction condition.
- Demonstrated a small correlation with WRAT as a measure of IQ, not hypothesized, for # words remembered under all conditions.
- Demonstrated a small correlation with SRT, as hypothesized, for task metrics time for each of the trials with the exception of the trial emphasizing the cognitive aspect of the task to remember the words.

Load Magazine-Radio Chatter (Table IIIF)

- Demonstrated a small correlation with NAB Numbers-Letters as a measure of executive function and attention, as hypothesized, for task metric errors under dual-task condition.
- Demonstrated a small correlation of CTMT as a measure of executive function and attention, as hypothesized, for task metrics # correct and errors under dual-task condition.
- Demonstrated a small correlation with WRAT as a measure of IQ, not hypothesized, for task metrics # correct and errors under dual-task condition.

ISAW-Grid (Table IIIG)

- Demonstrated a small correlation with NAB_DB as a measure of memory/attention, as hypothesized, for task metric of # grid coordinates remembered under single task condition.
- Demonstrated a small correlation with WRAT as a measure of IQ, not hypothesized, for task metric # grid coordinates remembered under single task condition.

Conclusions

Hypothesized correlations with neuro-behavioral measures, although small, were demonstrated for most tasks with the exception of the Patrol-Exertion task. Correlations were small, possibly due to complexity of the tasks with multiple factors affecting performance. In addition, the mTBI group were not tested at the time of performing AMMP for NAB and CTMT tests, which may have been a confounder given lag times.

Table IIIB. CQ Duty. CQ Duty task results. Results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample

	A. Task Performance Total Score	B. Specific Rule Breaks Total	C. # Rule Breaks Total	D. Total Visits to Complete Task	Total Time (Mins)
Tower of Hanoi: # moves	-0.3 (-0.48, -0.09) n=83, p=0.006*	0.14 (-0.08, 0.35) n=83 p=0.203	0.25 (0.03, 0.44) n=83, p=0.025*	0.36 (0.17, 0.53) n=92, p<0.001*	0.21 (0.01, 0.4) n=92, p=0.041*
Tower of Hanoi: Error percentile	-0.19 (-0.39, 0.03) n=83 p=0.085	0.14 (-0.07, 0.35) n=83 p=0.193	0.12 (-0.1, 0.33) n=83 p=0.278	0.36 (0.16, 0.53) n=83, p=0.001*	0.09 (-0.12, 0.3) n=83 p=0.399
Tower Hanoi Error: Total	-0.32 (-0.5, -0.12) n=83, p=0.003*	0.12 (-0.09, 0.33) n=83 p=0.266	0.15 (-0.07, 0.35) n=83 p=0.186	0.45 (0.26, 0.6) n=83, p<0.001*	0.12 (-0.1, 0.33) n=83 p=0.28
NAB Numbers-letters: Part D raw	0.23 (0.01, 0.44) n=76, p=0.041*	-0.05 (-0.28, 0.17) n=76 p=0.639	-0.14 (-0.35, 0.09) n=76 p=0.227	-0.3 (-0.47, -0.09) n=89, p=0.005*	-0.2 (-0.4, 0) n=89 p=0.054
NAB Numbers-Letters: Part D T-score	0.2 (-0.02, 0.41) n=77 p=0.076	-0.02 (-0.25, 0.2) n=77 p=0.832	-0.09 (-0.31, 0.14) n=77 p=0.44	-0.3 (-0.48, -0.1) n=92, p=0.004*	-0.18 (-0.37, 0.03) n=92 p=0.089
NAB Digit: Backward raw	0.19 (-0.04, 0.4) n=74 p=0.103	-0.18 (-0.39, 0.05) n=74 p=0.133	-0.09 (-0.31, 0.14) n=74 p=0.46	-0.05 (-0.25, 0.17) n=87 p=0.674	-0.16 (-0.36, 0.05) n=87 p=0.144
NAB Digit: Backward T-score	0.2 (-0.03, 0.41) n=75 p=0.087	-0.18 (-0.39, 0.05) n=75 p=0.115	-0.1 (-0.32, 0.13) n=75 p=0.393	-0.01 (-0.22, 0.19) n=90 p=0.904	-0.15 (-0.34, 0.06) n=90 p=0.169
CTMT: Composite Index	0.28 (0.06, 0.47) n=76, p=0.015*	-0.04 (-0.27, 0.18) n=76 p=0.713	-0.16 (-0.37, 0.07) n=76 p=0.171	-0.21 (-0.4, -0.01) n=91, p=0.041*	-0.4 (-0.56, -0.21) n=91, p<0.001*
WRAT: Raw score	0.29 (0.08, 0.48) n=83, p=0.007*	-0.14 (-0.35, 0.08) n=83 p=0.207	-0.13 (-0.34, 0.09) n=83 p=0.243	-0.25 (-0.43, -0.06) n=102, p=0.01*	-0.22 (-0.4, -0.03) n=102, p=0.024*
WRAT: Standardized score	0.29 (0.08, 0.48) n=83, p=0.007*	-0.15 (-0.35, 0.07) n=83 p=0.186	-0.16 (-0.37, 0.05) n=83 p=0.136	-0.26 (-0.43, -0.06) n=101, p=0.01*	-0.22 (-0.4, -0.03) n=101, p=0.024*
SRT: Baseline	-0.33 (-0.51, -0.12) n=83, p=0.003*	0 (-0.21, 0.22) n=83 p=0.968	0.07 (-0.15, 0.28) n=83 p=0.536	-0.04 (-0.24, 0.17) n=91 p=0.709	-0.02 (-0.22, 0.19) n=91 p=0.859
SRT: End of testing	-0.41 (-0.57, -0.21) n=81, p<0.001*	0.04 (-0.18, 0.25) n=81 p=0.749	0.04 (-0.18, 0.25) n=81 p=0.737	-0.02 (-0.23, 0.19) n=87 p=0.862	-0.04 (-0.25, 0.17) n=87 p=0.707

Table IIIC(1). Run-Roll-Aim 1. Run-Roll-Aim task results. Results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample

	Trial1 Total Time	**Trial 1- Correct responses / 14**	**Trial2 Total Time**	**Trial 2 Correct Responses / 14**	**Trial3 Total Time**	**Trial 3 Correct Responses / 14**
Tower of Hanoi: # moves	0.13 (-0.09, 0.34) n=80 p=0.241	-0.11 (-0.32, 0.11) n=80 p=0.342	0.06 (-0.17, 0.27) n=80 p=0.621	-0.08 (-0.3, 0.14) n=80 p=0.465	0 (-0.22, 0.22) n=79 p=0.978	0.06 (-0.16, 0.27) n=80 p=0.61
Tower of Hanoi: Error percentile	0.17 (-0.05, 0.37) n=80 p=0.138	0.1 (-0.12, 0.31) n=80 p=0.371	0.07 (-0.15, 0.28) n=80 p=0.55	-0.05 (-0.27, 0.17) n=80 p=0.643	0.19 (-0.03, 0.39) n=79 p=0.097	-0.03 (-0.25, 0.19) n=80 p=0.783
Tower Hanoi Error: Total	0.17 (-0.05, 0.38) n=80 p=0.123	0.08 (-0.14, 0.3) n=80 p=0.465	0.09 (-0.13, 0.31) n=80 p=0.405	-0.1 (-0.31, 0.12) n=80 p=0.386	0.18 (-0.05, 0.38) n=79 p=0.117	0.01 (-0.21, 0.23) n=80 p=0.915
NAB Numbers-letters: Part D raw	-0.31 (-0.5, -0.08) n=73, p=0.009*	0.1 (-0.13, 0.32) n=73 p=0.396	-0.4 (-0.58, -0.19) n=73, p<0.001*	-0.13 (-0.35, 0.1) n=73 p=0.258	-0.37 (-0.56, -0.16) n=72, p=0.001*	-0.03 (-0.26, 0.2) n=73 p=0.773
NAB Numbers-Letters: Part D T-score	-0.26 (-0.46, -0.03) n=74, p=0.026*	0.1 (-0.13, 0.32) n=74 p=0.401	-0.33 (-0.52, -0.11) n=74, p=0.004*	-0.08 (-0.3, 0.15) n=74 p=0.489	-0.32 (-0.51, -0.09) n=73, p=0.007*	-0.03 (-0.26, 0.2) n=74 p=0.792
NAB Digit: Backward raw	-0.15 (-0.37, 0.09) n=71 p=0.215	-0.1 (-0.33, 0.13) n=71 p=0.394	-0.13 (-0.35, 0.11) n=71 p=0.288	0.07 (-0.16, 0.3) n=71 p=0.554	-0.11 (-0.33, 0.13) n=70 p=0.378	-0.11 (-0.34, 0.12) n=71 p=0.349
NAB Digit: Backward T-score	-0.18 (-0.4, 0.05) n=72 p=0.129	-0.1 (-0.32, 0.13) n=72 p=0.404	-0.17 (-0.39, 0.06) n=72 p=0.153	0.1 (-0.14, 0.32) n=72 p=0.416	-0.12 (-0.34, 0.12) n=71 p=0.333	0.01 (-0.23, 0.24) n=72 p=0.958
CTMT: Composite Index	-0.28 (-0.48, -0.05) n=73, p=0.018*	0.15 (-0.08, 0.37) n=73 p=0.201	-0.31 (-0.5, -0.08) n=73, p=0.008*	-0.2 (-0.41, 0.03) n=73 p=0.086	-0.23 (-0.44, 0) n=72, p=0.049*	-0.06 (-0.28, 0.18) n=73 p=0.641
WRAT: Raw score	-0.15 (-0.36, 0.07) n=80 p=0.191	0.09 (-0.13, 0.31) n=80 p=0.417	-0.14 (-0.35, 0.08) n=80 p=0.201	0.12 (-0.1, 0.33) n=80 p=0.287	-0.17 (-0.38, 0.05) n=79 p=0.137	-0.11 (-0.32, 0.11) n=80 p=0.32
WRAT: Standardized score	-0.19 (-0.39, 0.03) n=80 p=0.09	0.11 (-0.11, 0.32) n=80 p=0.323	-0.15 (-0.36, 0.07) n=80 p=0.178	0.09 (-0.13, 0.3) n=80 p=0.438	-0.13 (-0.34, 0.1) n=79 p=0.259	-0.22 (-0.42, 0) n=80, p=0.047*
SRT: Baseline	0.06 (-0.16, 0.28) n=80 p=0.587	0.03 (-0.19, 0.24) n=80 p=0.817	0.2 (-0.02, 0.41) n=80 p=0.069	0.11 (-0.11, 0.32) n=80 p=0.324	0.11 (-0.12, 0.32) n=79 p=0.347	0.03 (-0.19, 0.25) n=80 p=0.779
SRT: End of testing	0.07 (-0.15, 0.29) n=78 p=0.528	0.07 (-0.16, 0.29) n=78 p=0.555	0.29 (0.07, 0.48) n=78, p=0.011*	-0.03 (-0.25, 0.19) n=78 p=0.781	0.19 (-0.03, 0.4) n=77 p=0.092	0.04 (-0.18, 0.26) n=78 p=0.706

Table IIIC(2). Run-Roll-Aim 2. Run-Roll-Aim task results. Results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes subjects who completed the task.

Complete sample

	Trail4 Total Time	**Trial 4 Correct Responses / 14**	**RRA Aggregate Correct**	**RRA_Aggregate Error**	**RRA Aggregate Time**
Tower of Hanoi: # moves	0.17 (-0.05, 0.38) n=80 p=0.13	-0.12 (-0.33, 0.1) n=80 p=0.279	-0.11 (-0.32, 0.11) n=80 p=0.326	0.11 (-0.12, 0.32) n=80 p=0.351	0.11 (-0.11, 0.32) n=80 p=0.317
Tower of Hanoi: Error percentile	0.13 (-0.1, 0.34) n=80 p=0.264	0.13 (-0.1, 0.34) n=80 p=0.265	0.09 (-0.14, 0.3) n=80 p=0.452	-0.08 (-0.29, 0.15) n=80 p=0.501	0.16 (-0.06, 0.37) n=80 p=0.146
Tower Hanoi Error: Total	0.16 (-0.06, 0.37) n=80 p=0.155	0.07 (-0.15, 0.28) n=80 p=0.547	0.05 (-0.17, 0.27) n=80 p=0.636	-0.06 (-0.28, 0.16) n=80 p=0.591	0.18 (-0.04, 0.39) n=80 p=0.104
NAB Numbers-letters: Part D raw	-0.45 (-0.62, -0.25) n=73, p<0.001*	0.05 (-0.18, 0.28) n=73 p=0.658	0.01 (-0.22, 0.24) n=73 p=0.956	-0.06 (-0.28, 0.18) n=73 p=0.631	-0.44 (-0.61, -0.23) n=73, p<0.001*
NAB Numbers-Letters: Part D T-score	-0.42 (-0.59, -0.21) n=74, p<0.001*	0.02 (-0.21, 0.25) n=74 p=0.853	0.01 (-0.22, 0.23) n=74 p=0.957	-0.06 (-0.28, 0.17) n=74 p=0.632	-0.37 (-0.55, -0.16) n=74, p=0.001*
NAB Digit: Backward raw	-0.3 (-0.5, -0.07) n=71, p=0.011*	0.14 (-0.1, 0.36) n=71 p=0.24	-0.01 (-0.24, 0.23) n=71 p=0.956	-0.03 (-0.26, 0.21) n=71 p=0.829	-0.19 (-0.4, 0.05) n=71 p=0.118
NAB Digit: Backward T-score	-0.35 (-0.54, -0.13) n=72, p=0.002*	0.15 (-0.08, 0.37) n=72 p=0.208	0.09 (-0.15, 0.31) n=72 p=0.468	-0.12 (-0.34, 0.11) n=72 p=0.314	-0.23 (-0.44, 0) n=72 p=0.055
CTMT: Composite Index	-0.41 (-0.58, -0.2) n=73, p<0.001*	0.18 (-0.05, 0.4) n=73 p=0.122	0.07 (-0.16, 0.3) n=73 p=0.528	-0.11 (-0.33, 0.12) n=73 p=0.344	-0.35 (-0.54, -0.13) n=73, p=0.002*
WRAT: Raw score	-0.16 (-0.37, 0.06) n=80 p=0.156	-0.11 (-0.33, 0.11) n=80 p=0.313	-0.07 (-0.28, 0.15) n=80 p=0.548	0.05 (-0.17, 0.27) n=80 p=0.663	-0.19 (-0.4, 0.03) n=80 p=0.087
WRAT: Standardized score	-0.16 (-0.37, 0.06) n=80 p=0.158	-0.13 (-0.34, 0.09) n=80 p=0.246	-0.15 (-0.36, 0.07) n=80 p=0.184	0.12 (-0.11, 0.33) n=80 p=0.309	-0.2 (-0.4, 0.02) n=80 p=0.078
SRT: Baseline	0.06 (-0.16, 0.28) n=80 p=0.587	0.03 (-0.19, 0.24) n=80 p=0.817	0.2 (-0.02, 0.41) n=80 p=0.069	0.11 (-0.11, 0.32) n=80 p=0.324	0.11 (-0.12, 0.32) n=79 p=0.347
SRT: End of testing	0.07 (-0.15, 0.29) n=78 p=0.528	0.07 (-0.16, 0.29) n=78 p=0.555	0.29 (0.07, 0.48) n=78, p=0.011*	-0.03 (-0.25, 0.19) n=78 p=0.781	0.19 (-0.03, 0.4) n=77 p=0.092

Table IIID(1). Patrol-Exertion 1. Patrol-Exertion task results. Results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample

	Z. Total points (X + Y) / 24	**How hard are you working STANDING**	**How hard are you working PRE-VIDEO**	**How hard are you working END VIDEO**
Tower of Hanoi: # moves	-0.12 (-0.33, 0.09) n=84 p=0.262	0.01 (-0.22, 0.25) n=70 p=0.914	0 (-0.21, 0.22) n=82 p=0.984	0.07 (-0.15, 0.28) n=84 p=0.546
Tower of Hanoi: Error percentile	-0.29 (-0.48, -0.09) n=84, p=0.007*	0.23 (-0.01, 0.44) n=70 p=0.061	0.1 (-0.12, 0.31) n=82 p=0.351	0.09 (-0.13, 0.3) n=84 p=0.412
Tower Hanoi Error: Total	-0.24 (-0.43, -0.02) n=84, p=0.03*	0.2 (-0.04, 0.41) n=70 p=0.101	0.06 (-0.16, 0.28) n=82 p=0.572	0.15 (-0.07, 0.35) n=84 p=0.173
NAB Numbers-letters: Part D raw	0.21 (-0.01, 0.42) n=77 p=0.064	-0.01 (-0.26, 0.23) n=64 p=0.91	0.02 (-0.21, 0.25) n=75 p=0.871	-0.1 (-0.32, 0.13) n=77 p=0.391
NAB Numbers-Letters: Part D T-score	0.2 (-0.02, 0.41) n=78 p=0.077	-0.05 (-0.29, 0.2) n=65 p=0.689	0.01 (-0.21, 0.24) n=76 p=0.901	-0.1 (-0.32, 0.12) n=78 p=0.374
NAB Digit: Backward raw	-0.14 (-0.36, 0.09) n=75 p=0.226	-0.16 (-0.39, 0.09) n=63 p=0.22	0.02 (-0.21, 0.25) n=73 p=0.87	-0.07 (-0.29, 0.16) n=75 p=0.572
NAB Digit: Backward T-score	-0.13 (-0.35, 0.1) n=76 p=0.258	-0.2 (-0.43, 0.05) n=64 p=0.108	0.05 (-0.19, 0.27) n=74 p=0.702	-0.05 (-0.28, 0.17) n=76 p=0.648
CTMT: Composite Index	0.2 (-0.03, 0.41) n=77 p=0.082	-0.23 (-0.45, 0.02) n=64 p=0.072	-0.11 (-0.33, 0.12) n=75 p=0.341	-0.14 (-0.35, 0.09) n=77 p=0.234
WRAT: Raw score	0.26 (0.05, 0.45) n=84, p=0.016*	-0.07 (-0.3, 0.17) n=70 p=0.575	0.07 (-0.15, 0.28) n=82 p=0.532	-0.1 (-0.31, 0.12) n=84 p=0.373
WRAT: Standardized score	0.23 (0.01, 0.42) n=84, p=0.039*	-0.01 (-0.24, 0.23) n=70 p=0.944	0.15 (-0.07, 0.36) n=82 p=0.173	-0.07 (-0.28, 0.14) n=84 p=0.498
SRT: Baseline	-0.17 (-0.37, 0.04) n=84 p=0.118	0.08 (-0.16, 0.31) n=70 p=0.526	-0.02 (-0.24, 0.2) n=82 p=0.865	0.11 (-0.11, 0.31) n=84 p=0.333
SRT: End of testing	0.04 (-0.18, 0.26) n=81 p=0.73	0.11 (-0.13, 0.34) n=68 p=0.371	0.1 (-0.13, 0.31) n=79 p=0.392	0.23 (0.01, 0.42) n=81, p=0.043*

Table IIID(2). Patrol-Exertion 2. Patrol-Exertion task results. Results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample	**Work Change Stand to End**	**Work Change Pre to End**	**Vision Clarity STANDING**	**Vision Clarity PRE-VIDEO**	**Vision Clarity END VIDEO**	**Vision Change Stand to End**	**Vision Change _Pre to End**
Tower of Hanoi: # moves	0.1 (-0.14, 0.33) n=70 p=0.412	0.07 (-0.15, 0.29) n=82 p=0.51	0.06 (-0.17, 0.3) n=70 p=0.595	0.03 (-0.18, 0.25) n=82 p=0.761	0.15 (-0.07, 0.35) n=84 p=0.17	0.2 (-0.03, 0.42) n=70 p=0.094	0.24 (0.03, 0.44) n=82, p=0.028*
Tower of Hanoi: Error percentile	-0.06 (-0.29, 0.18) n=70 p=0.643	0.01 (-0.2, 0.23) n=82 p=0.911	0.1 (-0.13, 0.33) n=70 p=0.39	0.04 (-0.18, 0.25) n=82 p=0.73	0.18 (-0.03, 0.38) n=84 p=0.099	0.19 (-0.05, 0.41) n=70 p=0.116	0.28 (0.07, 0.47) n=82, p=0.01*
Tower Hanoi Error Total	0.05 (-0.19, 0.28) n=70 p=0.683	0.11 (-0.11, 0.32) n=82 p=0.34	0.12 (-0.12, 0.34) n=70 p=0.327	0.07 (-0.15, 0.28) n=82 p=0.542	0.25 (0.04, 0.44) n=84, p=0.021*	0.29 (0.06, 0.49) n=70, p=0.015*	0.37 (0.17, 0.55) n=82, p=0.001*
NAB Numbers-letters: Part D raw	-0.06 (-0.31, 0.18) n=64 p=0.611	-0.14 (-0.36, 0.09) n=75 p=0.218	-0.09 (-0.33, 0.16) n=64 p=0.473	-0.08 (-0.3, 0.15) n=75 p=0.518	-0.05 (-0.27, 0.17) n=77 p=0.644	-0.05 (-0.29, 0.2) n=64 p=0.678	-0.05 (-0.27, 0.18) n=75 p=0.667
NAB Numbers-Letters: Part D T-score	-0.06 (-0.3, 0.18) n=65 p=0.61	-0.14 (-0.36, 0.09) n=76 p=0.219	-0.13 (-0.36, 0.12) n=65 p=0.32	-0.11 (-0.32, 0.12) n=76 p=0.356	-0.06 (-0.28, 0.16) n=78 p=0.576	-0.06 (-0.3, 0.19) n=65 p=0.649	-0.04 (-0.26, 0.19) n=76 p=0.75
NAB Digit: Backward raw	0.05 (-0.2, 0.3) n=63 p=0.689	-0.08 (-0.31, 0.15) n=73 p=0.493	-0.1 (-0.34, 0.15) n=63 p=0.425	-0.11 (-0.33, 0.12) n=73 p=0.344	-0.13 (-0.35, 0.1) n=75 p=0.253	-0.17 (-0.4, 0.08) n=63 p=0.184	-0.13 (-0.35, 0.11) n=73 p=0.29
NAB Digit: Backward T-score	0.1 (-0.15, 0.34) n=64 p=0.444	-0.09 (-0.31, 0.14) n=74 p=0.447	-0.09 (-0.33, 0.16) n=64 p=0.461	-0.09 (-0.32, 0.14) n=74 p=0.425	-0.12 (-0.34, 0.11) n=76 p=0.307	-0.16 (-0.39, 0.09) n=64 p=0.199	-0.12 (-0.34, 0.11) n=74 p=0.32
CTMT: Composite Index	0 (-0.24, 0.25) n=64 p=0.985	-0.04 (-0.27, 0.19) n=75 p=0.714	-0.22 (-0.44, 0.03) n=64 p=0.079	-0.21 (-0.42, 0.02) n=75 p=0.07	-0.24 (-0.44, -0.02) n=77, p=0.033*	-0.28 (-0.49, -0.04) n=64, p=0.024*	-0.24 (-0.44, -0.01) n=75, p=0.038*
WRAT: Raw score	0.05 (-0.18, 0.28) n=70 p=0.665	-0.16 (-0.36, 0.06) n=82 p=0.158	0.05 (-0.19, 0.28) n=70 p=0.698	0.1 (-0.12, 0.31) n=82 p=0.369	0.1 (-0.12, 0.31) n=84 p=0.364	0.07 (-0.17, 0.3) n=70 p=0.563	0.06 (-0.16, 0.28) n=82 p=0.569
WRAT: Standardized score	0.02 (-0.22, 0.25) n=70 p=0.869	-0.21 (-0.41, 0.01) n=82 p=0.062	0.06 (-0.18, 0.29) n=70 p=0.623	0.11 (-0.11, 0.32) n=82 p=0.339	0.09 (-0.12, 0.3) n=84 p=0.392	0.07 (-0.17, 0.3) n=70 p=0.592	0.04 (-0.17, 0.26) n=82 p=0.696
SRT: Baseline	0.11 (-0.13, 0.34) n=70 p=0.367	0.13 (-0.09, 0.34) n=82 p=0.233	0.24 (0, 0.45) n=70, p=0.049*	0.33 (0.12, 0.51) n=82, p=0.003*	0.35 (0.14, 0.52) n=84, p=0.001*	0.35 (0.13, 0.54) n=70, p=0.003*	0.32 (0.11, 0.5) n=82, p=0.004*
SRT: End of testing	0.13 (-0.12, 0.35) n=68 p=0.306	0.17 (-0.05, 0.38) n=79 p=0.134	0.21 (-0.03, 0.42) n=68 p=0.092	0.37 (0.16, 0.55) n=79, p=0.001*	0.58 (0.41, 0.71) n=81, p<0.001*	0.65 (0.49, 0.77) n=68, p<0.001*	0.65 (0.5, 0.76) n=79, p<0.001*

Table IIID(3). Patrol-Exertion 3. Patrol-Exertion task results. Results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample

	Patrol_Reaction Baseline Standing	**Patrol Reaction_baseline-Stepping**	**PatrolReactBEGIN**	**PatrolReactEND**
Tower of Hanoi: # moves	0.14 (-0.07, 0.35) n=84 p=0.189	-0.18 (-0.38, 0.04) n=84 p=0.111	-0.02 (-0.24, 0.2) n=80 p=0.85	0.02 (-0.2, 0.23) n=81 p=0.882
Tower of Hanoi: Error percentile	-0.22 (-0.42, -0.01) n=84, p=0.041*	-0.08 (-0.29, 0.14) n=84 p=0.463	-0.08 (-0.29, 0.15) n=80 p=0.498	0.12 (-0.1, 0.33) n=81 p=0.296
Tower Hanoi Error Total	-0.15 (-0.35, 0.06) n=84 p=0.169	-0.1 (-0.31, 0.12) n=84 p=0.36	-0.07 (-0.29, 0.15) n=80 p=0.535	0.08 (-0.14, 0.3) n=81 p=0.463
NAB Numbers-letters: Part D raw	-0.11 (-0.33, 0.12) n=77 p=0.335	-0.05 (-0.27, 0.18) n=77 p=0.663	-0.19 (-0.4, 0.05) n=73 p=0.113	-0.16 (-0.38, 0.07) n=74 p=0.161
NAB Numbers-Letters: Part D T-score	-0.11 (-0.33, 0.11) n=78 p=0.329	-0.03 (-0.25, 0.2) n=78 p=0.807	-0.11 (-0.33, 0.12) n=74 p=0.362	-0.1 (-0.32, 0.13) n=75 p=0.374
NAB Digit: Backward raw	-0.19 (-0.4, 0.04) n=75 p=0.097	-0.14 (-0.35, 0.09) n=75 p=0.247	-0.09 (-0.31, 0.15) n=71 p=0.48	-0.28 (-0.48, -0.05) n=72, p=0.019*
NAB Digit: Backward T-score	-0.22 (-0.43, 0) n=76 p=0.053	-0.18 (-0.39, 0.05) n=76 p=0.12	-0.08 (-0.3, 0.16) n=72 p=0.522	-0.21 (-0.42, 0.02) n=73 p=0.069
CTMT: Composite Index	-0.15 (-0.36, 0.08) n=77 p=0.194	-0.1 (-0.32, 0.13) n=77 p=0.393	-0.02 (-0.25, 0.21) n=73 p=0.864	-0.2 (-0.41, 0.03) n=74 p=0.093
WRAT: Raw score	-0.01 (-0.22, 0.2) n=84 p=0.921	0.1 (-0.12, 0.31) n=84 p=0.364	-0.21 (-0.41, 0.01) n=80 p=0.056	-0.1 (-0.31, 0.12) n=81 p=0.358
WRAT: Standardized score	-0.03 (-0.24, 0.19) n=84 p=0.789	0.07 (-0.15, 0.28) n=84 p=0.538	-0.25 (-0.44, -0.03) n=80, p=0.026*	-0.13 (-0.34, 0.09) n=81 p=0.254
SRT: Baseline	0.11 (-0.1, 0.32) n=84 p=0.303	0.18 (-0.04, 0.38) n=84 p=0.1	0.18 (-0.04, 0.39) n=80 p=0.104	0.26 (0.05, 0.45) n=81, p=0.018*
SRT: End of testing	0.1 (-0.12, 0.31) n=81 p=0.37	0.18 (-0.04, 0.39) n=81 p=0.102	0.31 (0.09, 0.5) n=77, p=0.006*	0.45 (0.26, 0.61) n=78, p<0.001*

Table IIIE(1). Agility 1. Illinois Agility-Packing List task results. Results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample

	Single Task Agility Time	Single Task Words Correct	Single Task Word Errors	DNI Task Words Correct	DNI Task Test Time	DNI Total Word Errors	Dual WORD Task Words Correct	Dual WORD Task Test Time
Tower of Hanoi: # moves	0.08 (-0.13, 0.29) n=86 p=0.467	-0.13 (-0.33, 0.08) n=86 p=0.235	0.16 (-0.05, 0.36) n=86 p=0.141	-0.09 (-0.29, 0.13) n=86 p=0.43	0.15 (-0.07, 0.35) n=86 p=0.173	-0.04 (-0.25, 0.18) n=86 p=0.734	-0.05 (-0.26, 0.16) n=86 p=0.646	0.23 (0.02, 0.42) n=86, p=0.034*
Tower of Hanoi: Error percentile	0.13 (-0.1, 0.34) n=77 p=0.263	-0.13 (-0.34, 0.1) n=77 p=0.27	0.21 (-0.02, 0.41) n=77 p=0.074	-0.14 (-0.35, 0.09) n=77 p=0.229	0.19 (-0.03, 0.4) n=77 p=0.09	0.04 (-0.19, 0.26) n=77 p=0.733	-0.1 (-0.32, 0.13) n=77 p=0.388	0.25 (0.03, 0.45) n=77, p=0.029*
Tower Hanoi Error Total	0.16 (-0.07, 0.37) n=77 p=0.176	-0.12 (-0.34, 0.11) n=77 p=0.293	0.19 (-0.04, 0.39) n=77 p=0.104	-0.11 (-0.32, 0.12) n=77 p=0.35	0.27 (0.05, 0.47) n=77, p=0.017*	0.02 (-0.21, 0.24) n=77 p=0.892	-0.06 (-0.28, 0.17) n=77 p=0.605	0.3 (0.08, 0.49) n=77, p=0.009*
NAB Numbers-letters: Part D raw	-0.03 (-0.25, 0.18) n=84 p=0.757	0.09 (-0.12, 0.3) n=84 p=0.39	-0.17 (-0.37, 0.04) n=84 p=0.117	-0.03 (-0.25, 0.18) n=84 p=0.762	-0.12 (-0.32, 0.1) n=84 p=0.288	0.15 (-0.06, 0.36) n=84 p=0.16	0.11 (-0.1, 0.32) n=84 p=0.301	-0.14 (-0.34, 0.08) n=84 p=0.207
NAB Numbers-Letters: Part D T-score	0.02 (-0.2, 0.23) n=86 p=0.886	0.11 (-0.11, 0.31) n=86 p=0.322	-0.18 (-0.37, 0.04) n=86 p=0.103	-0.02 (-0.23, 0.2) n=86 p=0.874	-0.07 (-0.27, 0.15) n=86 p=0.545	0.16 (-0.05, 0.36) n=86 p=0.133	0.1 (-0.11, 0.31) n=86 p=0.356	-0.1 (-0.3, 0.12) n=86 p=0.378
NAB Digit: Backward raw	-0.15 (-0.36, 0.07) n=82 p=0.176	0.17 (-0.05, 0.37) n=82 p=0.13	-0.09 (-0.3, 0.13) n=82 p=0.445	0.32 (0.11, 0.51) n=82, p=0.003*	0.01 (-0.21, 0.23) n=82 p=0.921	-0.18 (-0.38, 0.04) n=82 p=0.116	0.08 (-0.14, 0.29) n=82 p=0.491	0.01 (-0.2, 0.23) n=82 p=0.895
NAB Digit: Backward T-score	-0.18 (-0.38, 0.04) n=84 p=0.107	0.12 (-0.1, 0.33) n=84 p=0.276	-0.02 (-0.23, 0.2) n=84 p=0.883	0.24 (0.03, 0.43) n=84, p=0.026*	-0.02 (-0.23, 0.19) n=84 p=0.854	-0.11 (-0.32, 0.11) n=84 p=0.328	0.06 (-0.16, 0.27) n=84 p=0.61	-0.01 (-0.22, 0.21) n=84 p=0.936
CTMT: Composite Index	-0.14 (-0.34, 0.07) n=85 p=0.197	0.09 (-0.12, 0.3) n=85 p=0.388	-0.04 (-0.25, 0.17) n=85 p=0.703	-0.11 (-0.31, 0.11) n=85 p=0.33	-0.15 (-0.35, 0.07) n=85 p=0.176	0.2 (-0.02, 0.39) n=85 p=0.072	0.23 (0.01, 0.42) n=85, p=0.037*	-0.08 (-0.29, 0.14) n=85 p=0.466
WRAT: Raw score	0.01 (-0.19, 0.21) n=95 p=0.911	0.32 (0.12, 0.49) n=95, p=0.002*	-0.3 (-0.48, -0.11) n=95,p=0.003*	0.36 (0.17, 0.52) n=95, p<0.001*	0.17 (-0.04, 0.36) n=95 p=0.105	-0.09 (-0.29, 0.11) n=95 p=0.38	0.4 (0.22, 0.56) n=95, p<0.001*	0.11 (-0.09, 0.31) n=95 p=0.268

Complete sample	**Single Task Agility Time**	**Single Task Words Correct**	**Single Task Word Errors**	**DNI Task Words Correct**	**DNI Task Test Time**	**DNI Total Word Errors**	**Dual WORD Task Words Correct**	**Dual WORD Task Test Time**
WRAT: Standardized score	0.01 (-0.19, 0.21) n=95 p=0.946	0.34 (0.15, 0.51) n=95, p=0.001*	-0.32 (-0.49, -0.13) n=95, p=0.001*	0.34 (0.15, 0.51) n=95, p=0.001*	0.16 (-0.04, 0.35) n=95 p=0.122	-0.06 (-0.26, 0.14) n=95 p=0.56	0.42 (0.23, 0.57) n=95, p<0.001*	0.1 (-0.1, 0.3) n=95 p=0.333
SRT: Baseline	0.31 (0.1, 0.49) n=85, p=0.004*	0.03 (-0.19, 0.24) n=85 p=0.811	-0.04 (-0.26, 0.17) n=85 p=0.685	0.11 (-0.11, 0.31) n=85 p=0.337	0.31 (0.11, 0.49) n=85, p=0.004*	-0.1 (-0.3, 0.12) n=85 p=0.374	-0.11 (-0.31, 0.11) n=85 p=0.33	0.27 (0.06, 0.45) n=85, p=0.014*
SRT: End of testing	0.33 (0.12, 0.52) n=80, p=0.003*	0.04 (-0.19, 0.25) n=80 p=0.755	-0.1 (-0.31, 0.13) n=80 p=0.399	0 (-0.22, 0.22) n=80 p=0.974	0.33 (0.12, 0.51) n=80, p=0.003*	-0.02 (-0.24, 0.2) n=80 p=0.875	-0.04 (-0.26, 0.18) n=80 p=0.732	0.27 (0.05, 0.46) n=80, p=0.017*

Table IIIE(2). Agility 2. Illinois Agility- Packing List task results. Results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample

	Dual WORD Total Errors	**Dual AGILITY Task Words Correct**	**Dual AGILITY Test Time**	**Dual AGILITY Total WORD Errors**	**Aggregate TOTAL_WORDS Correct**	**Aggregate Total_Time**	**Aggregate Total WORD Errors**
Tower of Hanoi: # moves	-0.03 (-0.24, 0.19) n=86 p=0.808	-0.1 (-0.3, 0.12) n=86 p=0.376	0.13 (-0.09, 0.33) n=86 p=0.248	-0.06 (-0.27, 0.16) n=85 p=0.609	-0.1 (-0.31, 0.11) n=86 p=0.355	0.18 (-0.03, 0.38) n=86 p=0.092	-0.05 (-0.26, 0.17) n=86 p=0.677
Tower of Hanoi: Error percentile	0.02 (-0.21, 0.24) n=77 p=0.882	-0.07 (-0.29, 0.16) n=77 p=0.57	0.25 (0.02, 0.45) n=77, p=0.031*	-0.06 (-0.28, 0.16) n=76 p=0.59	-0.13 (-0.35, 0.1) n=77 p=0.253	0.24 (0.02, 0.44) n=77, p=0.033*	0 (-0.22, 0.22) n=77 p=0.996
Tower Hanoi Error Total	-0.02 (-0.24, 0.21) n=77 p=0.888	0.01 (-0.21, 0.24) n=77 p=0.916	0.31 (0.1, 0.5) n=77, p=0.006*	-0.14 (-0.35, 0.09) n=76 p=0.227	-0.07 (-0.29, 0.16) n=77 p=0.561	0.31 (0.09, 0.5) n=77, p=0.006*	-0.06 (-0.28, 0.17) n=77 p=0.618
NAB Numbers-letters: Part D raw	0.01 (-0.21, 0.22) n=84 p=0.957	0.01 (-0.2, 0.23) n=84 p=0.914	-0.15 (-0.35, 0.07) n=84 p=0.175	0.1 (-0.12, 0.31) n=83 p=0.354	0.04 (-0.17, 0.26) n=84 p=0.695	-0.14 (-0.35, 0.07) n=84 p=0.196	0.12 (-0.1, 0.32) n=84 p=0.293
NAB Numbers-Letters: Part D T-score	0.04 (-0.17, 0.25) n=86 p=0.724	0.02 (-0.19, 0.23) n=86 p=0.863	-0.1 (-0.31, 0.11) n=86 p=0.34	0.11 (-0.11, 0.31) n=85 p=0.33	0.05 (-0.17, 0.26) n=86 p=0.668	-0.09 (-0.3, 0.12) n=86 p=0.392	0.13 (-0.08, 0.34) n=86 p=0.217
NAB Digit: Backward raw	0.04 (-0.18, 0.25) n=82 p=0.732	0.23 (0.01, 0.43) n=82, p=0.038*	0.04 (-0.18, 0.25) n=82 p=0.726	-0.1 (-0.31, 0.12) n=81 p=0.388	0.27 (0.06, 0.46) n=82, p=0.015*	0.02 (-0.2, 0.24) n=82 p=0.844	-0.1 (-0.31, 0.12) n=82 p=0.386
NAB Digit: Backward T-score	0.05 (-0.17, 0.26) n=84 p=0.67	0.26 (0.04, 0.45) n=84, p=0.019*	-0.02 (-0.23, 0.2) n=84 p=0.865	-0.15 (-0.36, 0.06) n=83 p=0.165	0.24 (0.02, 0.43) n=84, p=0.03*	-0.02 (-0.23, 0.2) n=84 p=0.882	-0.09 (-0.3, 0.12) n=84 p=0.395
CTMT: Composite Index	-0.16 (-0.36, 0.06) n=85 p=0.147	0.13 (-0.08, 0.34) n=85 p=0.231	-0.14 (-0.34, 0.07) n=85 p=0.197	-0.01 (-0.22, 0.21) n=84 p=0.937	0.12 (-0.1, 0.32) n=85 p=0.292	-0.13 (-0.33, 0.09) n=85 p=0.244	-0.01 (-0.22, 0.21) n=85 p=0.949
WRAT: Raw score	-0.22 (-0.4, -0.02) n=95, p=0.031*	0.36 (0.17, 0.52) n=95, p<0.001*	0.17 (-0.03, 0.36) n=95 p=0.104	-0.09 (-0.29, 0.11) n=94 p=0.364	0.49 (0.32, 0.63) n=95, p<0.001*	0.16 (-0.05, 0.35) n=95 p=0.132	-0.18 (-0.37, 0.02) n=95 p=0.079
WRAT: Standardized score	-0.22 (-0.4, -0.02) n=95, p=0.035*	0.42 (0.24, 0.57) n=95, p<0.001*	0.15 (-0.05, 0.34) n=95 p=0.14	-0.15 (-0.34, 0.06) n=94 p=0.158	0.51 (0.34, 0.65) n=95, p<0.001*	0.14 (-0.06, 0.33) n=95 p=0.167	-0.19 (-0.38, 0.01) n=95 p=0.064
SRT: Baseline	0.14 (-0.08, 0.34) n=85 p=0.216	-0.07 (-0.28, 0.14) n=85 p=0.502	0.37 (0.17, 0.54) n=85, p=0.001*	0.1 (-0.12, 0.31) n=84 p=0.372	-0.03 (-0.25, 0.18) n=85 p=0.751	0.33 (0.12, 0.51) n=85, p=0.002*	0.07 (-0.15, 0.28) n=85 p=0.533
SRT: End of testing	0.05 (-0.17, 0.26) n=80 p=0.678	0.03 (-0.19, 0.25) n=80 p=0.801	0.45 (0.26, 0.61) n=80, p<0.001*	-0.04 (-0.26, 0.18) n=79 p=0.703	-0.01 (-0.23, 0.21) n=80 p=0.96	0.36 (0.16, 0.54) n=80, p=0.001*	0 (-0.22, 0.22) n=80 p=0.975

Table IIIF. Load Magazine-Radio Chatter. Correlation results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample

	3. Correct Single/ 9	**5. Correct Dual/ 9**	**RadioChatErrors Single**	**RadioChatErrors Dual**	**RadioChatErrorsDual _minus_single**	**RadioChatCorrect Sing-CorrectDual**
Tower of Hanoi: # moves	-0.07 (-0.27, 0.14) n=92 p=0.508	-0.14 (-0.33, 0.07) n=92 p=0.197	0.09 (-0.12, 0.29) n=92 p=0.385	0.17 (-0.03, 0.36) n=92 p=0.102	0.04 (-0.17, 0.24) n=92 p=0.714	0.04 (-0.17, 0.24) n=92 p=0.711
Tower of Hanoi: Error percentile	-0.14 (-0.34, 0.08) n=82 p=0.22	-0.19 (-0.39, 0.02) n=82 p=0.082	0.15 (-0.07, 0.36) n=82 p=0.169	0.2 (-0.02, 0.4) n=82 p=0.073	-0.01 (-0.22, 0.21) n=82 p=0.959	0.02 (-0.2, 0.23) n=82 p=0.887
Tower Hanoi Error Total	-0.15 (-0.35, 0.07) n=82 p=0.188	-0.18 (-0.38, 0.04) n=82 p=0.111	0.17 (-0.05, 0.37) n=82 p=0.134	0.18 (-0.04, 0.38) n=82 p=0.101	-0.03 (-0.25, 0.19) n=82 p=0.768	-0.01 (-0.22, 0.21) n=82 p=0.953
NAB Numbers-letters: Part D raw	0.14 (-0.07, 0.34) n=90 p=0.179	0.24 (0.03, 0.42) n=90, p=0.025*	-0.13 (-0.33, 0.08) n=90 p=0.22	-0.27 (-0.45, -0.07) n=90, p=0.01*	-0.08 (-0.28, 0.13) n=90 p=0.479	-0.04 (-0.25, 0.17) n=90 p=0.689
NAB Numbers-Letters: Part D T-score	0.16 (-0.05, 0.35) n=93 p=0.136	0.28 (0.08, 0.46) n=93, p=0.007*	-0.13 (-0.33, 0.07) n=93 p=0.204	-0.31 (-0.48, -0.11) n=93, p=0.003*	-0.1 (-0.3, 0.11) n=93 p=0.34	-0.06 (-0.26, 0.14) n=93 p=0.542
NAB Digit: Backward raw	0.11 (-0.1, 0.31) n=88 p=0.305	0.16 (-0.05, 0.36) n=88 p=0.134	-0.02 (-0.23, 0.19) n=88 p=0.845	-0.14 (-0.34, 0.07) n=88 p=0.197	-0.08 (-0.29, 0.13) n=88 p=0.432	-0.01 (-0.22, 0.2) n=88 p=0.894
NAB Digit: Backward T-score	0.16 (-0.05, 0.35) n=91 p=0.141	0.19 (-0.01, 0.38) n=91 p=0.065	-0.1 (-0.3, 0.11) n=91 p=0.365	-0.19 (-0.38, 0.02) n=91 p=0.074	-0.04 (-0.25, 0.16) n=91 p=0.673	0 (-0.2, 0.21) n=91 p=0.986
CTMT: Composite Index	0.15 (-0.06, 0.34) n=92 p=0.167	0.35 (0.15, 0.52) n=92, p=0.001*	-0.15 (-0.34, 0.06) n=92 p=0.157	-0.41 (-0.57, -0.22) n=92, p<0.001*	-0.16 (-0.35, 0.05) n=92 p=0.133	-0.12 (-0.32, 0.08) n=92 p=0.237
WRAT: Raw score	0.15 (-0.05, 0.33) n=102 p=0.139	0.35 (0.17, 0.51) n=102, p<0.001*	-0.1 (-0.29, 0.1) n=102 p=0.318	-0.35 (-0.51, -0.17) n=102, p<0.001*	-0.18 (-0.36, 0.02) n=102 p=0.077	-0.14 (-0.32, 0.06) n=102 p=0.17
WRAT: Standardized score	0.13 (-0.06, 0.32) n=101 p=0.184	0.33 (0.15, 0.5) n=101, p=0.001*	-0.1 (-0.29, 0.1) n=101 p=0.328	-0.33 (-0.49, -0.14) n=101, p=0.001*	-0.16 (-0.34, 0.04) n=101 p=0.109	-0.14 (-0.32, 0.06) n=101 p=0.172
SRT: Baseline	-0.18 (-0.37, 0.03) n=90 p=0.099	-0.19 (-0.38, 0.02) n=90 p=0.072	0.18 (-0.03, 0.37) n=90 p=0.093	0.29 (0.09, 0.47) n=90, p=0.005*	0.05 (-0.16, 0.25) n=90 p=0.659	-0.02 (-0.23, 0.19) n=90 p=0.847
SRT: End of testing	-0.12 (-0.32, 0.1) n=86 p=0.292	-0.06 (-0.26, 0.16) n=86 p=0.609	0.15 (-0.07, 0.35) n=86 p=0.18	0.13 (-0.09, 0.33) n=86 p=0.241	-0.05 (-0.26, 0.16) n=86 p=0.648	-0.07 (-0.28, 0.14) n=86 p=0.523

Table IIIG. ISAW-Grid. ISAW-Grid task results are presented as: Pearson correlation (95% CI), number of subjects used to calculate the correlation, and p-value. An asterisk next to a p-value denotes statistical significance at level 0.05. Includes only subjects who completed the task.

Complete sample

	Single Task Median Time (secs)	**Single Task Cognitive: # Grid Coordinates Correct**	**DualTask Median Time (secs)**	**Dual-task Cognitive: # Grid Coordinates Correct**
Tower of Hanoi: # moves	0.03 (-0.18, 0.23) n=91 p=0.805	-0.19 (-0.38, 0.02) n=91 p=0.073	0.04 (-0.17, 0.24) n=93 p=0.715	-0.09 (-0.29, 0.11) n=93 p=0.378
Tower of Hanoi: Error percentile	0.02 (-0.19, 0.24) n=83 p=0.836	-0.21 (-0.41, 0) n=83 p=0.053	0.08 (-0.13, 0.29) n=84 p=0.444	0.07 (-0.14, 0.28) n=84 p=0.506
Tower Hanoi Error Total	0.03 (-0.19, 0.25) n=83 p=0.777	-0.24 (-0.44, -0.03) n=83, p=0.027*	0.1 (-0.12, 0.31) n=84 p=0.373	0.07 (-0.15, 0.28) n=84 p=0.518
NAB Numbers-letters: Part D raw	-0.09 (-0.29, 0.13) n=86 p=0.426	0.13 (-0.08, 0.34) n=86 p=0.215	-0.05 (-0.25, 0.16) n=90 p=0.641	-0.15 (-0.35, 0.06) n=90 p=0.162
NAB Numbers-Letters: Part D T-score	-0.06 (-0.27, 0.15) n=89 p=0.545	0.13 (-0.08, 0.33) n=89 p=0.217	-0.08 (-0.27, 0.13) n=93 p=0.474	-0.11 (-0.3, 0.1) n=93 p=0.303
NAB Digit: Backward raw	-0.2 (-0.4, 0.01) n=84 p=0.066	0.49 (0.31, 0.64) n=84, p<0.001*	0.16 (-0.05, 0.36) n=88 p=0.142	-0.06 (-0.27, 0.15) n=88 p=0.552
NAB Digit: Backward T-score	-0.27 (-0.46, -0.06) n=87, p=0.011*	0.46 (0.28, 0.61) n=87, p<0.001*	0.07 (-0.14, 0.27) n=91 p=0.537	-0.08 (-0.28, 0.13) n=91 p=0.463
CTMT: Composite Index	0 (-0.2, 0.21) n=88 p=0.963	0.26 (0.05, 0.44) n=88, p=0.015*	0.01 (-0.19, 0.22) n=92 p=0.916	0.05 (-0.16, 0.25) n=92 p=0.632
WRAT: Raw score	0.04 (-0.16, 0.24) n=99 p=0.697	0.39 (0.21, 0.55) n=99, p<0.001*	0.14 (-0.05, 0.33) n=103 p=0.145	-0.08 (-0.27, 0.11) n=103 p=0.416
WRAT: Standardized score	0.02 (-0.18, 0.21) n=99 p=0.869	0.36 (0.18, 0.52) n=99, p<0.001*	0.15 (-0.04, 0.34) n=103 p=0.121	-0.08 (-0.27, 0.11) n=103 p=0.404
SRT: Baseline	0.19 (-0.02, 0.38) n=90 p=0.081	-0.14 (-0.34, 0.07) n=90 p=0.181	-0.2 (-0.39, 0.01) n=91 p=0.064	0.08 (-0.12, 0.28) n=91 p=0.434
SRT: End of testing	0.21 (0, 0.41) n=84 p=0.053	-0.12 (-0.32, 0.1) n=84 p=0.286	-0.15 (-0.35, 0.06) n=86 p=0.161	0.1 (-0.12, 0.3) n=86 p=0.369

AIM 4: DETERMINE ABILITY OF DUAL-TASK AND MULTITASK TEST ITEMS TO DISCRIMINATE BETWEEN HEALTHY CONTROL SM AND SM WITH MTBI SYMPTOM COMPLEX.

As described above, the AMMP battery of 6 tasks was administered to healthy SM (controls) and those with known mild traumatic brain injury symptom-complex. Except for the inertial sensor findings on the ISAW-grid task which was unchanged throughout the iterative reliability process, data were collected on SM stationed at Fort Bragg. The inertial sensor data analysis for the ISAW-grid including findings from HC subjects from USARIEM as well as Fort Bragg. Findings on between-group differences are reported first for AMMP multitasks (CQ Duty, Run-Roll-Aim, Patrol-Exertion) and then AMMP dual-tasks (Illinois Agility-Packing List, Load Magazine-Radio Chatter, ISAW-Grid,).

Known Groups Methods

<u>Data source</u>

Tasks were administered to participants and score sheets were completed. Analysis for each task includes subjects who completed that task. For certain tasks, data collected as part of evaluating IRR were included for items that did not change and had high IRR. This included CQ Duty (number of visits and total time), Load-Magazine-Radio Chatter, and ISAW-grid tasks. Since these tasks from IRR were scored by more than one individual, a data set to be used for known groups analysis was selected randomly from among the 2 or 3 raters.

<u>Analysis</u>

Tests for significant differences between groups for continuous data included the t-Test for independent groups to test for difference of means if the data met the criteria for a normal distribution, otherwise, the Mann-Whitney U test for independent groups was used to test the difference in medians. In most cases, data distributions did not meet criteria for normal distribution as tested with the Shapiro-Wilk Test. Chi-Square was used to test for significant differences between groups for dichotomous variables such as number completing the task. A two sided p-value < 0.05 was required for significance. SPSS V22.0 (IBM Inc.) was used for analysis.

Effect sizes were calculated for task items that were significantly different between groups. Non-parametric effect sizes were calculated as; z/sqrt(n), z= calculated z-score based on ranks, n= total of HC and mTBI[9]. In reading this document, be aware that cut points for non-parametric effect sizes are: 0.1 as small, 0.3 as medium, and 0.5 as large. Cohen's d effect size based on mean and standard deviation, has cut points that are greater at: small as 0.2, medium as 0.5, large as 0.8.

CHARGE OF QUARTERS (CQ) DUTY

Introduction

Performance-based assessments that place demands on multitasking are known to be sensitive to executive dysfunction. The CQ Duty task was developed to target executive dysfunction using a military type task scenario.

Description

CQ Duty is a performance-based multitasking assessment that was developed using the structure and metrics of the Multiple Errands Test (MET)[10].To perform the CQ Duty task, SM are given a list of tasks to carry-out as efficiently as possible using supplies and information from 4 taped-off work areas. The primary tasks include reporting a duty shift change, assembling a footstool from PVC pipe, reporting information to a superior at various times, and inventorying supplies while remembering to carry-out embedded prospective memory assignments[3]. Performance is characterized in terms of the following metrics: accurate task completion; performance time; number of visits between the 4 work areas made to complete the exercise; and the number of times the subject broke task rules. See details of task set up, test administration and scoring in the AMMP Manual (Appendix 4).

Rationale

Performance-based assessments that place demands on multitasking are known to be sensitive to executive dysfunction[11]. The MET is a widely used research metric that was designed to measure executive dysfunction in community dwelling individuals with mild cognitive impairment[10]. Patients are required to structure their completion of a series of interleaving tasks in the hospital lobby[12-14] or a shopping center[13], without engaging the examiner. The MET has been shown to be sensitive to executive dysfunction after both traumatic brain injury[12] and mild stroke[14] but has limited clinical feasibility[15].

Similar to the MET, the CQ Duty places demands on multitasking based on the definition of that term proposed by Burgess[16], who proposed that multitasking has the following key elements including many discrete but interleaving tasks that have to be completed one at a time; interruptions and unexpected outcomes occur; and involve delayed intentions that place demands on prospective memory. However, the CQ Duty was designed to overcome the MET's difficulties with clinical feasibility by keeping test administration to around 30 minutes and allowing test-task set up in most clinical environments.

Hypotheses/expectations

We hypothesized that the CQ Duty primarily places demands on executive functioning, which would most likely be evidenced in the number of visits to the 4 work areas taken during the exercise (less visits indicative of greater foresight and planning). Similarly, we hypothesized some correlation between the aforementioned metric and number of moves on the TOH[17], CTMT[18], both measures of executive functioning, and the WRAT 4 Reading Test[19], a proxy for intelligence and education level.

Method

As part of the AMMP validation study to evaluate IRR and known-group discrimination, the CQ Duty was administered to SM with mTBI and HCs. CQ Duty assessment solely relied on observational metrics, as described above.

Between-groups analyses for number of visits and performance time were conducted on 51 HCs and 51 SM with mTBI. Between-groups analyses for task performance and rule breaks were conducted on 50 HCs and 33 SM with mTBI. As described earlier, an iterative approach to scoring refinement was used to optimize inter-rater reliability in the first half of the study. Performance time and number of visits remained consistent throughout the entire data collection period, thus there were larger numbers in these analyses, whereas there small changes were made in task performance and rule break scoring methods. Finally, between group analyses are provided with and without data from Subject 83. This HC took 51 visits to complete the task, an outlier by either group definition.

Results

As summarized in Table IVA, study findings suggest statistically significant differences between known groups of HC SM and SM with mTBI in task performance accuracy and number visits taken to the 4 work areas to complete the exercise (going forward, referred to a "number of visits"). However, effect sizes (calculated using Cohen's *d*) were relatively small. There were no group differences between performance time and rules broken.

As hypothesized, there appear to be a small, statistically significant correlations between CQ Duty and reading ability (WRAT 4) and neurocognitive measures of executive functioning (TOH and CTMT) (Table IVB). Although these correlations are significantly different from zero, their magnitude indicates limited influence on performance metrics.

In order to evaluate order-effects, 28 of the 51 HC subjects and 29 of the 51 mTBI subjects performed the CQ Duty is the first half of their testing session (either first, second or third) while the remainder of the subjects performed the CQ Duty in the second half of their session (either fourth, fifth, or sixth). There was no evidence of an order effect (p = 0.842).

Finally, there is additional evidence that the CQ Duty can identify outliers relative to the performance of HCs. A distribution free method for identification of outliers was used due to the non-normality of the data. Using the interquartile range (IQR) for the HCs defined as the 25^{th} to 75^{th} percentiles, the cut point for the outlier was calculated using Tukey's definition of 1.5 times the range of the IQR (i.e. if the 25^{th} percentile started at 10 and the 75^{th} percentile ended at 16, the range is 6 (16-10) and the outlier cut point would be 25 (16 + 6*1.5). Five subjects with mTBI were identified as outliers based on Total number of visits using the Tukey criteria compared to zero HCs. (See Section V for more information on identification of outliers).

Table IVA. Between-group comparisons of key CQ Duty metrics

Metric (#HC, #mTBI)	**HC Mean (SD) Median (Range)**	**mTBI Mean(SD) Median(Range)**	**p-value, method**
Task performance (50,33) **Remove case with 51 visits (ID83-Control) (49,33)**	34.4 (2.8) 35 (29-38) 34.5 (2.8) 35 (29-38)	32.6(3.9) 34(21-37)	0.020, Mann-Whitney Effect size:0.25 0.017, Mann-Whitney Effect size:0.25
# of Visits(51,51) **Remove case with 51 (ID83-HC) visits (50,51)**	12.6 (6.7) 11 (6-51) 11.86 (3.8) 11 (6-22)	14.4(5.3) 13(7-30)	0.027, Mann-Whitney Effect size:0.22 0.016, Mann-Whitney Effect size:0.24
Time (mins) (51,51) **Remove case ID83 (50,51**	18.9 (4.8) 18 (11.7-31.9) 18.6 (4.5) 18.0 (11.7-30.8)	20.1(4.9) 19.3(13.1-37.0)	0.171, t-test 0.121,t-test
	n (% of total)	**n (% of total)**	
Total rules broken (50,33) **Remove case ID83 (49,33)**	0 rules:33,(66.0%) 1 rule:14 (28.0%) 2 rules:3 (6.0%)	0:20 (60.6%) 1:9 (27.3%) 2:4 (12.1%)	0.687, chi-square, Monte-Carlo Simulation 0.683
Total Times Rules Broken>3 (50,33) **Remove case ID83 (49,33)**	7 (14.0%) 7 (14.3%)	5 (15.2%)	1, Fisher Exact Test 1, Fisher Exact
Complete (52,51)	51 (98.1%)	100%	1, Fisher exact

Table IVB. Correlation between CQ Duty metrics and neurocognitive measures (Pearson correlation coefficients)

Neurocognitive measures	**Task performance accuracy total score**	**Total # of visits to complete the task**	**Total time to perform the task**
Tower of Hanoi: number of moves	-0.3, p=0.006 n=83	0.36, p<0.001 n=92	0.21, p=0.041 n=92
CTMT: Sum	0.28, p=0.015 n=76	-0.21, p=0.045 n=91	-0.4, p<0.001 n=91
CTMT: Composite index	0.28, p=0.015 n=76	-0.21, p=0.041 n=91	-0.4, p<0.001 n=91
WRAT: Raw score	0.29, p=0.007 n=83	-0.25, p=0.01 n=102	-0.22, p=0.024 n=102

Discussion

These data suggest that the number of visits needed to perform the CQ Duty and total accuracy of task performance appear to distinguish between groups of HC SM and those who with known mTBI who are receiving rehabilitation services for mTBI-related symptoms. However, the effect sizes were relatively small. As hypothesized, there was a small correlation between these metrics and neurocognitive measures specific to executive functioning and intelligence/education level. All told, these data suggest that the CQ Duty may help identify existing problems with executive functioning that may be a barrier to return to duty. These findings are similar to that involving with MET and individuals with traumatic brain injury[12] and mild stroke[14].

The 2 groups of SM understudy had a wide range of within-group characteristics, which may have contributed to the small effect sizes. For example, the research team did not have specific information regarding the symptomatology for which the SM with mTBI were receiving rehabilitation services. Therefore, within the mTBI group, SM may not have had lingering executive dysfunction but have had sensorimotor difficulties unlikely to be challenged by the CQ Duty. Further study of the CQ Duty is needed to evaluate its sensitivity and specificity. Such information could be valuable in determining whether or not the CQ Duty is a useful metric for identifying SM with mTBI who would benefit from cognitive rehabilitation.

Further study is also needed to fully understand the relationship between intelligence/education level, CQ Duty performance, and relevance for RTD decision-making. Beyond executive functioning, the CQ Duty places obvious demands on reading comprehension. While the correlation is relatively small, there appears to be an association between CQ Duty performance and intelligence/education level, which may or may not be relevant to return to duty decision-making for all military occupational specialties.

Recommendations

Further study is needed to evaluate the responsiveness to change or improvement with intervention, and to sensitivity and specificity of the CQ Duty. This would be particularly important in confirming its ability to identify existing executive dysfunction in SM with presumably resolved mTBI in the context of return to duty decision-making. Studying responsiveness to change would require an alternate form of this AMMP task as once this task is completed, the subject would likely retain the solution invalidating repeated testing with the same task.

PATROL-EXERTION MULTITASK

Introduction

The Patrol-Exertion task is a performance-based multitasking assessment that was developed using the broad dictionary definition of multitasking while incorporating multiple known vulnerabilities following concussion/mTBI. During the Patrol-Exertion task, the subject is challenged to gather information from video surveillance and radio communications while exercising at 65 to 85% of the subject's age predicted maximal heart rate by doing continuous step-ups on an exercise step to simulate a dismounted patrol. IED markers and pertinent logistical information must be recalled and reported at specific times while also requiring a reaction time trigger switch press to an intermittently occurring tone sound.

Description

The SM will be fitted with a Polar Heart Rate (HR) monitor (chest strap) with the evaluator holding the wrist watch sized monitor to follow the heart rate, an Army combat helmet and eye protection (clear lenses), and hold a simulated weapon to increase realism of the condition. The simulated weapon will have a small switch attached to the hand grip and a small speaker attached to upper barrel of the simulated weapon. Two 30 second baseline trials of randomly occurring tones requiring a reaction time trigger press occur before starting the patrolling video. The first trial occurs while the subject is standing still and the second trial occurs while the subject is stepping on the aerobics step. A total of 11 tones will sound at preset times during the video instructions on IED markers and the virtual patrolling scenario requiring the SM to press the switch. This is done to assess the SM reaction time during a cognitive and exertional activity. The participant will listen to about 2-3 minutes of instructions and then begin continuous stepping onto a 4” step platform to increase heart rate to between 65-85% of his or her age predicted HR maximum to require moderate exertion that could increase exertional symptoms associated with mTBI. During the continued stepping, the participant watches an approximately 12 minute virtual reality scene created for the project by the developers of Virtual Afghanistan (Institute for Creative Technologies University of Southern California). Approximately the first 5 minutes of the video includes instructions for the tactical pause reports on IED markers that they might see in the video and the Patrol Report to be given at the end of the video. The SM is told to watch for activities on the video that are relevant to a post-patrol report. Cues are provided if necessary to maintain heart rate in the target range of 65-85% of age-predicted maximal heart rate. If unable to exert at the desired range, the participant is permitted to complete the assessment at his or her own pace or if necessary, to stop the test. Following the video scenario, the participant will answer questions in support of a post-patrol report into a recording microphone. The report is analyzed for correctness of responses for both the tactical pause IED marker reports and the reconnaissance or post-patrol report questions. Reaction times are recorded by Bluetooth onto a laptop using in house developed JAVA software (see training manual materials for this task. Visual attention, memory and decision-making under moderate exertional conditions are often impaired following mTBI. This task places demands on divided and alternating attention, working memory, visual attention, vertical gaze stability, visual scanning, reaction time, auditory and visual processing under a condition of moderate exertion. This test takes 23-25 minutes to perform including instructions and set up of subject.

Rationale

This multitask is based on the general definition of multitasking from the dictionary (American Heritage® Dictionary of the English Language, Fifth Edition. Copyright © 2011 by Houghton Mifflin Harcourt Publishing Company. Published by Houghton Mifflin Harcourt Publishing Company) which states that multitasking is engaging in more than one activity at the same time or serially switching one’s attention back and forth from one activity to another. In developing the Patrol-Exertion task, the AMMP team focused on including a number of the known vulnerabilities following mTBI including exertional intolerance and impaired reaction time as well as impaired gaze stability in the setting of an operationally relevant patrol task requiring cognitive engagement and decision-making. This task places demands on divided and alternating attention, working memory, visual attention, vertical gaze stability, visual scanning, reaction time, auditory and visual processing under a condition of moderate exertion.

Hypotheses/expectations

The Patrol-Exertion task is a multitask requiring multiple concurrent tasks including exertion (to 65-85% of age predicted maximum heart rate) by continuous stepping on an aerobics step, auditory and visual processing and reporting relevant information and reacting to a tone as fast as possible. The expectation was for a decrement in the ability to identify IED markers and answer post patrol questions as well as slower reaction times in subjects with mTBI as compared to HCs. Given that this task requires sustained attention with some executive function, it was expected to correlate to standard neurocognitive tests of attention and memory including the CTMT, the NAB Digits forward/Digits backward, NAB Numbers and Letters, and the TOH. A correlation with WRAT Reading was not necessarily hypothesized; however, the expectation would be that a subject who is of higher intelligence may be more able to develop a strategy for being successful at this task. As this task evaluated reaction time in a complex context, the reaction time metric was expected to correlate with the standard SRT test, part of the ANAM.

Method

As part of the AMMP validation study to evaluate IRR, known group discrimination, and convergent and discriminate validity, the Patrol-Exertion task was administered to SM with mTBI and HCs. The Patrol-Exertion task assessment relied on both instrumented, subject reported and observational metrics, including number of IED markers identified and post patrol questions answered. The reaction time component of the task was instrumented and the number of milliseconds to react was transferred via Bluetooth technology and recorded from a computer screen. Subjects were asked to verbally rate their visual clarity on a 0 (normal, clear and stable vision) to 10 (extremely blurry or jumpy vision "the worst it could be"). Subjects were asked to rate how hard they were working using the standard rate of perceived exertion scale (6-20 Scale, http://www.cdc.gov/physicalactivity/basics/measuring/exertion.htm). Between-groups analyses for these metrics were conducted on 51 HCs and 35 SM with mTBI. As this AMMP task required multiple revisions, not all subjects tested early in the Fort Bragg testing were evaluated on all components of Patrol-Exertion metrics. See Table IVC for the specific number of subjects tested on each metric.

Results

Non parametric between groups analysis revealed significant differences in the report of issues with visual clarity and in the reaction time both at the beginning and the end of the task between HCs and concussed personnel (Table IVC). The correct responses to IED markers and post patrol questions and the report of "how hard are you working" (using Rate of Perceived Exertion Scale) did not distinguish groups. As discussed under Aim 2, the significant correlations between the total correct responses to IED marker reporting and post patrol questions to the error percentile of the TOH and to the WRAT Reading score did not meet the benchmark of ≥ failing to support the concept that reported responses had some correlation to executive function and to a proxy for measure of intelligence and education. A possible reason for this may be due to the patrolling video used for this task which was not highly complex or difficult to follow. The correct responses to IED markers and post patrol questions also did not correlate to the measures of attention and memory (CTMT and NAB). SRT measured at the end of the AMMP battery was used as a measure of fatigue. This reaction time did correlate to the reaction times tested in this task both at the beginning of stepping (first half of video) and at the end of stepping (second half of video) (Table IVC and Aim 2, Table IIID(3)).

Discussion

Subjects with mTBI had slower reaction times and more reports of poor visual clarity with jumpy and blurry vision than HC. Reaction times at baseline either standing or stepping without watching the video were not significantly different between the groups, while those tested during the video (watching video, stepping to simulate exertion, and responding to reaction time tone sounds) did distinguish the groups; supporting the concept that multiple task overlays tax a limited and shareable amount of brain resources that may be limited as a result of the mTBI. As these are performance based assessments, the mechanism or cause of the findings cannot be determined. It is speculated that given the number of visual system and vestibular complaints reported by subjects with mTBI (see patient demographic information Tables B3 and B5) that vestibular system residual deficits following mTBI may play a role in the these findings.

Recommendations

The next step would be to evaluate the Patrol-Exertion task on subjects who are at the point of being ready to return to duty to see if it correlates well with standard RTD assessments and predicts successful or failed duty abilities. It is recommend that consideration be made to modify the patrolling video used in this task to a busier, louder and more complex environment requiring more focused attention with additional executive function or decision-making requirements. These changes may also improve the correlation of task metrics to standard neurocognitive tests for executive function, IQ and attention. If this task is to be used to inform readiness to return-to-duty, a longitudinal study exploring the predictive validity, and information on normative data on HCs (ultimately would want to establish cut-points for definite "Go" and "No Go" parameters) are needed. If it is to be used to measure progress for RTD, responsiveness to change as a SM recovers spontaneously or responds to treatment should be evaluated, this would require an alternate form patrolling video. Further study is needed to evaluate the sensitivity and specificity of the Patrol-Exertion task.

Table IVC. Patrol-Exertion Multitask Between Group Findings and Correlations

Patrol- Exertion	**Scoring Reliability**	**Known Groups Analysis**	**Correlations to Standard Neurocognitive tests**			
Metrics	Fort Bragg	HC	mTBI		ICC (95% CI), n, p-value	
	n = 26 19 mTBI, 7 HC	Mean (SD), Median (Range)	Mean (SD), Median (Range)	p-value		
	ICC (95% CI)				TOH # moves	WRAT Reading (IQ)
IED & Patrol Questions correct	0.97 (0.95-0.99)	N=51 18.2(2.6), 19(11-22)	N=33 17.5 (2.8) ,18 (10-22)	0.179	-0.12 (-0.33, 0.09) n=84 p=0.262	0.26 (0.05, 0.45) n=84, p=0.016*
Vision Clarity initial	0.99 (0.97-1)	N=45 0.13 (0.4), 0 (0-2)	N=25 0.79 (2.3), 0 (0-5)	0.002,	0.06 (-0.17, 0.3) n=70 p=0.595	0.05 (-0.19, 0.28) n=70 p=0.698
Vision Clarity end	0.99 (0.98-1)	N=51 0.4 (0.9), 0 (0-4)	N=33 1.6 (2.0), 1 (0-8)	<0.001	0.15 (-0.07, 0.35) n=84 p=0.17	0.1 (-0.12, 0.31) n=84 p=0.364
RPE end	1.0 (1-1)	N=51 11.2 (2.0), 11 (7-15)	N=33 12.1 (2.3), 12 (7-17)	0.133	0.07 (-0.15, 0.28) n=84 p=0.546	-0.1 (-0.31, 0.12) n=84 p=0.373
Reaction time – early (mean of 6)	*	N=48 590.4 (224.1), 538.8 (297.5-1305)	N=32 681.6 (216.9), 640 (370-1400)	0.013	-0.02 (-0.24, 0.2) n=80 p=0.85	-0.21 (-0.41, 0.01) n=80 p=0.056
Reaction time-late (mean of 5)	*	N=48 547.1 (209.7), 535.2(334-930)	N=33 674.1 (209.7), 602 (471-1400)	0.002	0.02 (-0.2, 0.23) n=81 p=0.882	-0.1 (-0.31, 0.12) n=81 p=0.358

RUN-ROLL-AIM

Introduction

This Run-Roll-Aim task is a performance-based multitasking assessment that was developed using the broad dictionary definition of multitasking (engaging in more than one activity at the same time or serially switching one's attention back and forth from one activity to another) while incorporating multiple known vulnerabilities following concussion/mTBI, specifically tasks that challenge the vestibular system.

Description

The SM completes a high level mobility task with multiple maneuvers while carrying a simulated weapon. Maneuvers are cued by a remotely controlled computer screen, requiring a rapid start, running, avoiding a "trip wire" obstacle, 3-5 second rush, combat rolling, search for visual targets through a short focal point (insect or bird viewing) scope mounted in place of a weapon scope on a mock M-16, rapid lateral dodging and back pedaling. This task requires the SM to demonstrate high level balance and mobility skills not unlike those required in a battlefield situation, alternating between quick position changes and focused visual search through a weapon scope. Rapid head and body position changes stimulate the vestibular system, so SM with vestibular impairment may have difficulty with this task. This test takes approximately 13-14 minutes to perform.

Rationale

During initial task development and end-user feedback we devised a new task (Run-Roll-Aim) that involves maneuvers known to be used in military training that might provoke the vestibular system (rolling, speeded movement from one position to another). We also expected that dynamic visual acuity could be impaired during movement, so we included a "trip wire" obstacle. Given the potential for vestibular system impairment, we incorporated a visual search task through a scope on a simulated weapon.

Researchers that study older adult cognition during mobility tasks have used a "directional Stoop" component to walking tasks that presents two stimuli to direct movement. An arrow (an automatic cue) and a letter, R or L (less automatic cues) are presented together. Subjects are instructed to follow the letter in the direction of the roll. Both congruent (R and right pointing arrow) and incongruent (R with left pointing arrow) are presented, necessitating 4 trials to provide congruent and incongruent cues in both directions.

This task does not meet all of the conditions that are described for multitask scenarios, as the sequence of maneuvers is cued by a computer screen and there is one way to accomplish the task, however, it does incorporate several cognitive functions (remember the target – odd or even numbers, inhibit automatic response to directional Stroop). During pilot testing, this task is one that SM clearly enjoyed completing given the face validity of the combined skills is strong. It challenges mobility in a way that is unlike any other balance test that is in use in clinical practice.

Since dual-task movement impairments post-concussion have only been detected using laboratory measures, we incorporated the use of wireless inertial sensors on the head and torso so that we might compare more instrumented measures between groups in the event that the simple observational measures did not detect differences.

Hypotheses/expectations

We expected that multiple components of the Run Roll Aim task could present challenges for individuals with mTBI. Given the Stroop effect requires inhibition of automatic responses in the incongruent condition, we expected that individuals with mTBI who may have reduced frontal inhibitory function, may have more difficulty with the incongruent trial cues (longer delay in response, rolling the wrong direction, etc). Individuals with vestibular impairment as a result of mTBI we be expected difficulty with dynamic transitions, with dynamic visual acuity and with visual search and thus score lower than HC on task metrics.

Method

As part of the AMMP validation study to evaluate inter-rater reliability and known-group discrimination, the Run-Roll-Aim was administered to SM with mTBI and HCs. Observational and inertial sensor data were collected. Between-groups analyses for trial and total time (all 4 trials) and odd/even numbers and task components (miss trip wire, roll direction, etc.) correct and errors in each trial and in total (all 4 trials) were conducted on 50 HC and 30 SM with mTBI. Subjects with mTBI tested initially at Fort Bragg were not given a practice trial so there data was not included in the between groups analysis.

Results

<u>Observational data</u>

Observational data were reliably rated with the exception of the total error ratings. This is in part because errors were few in number on the task in general, so with a reduced range, ICC values are affected. In addition, the attempt to characterize the Stroop response during the fast paced task was problematic. We expect that an additional problem with reliability relates to the rating of a “hesitation” of more than 1 second associated with Stroop response. This is difficult to judge reliability just by watching unless the delay is longer. We plan additional analyses of this element of the scoring prior to publication of findings about this task.

The observational data from Run-Roll-Aim were not sensitive to group differences (see Table IVD). The relatively gross nature of performance that one can observe and rate by observations is likely a reason for this. There were group differences in the ability to complete the task, as a 4 individuals with mTBI were unable to complete practice and 2 others required extended rest periods between tasks and all 4 test trials as a result of increased symptoms. This did not occur with any of the HC subjects.

Table IVD. Run-Roll-Aim Multitask Findings

	Scoring Reliability	Known Groups Analysis*			Correlations to Standard Neurocognitive tests	
Metrics	Fort Bragg	HC	mTBI		ICC (95% CI), n, p-value	
	n = 26 19 mTBI, 7 HC	n = 50 Mean (SD) Median (Range)	n = 30 Mean (SD) Median (Range)	p-value		
	ICC (95% CI)				Tower of Hanoi # moves	WRAT Reading (IQ)
Trial 1 time (seconds)	Not evaluated	0.80 (0.24) 0.74 (0.54-1.8)	0.80 (0.21) 0.74 (0.57-1.4)	0.893	0.13 (-0.09, 0.34) n=80 p=0.241	-0.15 (-0.36, 0.07) n=80 p=0.191
Trial 1 correct	0.999 (0.997-1)	13.5 (0.70) 14 (11-14)	13.2 (1.0) 13 (9-14)	0.159	-0.11 (-0.32, 0.11) n=80 p=0.342	0.09 (-0.13, 0.31) n=80 p=0.417
Trial 1 errors	0.96 (0.91-1)	1.9 (1.3) 2 (0-6)	2.4 (2.3) 2 (0-11)	0.317	*	*
Total time (4 trials)	*	2.9 (0.59) 2.8 (1.9-4.2)	3.0 (0.57) 3 (2.2-4.3)	0.515 t-test	0.11 (-0.11, 0.32) n=80 p=0.317	-0.19 (-0.4, 0.03) n=80 p=0.087
Total correct (4 trials)	*	4.9 (4.6) 4 (0-25)	5.4 (4.4) 4 (0-16)	0.438	-0.11 (-0.32, 0.11) n=80 p=0.326	-0.07 (-0.28, 0.15) n=80 p=0.548
Total errors (4 trials)	0.64 (0.13-0.92)	4.9 (4.6) 4 (0-25)	5.4 (4.4) 4 (0-16)	0.438	0.11 (-0.12, 0.32) n=80 p=0.351	0.05 (-0.17, 0.27) n=80 p=0.663
*Known groups analysis with Mann-Whitney U unless otherwise noted						

Inertial sensor data

As a component of an exploratory assessment for identifying subtle mobility differences not detectible with observational metrics, inertial sensors were incorporated into this task. For this, the SM wears an inertial sensor (triaxial accelerometer, gyroscope and magnetometer; *NexGen Ergonomics*) on an adjustable headband positioned at the SMs forehead and an inertial sensor at the SM's lumbar area. Data transmitted wirelessly from this sensor includes specific time for completion of components of maneuver, maximal angular velocity of head movement and trunk during combat roll and acceleration values for all components of movement.

Inertial sensor data were sensitive to group differences (refer to those analyses), consistent with the laboratory type nature of measurement necessary to detect subtle changes in movement associated with mTBI/concussion. 37 HC and 37 mTBI subjects, who did all 4 runs of the Run-Roll-Aim test, were selected for the first analysis. This first analysis was confined to the "roll" section of the test. Each subject's performance on the test was recorded with a 3-axial accelerometer and a 3-axial gyroscope (NexGen Ergonimics *SXT* IMU 8GB memory) attached to the head and another such pair attached to the torso. Thus, the data obtained from each subject comprise 12 time series of measurements. Each time series was transformed into the frequency domain using 512-point Fast Fourier Transform (FFT), yielding 256 data points for each time series and the total of 12288 data points from 12 sensors and 4 test repeats (256x4x12). Out of these 12288 data points, 300 points were selected as discriminative features.

To visualize the distribution of 37 HC and 37 mTBI subjects in such 300-dimensional feature space (in which each subject is represented by a point), all 74 subjects were projected onto a 2-dimensional plane, which was chosen by PLS-DA (Partial Least Squares – Discriminative Analysis) algorithm so as to maximize the spatial separation of HC and mTBI (labeled "BI" on Figures IVA-IVC) subjects. This projection is shown in Figure 2, revealing prominent and distinct clustering of the two groups.

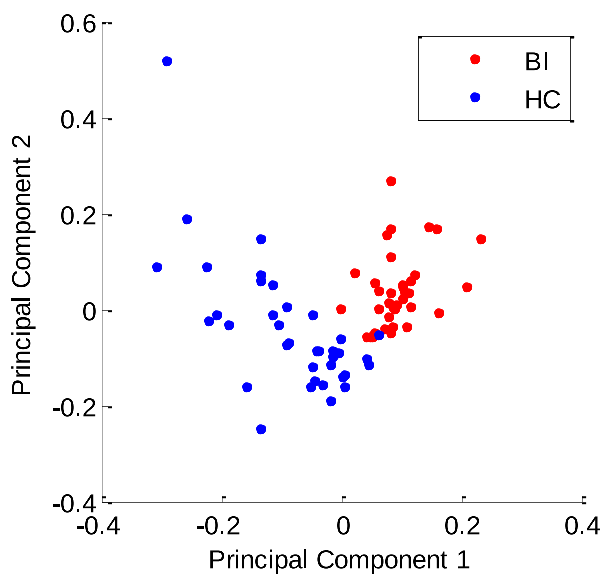


Figure 2. Combat Roll: Principal Component Analysis of mTBI ("BI") and HC subjects

Next, a linear Support Vector Machine (SVM) was trained to discriminate between HC and mTBI subjects using their 300-feature vectors as inputs. The discriminative performance of SVM was cross-validated using the leave-one-out approach. 31 out of 37 mTBI subjects (84%) were correctly classified by SVM as such, and 23 out of 37 HC subjects (62%) were also classified correctly. The distributions of SVM scores of BI and HC populations are plotted in Figure 3, showing significant shift of the mTBI ("BI") distribution relative to the HC distribution.

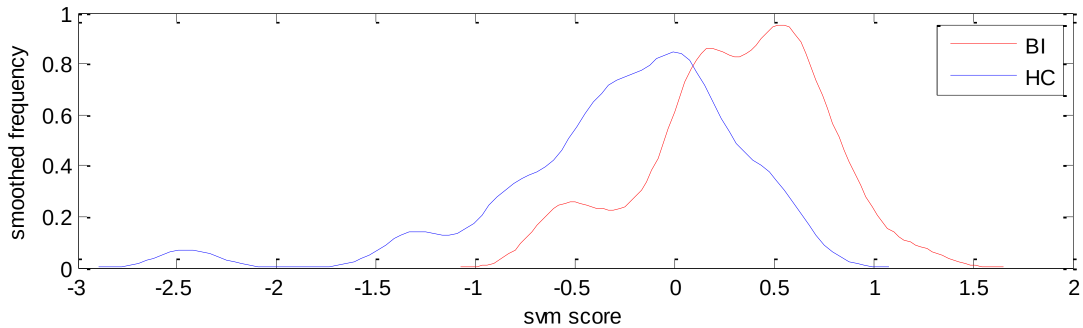


Figure 3. SVM discrimination of mTBI ("BI") versus HC subjects

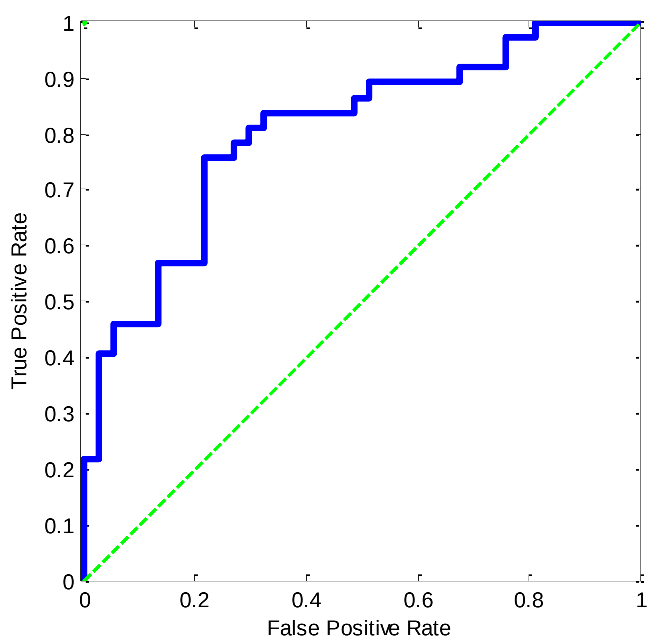


Figure 4. The ROC curve of the mTBI ("BI") and HC distributions. Area under the ROC curve (AUC) is 0.804.

The ROC curve of the mTBI and HC distributions is plotted in Figure IVC. Area under the ROC curve (AUC) is 0.804 (Figure 4).

All of the above results were obtained only from roll segments. When we analyzed other Run-Roll-Aim test sections (i.e., forward run and backward run), we found AUC = 0.554 for forward run and AUC = 0.582 for backward run. When we merged forward, roll and backward sections together, we found AUC = 0.585. These results show that the roll section contains much more information to discriminate subjects with mTBI than the other sections of the task.

Discussion

The Run-Roll-Aim task includes complex activities that are performed sequentially with the entire task taking less than a minute to complete in most instances. There are challenges with the fast paced performance of the task for the examiner who operates the slides that cue each part of the task to be able to watch performance of the task, and record responses all at the same time. Further examination of the type of errors that were made during testing may be instructive in understanding if the directional Stroop cue should continue to be a part of future testing. It is likely that more sensitive instrumentation may be required to detect subtle delays associated with information processing during the task.

The visual stimuli that were used in the task are relatively crude (numbers on an array on the computer screen). In addition it was not uncommon for subjects to experience some difficulty with viewing the visual targets via the close range short focal point scope, as a small shift in position could cause the scope to require refocusing. The visual aspect of the task, if it is to be continued could be improved. Virtually no one had difficulty avoiding the trip wire, so this aspect of the task could be modified or eliminated. It is clear that some subjects with mTBI had symptoms that were provoked such that they couldn't complete all the trials of the task, so including some higher level mobility skill such as this in future test batteries is advised.

In order to capture movement differences between groups, the inertial sensors were essential. It is possible that the task could be further instrumented to improve the ability to detect performance issues that are difficult to observe. The face validity of the task can't be denied, however, so the potential for this task to be refined further, perhaps using a shorter distance to make it more clinically feasible is reasonable to pursue in future testing.

Recommendations

As described in the discussion section above, a number of revisions to this task would be required to improve the observational metrics before it might be considered for use to discriminate HCs from SM with residual mTBI issues. It appears that the most salient components of this task are the symptoms evoked and pattern of movement detected by the combat rolls which may only be detected using very sophisticated time series analyses of inertial sensor data. Possible revisions to the observational metrics of this task may involve further instrumentation to a mock weapon to allow detection of the time it takes a subject to acquire a target after one or several combat rolls in order to capture the effects of vestibular vulnerabilities following mTBI. There are a number of additional analyses that are to be completed for the current inertial sensor data set including further standard analyses on angular accelerations, and head and torso path during the combat rolls.

ILLINOIS AGILITY TEST-PACKING LIST

Introduction

The Illinois Agility Test-Packing List is a standard dual-task with the expectation that there would be a dual-task cost in terms of number of recalled packing list words cost in terms of time to run the course.

Description

The Illinois Agility Test-Packing List requires running distances of 30' with rapid direction changes and navigation of serpentine or figure of eight obstacles during the middle part of the obstacle course[20]. Next, a packing list memory task assesses the participant's ability to retain up to 7 items on a word list. The results of this single condition memory task are used as a baseline for the dual-task condition. The agility task and the memory task are done at the same time (i.e., in a dual-task condition). Accuracy of memory recall and time to complete the agility task are measured in single and dual-task conditions. Running the agility course was selected for dual-task performance because walking may be too simple for SMs who have high levels of athletic ability. The ability to move quickly while remembering information has relevance to duty situations. This test takes approximately 12 minutes to perform.

Rationale

Given another AMMP task (ISAW-Grid) used a number memory task, comparable to a task from the Walking And Remembering test, during the Illinois Agility-Packing List task we devised an alternative word list task (packing list) in order to increase the diversity of cognitive challenges in the test battery. A grocery list shopping task developed by Hyndman[21] for use in stroke survivors was used initially in pilot testing with ROTC cadets at University of North Carolina-Chapel Hill (UNC-CH). The "face validity" of a grocery list was lacking, however, so we worked with our military team members to create lists of items that would be appropriate to pack if a service member were to be deployed. We included clothing/personal gear, weapons, and first aid on each 7 item list, making the total number of syllables in each list comparable. Through initial testing we identified items that were commonly confused when recited out loud, and simplified many of the items included on each list. We also made sure that items that could easily be associated with each other were not included on the same word list, and created 6 words lists for use during testing. No items were repeated on any list.

This cognitive task is a working memory task, and we know that typical working memory span is 7 +/- 2. Consistent with testing that has been done with individuals with more moderate TBI and with older adults, we modified the word list length for each subject based on how they performed on the first word list task, therefore the cognitive task could include 5 to 7 words, presenting a cognitive challenge that is "customized" to each subject. This task is more difficult than number list memory tasks, because the word lists cannot be as easily "chunked" for memory as numbers can (1-3-4 can be remembered as 134 and reduce the working memory load from 3 items to 1).

Given dual-task researchers have advocated for priority instructions during repeated dual-task practice, we had individuals perform the first dual-task trial as they would do spontaneously and then asked subjects to prioritize the cognitive or motor task in repeated trials (counterbalanced). The theory for including these instructions relates to the ability to flexibly allocate attention to one task or the other, a volitional prioritization we would expect an HC subject to accomplish, but perhaps those with mTBI may have more difficulty completing.

Since dual-task movement impairments post-concussion have only been detected using laboratory measures, we incorporated the use of wireless inertial sensors (see description under Run-Roll-Aim task) on the head and torso so that we might compare more instrumented measures between groups in the event that the simple observational measures did not detect differences.

Hypotheses/Expectations

We anticipated that SM would be motivated to run the agility course quickly. We expected to see dual-task interference during the dual-task conditions that would likely affect the cognitive task in the uninstructed condition, given SM place significant value on physical skills. During the prioritized conditions we expected that greater dual-task interference would be observed on the cognitive task in the motor priority task, and on the motor task in the cognitive priority task. We expected that we could see some issues with fatigue toward the end of the trials so we planned to provide brief rests especially if a subject demonstrated increased respiratory rate. Since this is a new task combination, we did not know what the amount of dual-task interference would be that is "normal", but expected that those with mTBI would show greater dual-task interference than the healthy controls across conditions.

We expected that individuals with vestibular impairment as a result of mTBI may have difficulty with the transitions from prone to standing and with the turns necessary to traverse the obstacle course. In addition we anticipated that individuals with mTBI could have difficulty completing this running task as a result of balance impairment or as a result of difficulty with exertional symptoms.

Method

As part of the AMMP validation study to evaluate inter-rater reliability and known-group discrimination, the Run-Roll-Aim was administered to SM with mTBI and HC. Observational and inertial sensor data were collected. Between-groups analyses for run time and recalled packing list words in single and dual-task conditions were conducted on 50 HC and 45 SM with mTBI.

Results

Observational data

Acceptable IRR of observed responses were obtained during Illinois Agility-Packing List testing with HC and those with mTBI, although some work was required to improve rules for interpreting correct word responses (only accepting exact responses as correct and removing multiple part words from the packing lists, i.e., 100 mph tape).

The Illinois Agility-Packing List dual-task condition was not effective in differentiating between HC and mTBI subjects when comparing single or dual-task performance scores based on observation (words correct and movement speed) (Table IVE(1)). Group differences in movement were detected with instrumented inertial sensors, consistent with previous research on concussion.

Table IVE(1). Illinois Agility-Packing List Between Groups Comparisons and Correlations

	Scoring Reliability	**Known Groups Analysis***			**Correlations to Standard Neurocognitive tests**	
Metrics	Fort Bragg	HC	mTBI		ICC (95% CI), n, p-value	
	n = 23 18 mTBI, 5 HC	n = 50 Mean (SD) Median (Range)	n = 45 Mean (SD) Median (Range)	p-value		
	ICC (95% CI)				TOH, number of moves	WRAT Reading (IQ)
Words correct Single task	1.0 (1-1)	5.5(0.8) 6(4-7)	5.6(0.8) 6(4-7)	0.722	-0.13 (-0.33, 0.08) n=86 p=0.235	0.32 (0.12, 0.49) n=95, p=0.002*
Time(secs) Single task	0.99 (0.98-0.99)	19.8(2.3) 19.1(16.1-26.1)	19.9(2.3) 19.1(16.1-25.0)	0.338	0.08 (-0.13, 0.29) n=86 p=0.467	0.01 (-0.19, 0.21) n=95 p=0.911
Word errors Single task	1.0 (1-1)	1.7(1.2) 2(0-5)	1.6(1.2) 1(0-5)	0.483	0.16 (-0.05, 0.36) n=86 p=0.141	-0.3 (-0.48, -0.11) n=95, p=0.003*
Words correct Dual-Cognitive	1.0 (1-1)	4.5(1.0) 5(2-6)	4.3(1.0) 4(2-6)	0.354	-0.05 (-0.26, 0.16) n=86 p=0.646	0.4 (0.22, 0.56) n=95, p<0.001*
Time (secs) Dual-Cognitive	0.99 (0.989-.997)	18.8(1.9) 18.4(15.5-23.9)	19.3(2.2) 18.8(15.2-26.0)	0.320	0.23 (0.02, 0.42) n=86, p=0.034*	0.11 (-0.09, 0.31) n=95 p=0.268
Word errors Dual-Cognitive	0.996 (0.987-1)	1.3(1.3) 1(0-4)	1.6(1.3) 1(0-5)	0.387	-0.03 (-0.24, 0.19) n=86 p=0.808	-0.22 (-0.4, -0.02) n=95, p=0.031*
*Known groups analysis with Mann-Whitney U unless otherwise noted						

We also discovered that subjects were not shifting priority to the cognitive task even if instructed to do so. This was the case for those with or without mTBI. Our efforts to compare dual-task costs, as is the customary approach was confounded by our use of different length word lists based on the single task testing. In these tests when there are multiple trials of cognitive tasks, there is the potential for recalling words from prior word lists in the later trials. Conversely, there is the potential for reduction in movement speed in later agility test trials as a result of fatigue. The results below show that a greater number of mTBI subjects were not able to complete the series of trials, a result approaching significance (Table IVE(2)).

Table IVE(2). Illinois Agility-Packing List Dual Task Cost Findings

Metric (50HC, 46mTBI)	HC Mean(SD) Median(Range)	mTBI Mean(SD) Median(Range)	p-value, Method
Single word	5.5(0.8) 5.5(4-7)	5.6(0.8) 6(4-7)	0.396, Mann-Whitney
Single Time(secs)	19.6(2.4) 19.3(16.1-26.1)	19.8(2.3) 19.1(16.1-25.0)	0.514, Mann-Whitney
Single_Word_error	1.8(1.2) 2(0-5)	1.6(1.2) 1(0-5)	0.259, Mann-Whitney
Cost dni time (%)	-2.6(4.8) -1.7(-16.9-7.6)	-2.8(9.0) -1.6(-28.2-22.1)	0.970, Mann-Whitney
Cost mob time(%)	2.9(5.4) 2.9(-7.4-19.1)	2.4(8.5) 2.8(-28.2-21.2)	0.529, t-Test
Cost dcog time(%)	-1.6(7.4) -1.7(-15.3-17.2)	-2.8(12.2) -1.1(-38.1-28.9)	0.837, Mann-Whitney
Cost dni word(%)	18.9(16.9) 16.7(0-66.7)	18.7(16.1) 18.3(0-66.7)	0.970, Mann-Whitney
Cost mob word(%)	20.8(18.2) 20.0(-25.0-50.0)	23.0(16.3) 20.0(0-66.7)	0.575, Mann-Whitney
Cost dcog word(%)	17.2(16.6) 16.7(0-50.0)	23.3(16.9) 20.0(0-60.0)	0.075, Mann-Whitney
Cost dni word errors(%)	31.1(113.1) 45.0(-300-300)	33.2(117.2) 50.0(-300-300)	0.932, Mann-Whitney
Cost mob word errors(%)	9.9(137.4) 167(-300-400)	31.4(139.9) 50.0(-400-400)	0.300, Mann-Whitney
Cost dcog word errors(%)	37.3(110.0) 50(-200-400)	35.4(142.8) 50(-300-400)	0.793, Mann-Whitney
Complete all trials	50 of 53(94.3%)	46 of 55(83.6%)	0.070, Fisher Exact
DNI = do not instruct; MOB = Mobility priority; COG = cognitive priority			

<u>Inertial sensory data</u>

Inertial sensor data analysis steps are illustrated in the Figure 5 (described below).

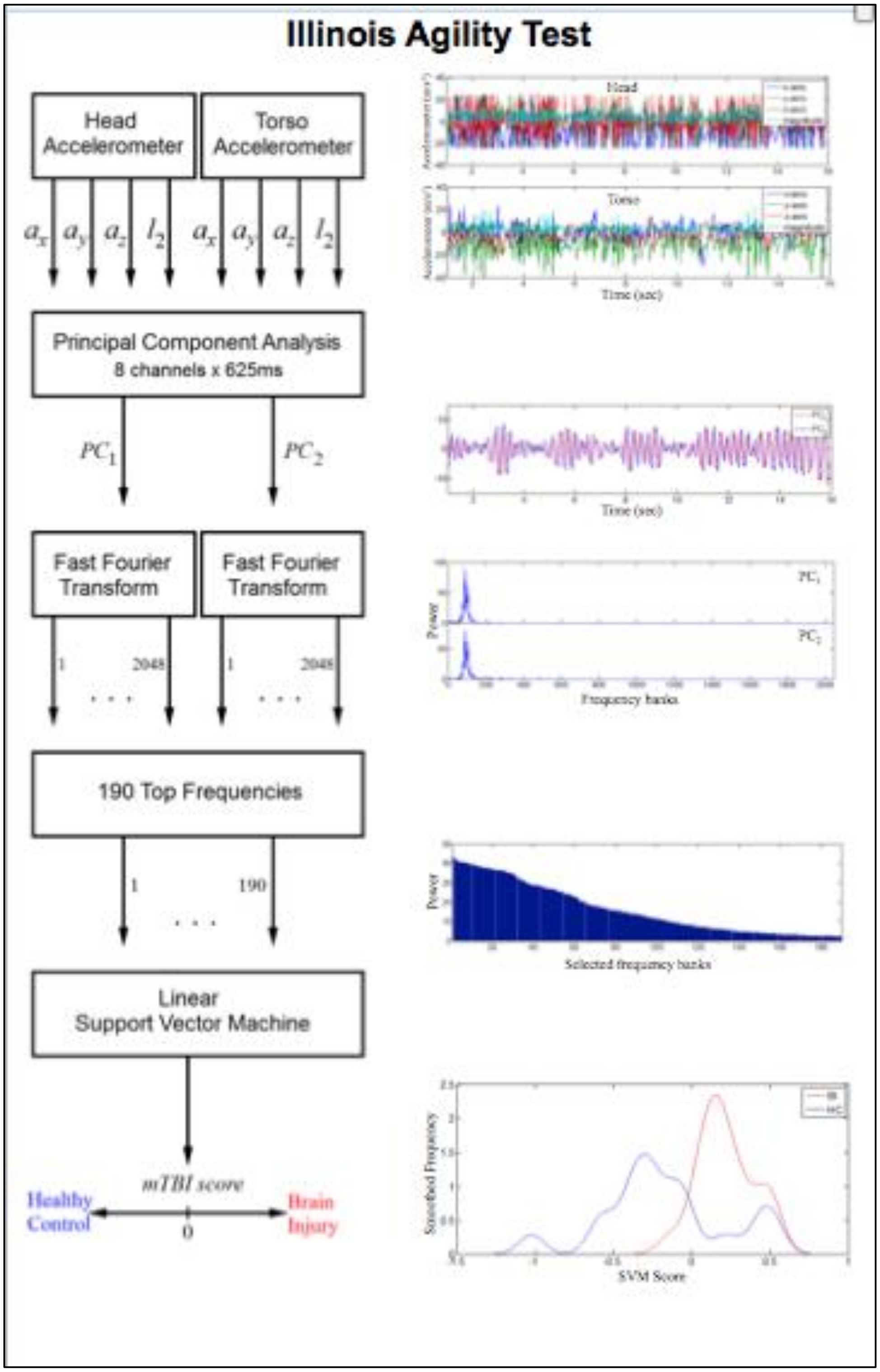


Figure 5. Analysis steps for Illinois Agility-Packing List task inertial sensor accelerometer data.

Only the accelerometer trace from the NexGen sensors were used for this analysis. Linear data from the 3 axes of accelerometry and one non-linear measure l_2 were included in this first attempt to analyze the inertial sensor data. There were 18 HC and 18 mTBI subjects included in the analysis. Two principal components were extracted as a way to reduce the amount and redundancy of available data to be considered. The data were then

Fast Fourier Transformed to examine the frequencies in the movements as the next step. Most frequencies were in the lower domains, so the 190 frequencies with the highest level of power were used in the creation of a linear support vector machine. This method is commonly used in classification research. The SVM was trained with the data from the mTBI and HC subjects considering the differences in the 190 characteristics of movement during the Illinois Agility-Packing List task. The ability of the SVM to correctly classify was then cross validated using the leave one out approach, where each subject was assigned a score that was < 0 if HC and >0 if in the mTBI group. The results of the classification showed 14/18 control subjects (77.7% accuracy) were correctly classified and 17/18 mTBI subjects (94.4% accuracy). The results from the ROC curve are shown below, where the area under the curve is .807 (Figure 6).

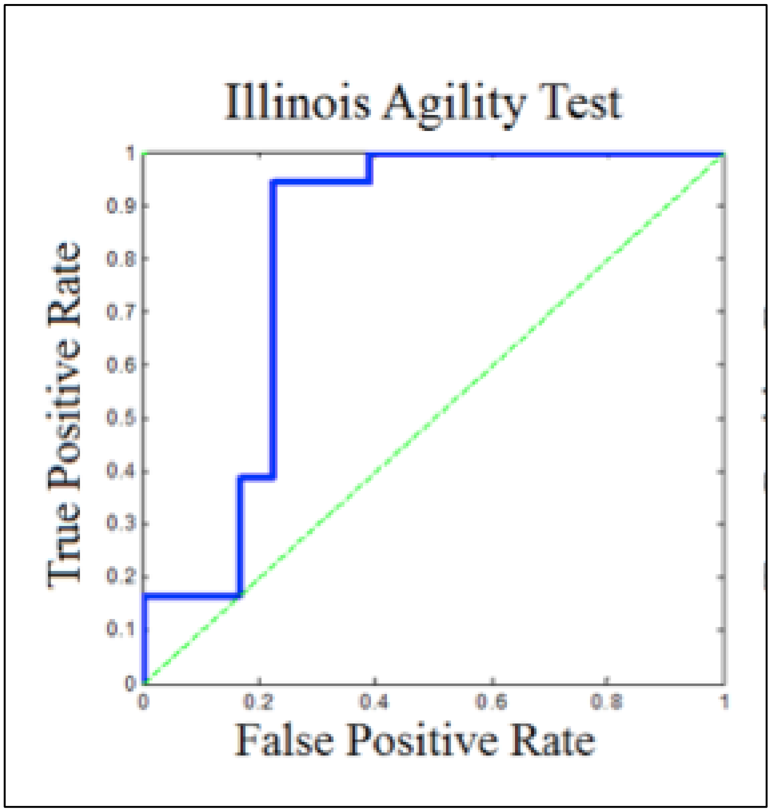


Figure 6. ROC curve for Illinois Agility-Packing List using SVM classification

The Principal Components Analysis done in the process of preparing the data for the SVM can also be used to visualize potential differences in movement characteristics between the groups, demonstrating separation of the groups in a way that is very encouraging given this first attempt at analysis of the sensor data (Figure 7).

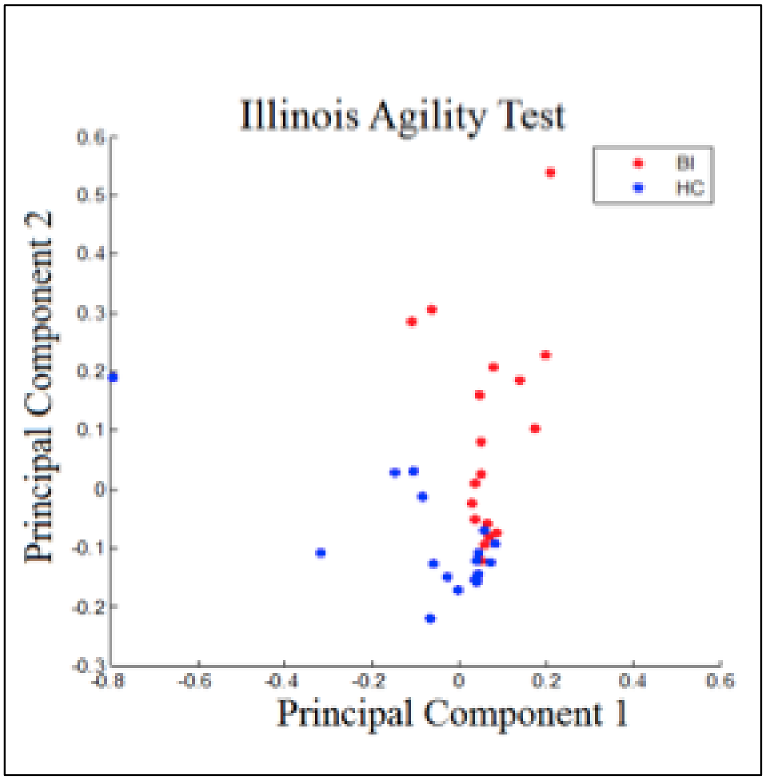


Figure 7. Principal Component Analysis to discriminate mTBI and HC subjects in Illinois Agility-Packing List prone to stand component.

Discussion

Unfortunately, the expected dual-task interference for the cognitive task (seen in other dual-task items in the AMMP) was not observed with observational measures. Active duty SM are continually trained on agility type tasks and SMs are very competitive, so there were not group differences in time for those who could complete the task. There were subjects with mTBI and one HC subject (aggravation of prior minor ankle condition) who were not able to complete all the trials, so for those individuals, this task did identify problems with higher level exertion with quick running.

The cognitive task used in this task was problematic. We allowed a shorter word list for those with limited working memory. Post-study advisement by a neuropsychologist suggests that using the 7 item word list for all subjects may be a better strategy in future testing. The lack of range that was introduced by making the task easier for subjects with shorter working memory span may have reduced the ability to identify deficits, and also reduce the possible dual-task costs given those values are computed based on single task performance. Likely requiring this longer word list for everyone would challenge those with mTBI to a greater degree and illustrate dual-task effects. For future testing, either use of a consistent 7 item word list or consideration of the grid memory task may be advisable. Given the number memory task is one that has been tested more consistently through the Walking and Remembering Test[22], and demonstrated group differences in the current study, considering the flexible use of mobility tasks paired with differing cognitive tasks may be studied further. Our efforts to have subjects "shift priority" to the cognitive task were not successful. This is not completely surprising, given the value that individuals in the military place on physical prowess. For future testing in similar groups, use of the priority instructions may be eliminated.

Recommendations

Revision of the cognitive component of this task and further re-evaluation of this tasks ability to discriminate groups is recommended. This is a higher level mobility task and with an appropriate and more challenging cognitive task might be expected to distinguish mTBI with residual issues and HC subjects at the point they are thought to be ready to return to duty. There are a number of additional analyses that are to be completed for the current inertial sensor data set including further standard analyses on angular accelerations and path specifically during the serpentine partial turns in this task. Once this is done, further exploration of the use of time series analyses with inertial sensor data on a modified Illinois Agility task should be considered.

INSTRUMENTED STAND AND WALK – GRID COORDINATES

Introduction

The ISAW-Grid task involves using wireless wearable inertial sensors (Opal System includes precision triaxial accelerometers, gyroscopes and magnetometers) and a clinical software program to measure static postural sway and then dynamic stability during walking and turning. A grid memorization task provided in the context of a patrol mission provides the cognitive challenge. This task may be better tolerated all across the recovery continuum when other AMMP tasks may be too challenging for the acutely concussed soldier. Walk time and the number of recalled grid coordinates are the metrics along with the sensor data.

Description

The SM performs the Instrumented Stand and Walk (ISAW) test (developed by APDM, Inc., Portland, OR) which includes instrumented and timed assessment of quiet standing for 30 seconds, assessment of dynamic stability during walking for two 7 m (23 foot) lengths with a 180 degree turn at midpoint (Mancini et al 2012) – see Figure 8. The SM was asked to memorize an 8 digit alphanumeric grid coordinate provided within the context of a simulated patrol mission brief and report the exact sequence back to the examiner after 45 seconds. Finally, both the ISAW and the grid memorization tasks will be performed simultaneously. Accuracy of grid coordinate recall, and a number of inertial sensor variables including postural sway area, gait path variability, turn dynamics and time to complete the ISAW (i.e. gait speed) were measured in single and dual-task conditions. This test takes approximately 15-17 minutes to perform including 3 trials of the single task and 3 trials of the dual-task condition in addition to instructions and sensor set-up.

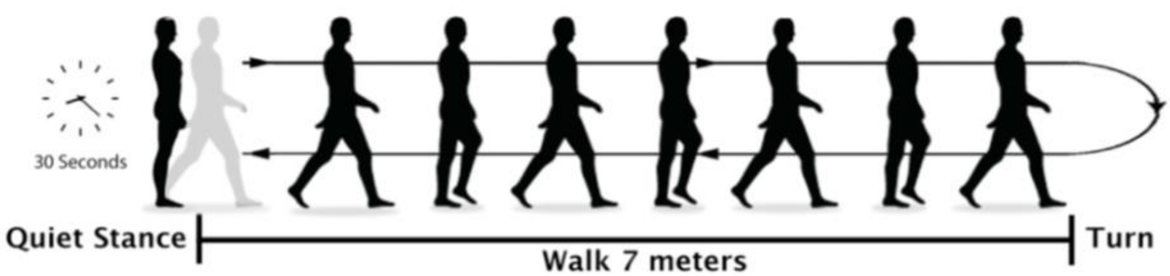


Figure 8. The ISAW protocol, courtesy of APDM, Inc., Portland, OR.

Rationale

This task assesses balance during normal standing and gait stability when walking at a comfortable pace and including a 180 degree turn as well as working memory under normal, sub-maximal exertion conditions[23]. The ability to learn and retain operationally relevant information such as that provided in this task while completing a motor task has relevance to functional duty demands. It is also not a strenuous physical task and would be expected to be tolerated by subjects with acute concussion.

Hypotheses/expectations

A dual-task paradigm requires an individual to perform two tasks simultaneously (in this project: a motor and a cognitive task), in order to compare dual-task performance with single-task performance. The interpretation assumes that human processing resources are limited and shareable; and that in concussion and other types of mild brain injury an overload in these processing resources is more easily reached. Dual-task performance is often measured as a "cost" relative to performance of each activity in a single domain condition. Dual-task effects include a) interference (cost) which is defined as performance under dual-task conditions results in a decrement relative to single task performance. A second dual-task effect is called b) enhancement (benefit) in which performance under dual-task conditions results in an improvement relative to single task performance. Gait and executive functioning (cognitive process that regulates, controls, and manages other cognitive processes; executive functioning includes ability to divide attention during ambulation) become more closely associated as locomotor challenge becomes more challenging and with the addition of a dual-task such as walking while reading signs or while talking with a friend.

The ISAW-Grid is a standard dual-task with the expectation that there would be a dual-task cost in terms of number of recalled grid coordinates, the time to walk the course in addition to inertial sensor data findings with a special focus on sway area, gait velocity and variability and turn dynamics. We also in general expected that subjects with mTBI would have more difficulty with the grid-coordinate recall in both the single and the dual-task condition due to issues with memory and to a lesser extent, attention. A correlation to the standard memory neurocognitive test of NAB Digits forward/Digits backward and NAB Numbers and Letters was expected.

Method

As part of the AMMP validation study to evaluate IRR, known-group discrimination and convergent and discriminate validity, the ISAW-Grid was administered to SM with mTBI and HC subjects. ISAW-Grid assessment relied on observational metrics, including number of recalled grid coordinates and time (measured with a stopwatch) to complete the 7 meter walk with the 180 degree turn at the 7 meter mark. Inertial sensor data as described above was also collected using a commercially available software program (ISAW-Grid) from APDM, Inc. (Portland, OR).

Between-groups analyses for recalled grid coordinates and for walk time in single and dual-task condition were conducted on 52 HCs and 51 SM with mTBI. Between-groups analyses for all inertial sensor variables (www.apdm.com/mobility) were also evaluated for 42 subjects with mTBI and 62 HCs. NOTE that the inertial sensor findings were evaluated on HC subjects both at USARIEM and at Fort Bragg. A comparison of data was done between 20 HCs from USARIEM and HCs from Fort Bragg with no differences found for the variables related to turn metrics ($p = 0.11$ to 0.78), which thus allowed the data to be combined.

Inertial sensor data

Our approach used wireless sensors on a belt placed at the lumbar spine (Opal) and around the ankles. Each sensor has a 3D accelerometer and 3D angular rate sensor, and uses a Mobility Lab (APDM company, Portland OR) system to automatically quantify sway, gait, and turning metrics. Data from these sensors is wirelessly transmitted (via radio waves) to a laptop where automatic algorithms calculate up to 42 different sway and gait measures for each trial[24]. Using the commercially available ISAW program, 3 trials of single task stand and walk were collected. The median scores were used for the between groups analysis; this was also done in the dual-task condition. The primary variables that we planned evaluate included:

Recorded and calculated by APDM Opal system. To include, but not limited to:

- Centroidal Frequency during sway
- Frequency dispersion during sway
- Median RMS Postural Sway (total sway area, cm^2) in single task condition
- Median RMS Postural Sway (total sway area, cm^2) in dual-task condition
- Gait Speed (m/s) in single task condition
- Gait Speed (m/s) in dual-task condition
- Gait variability (CV) in single task condition

- Gait variability (CV) in dual-task condition
- Peak Turning velocity in single task condition
- Peak Turning velocity in dual-task condition

Results

Observational data

Number of recalled grid coordinates in the dual-task condition was able to distinguish groups ($p<0.008$). Recall of grid coordinates in the single task condition, as well as walk time (seconds) in the single and dual-task condition did not distinguish groups (Table IVF(1)). Findings presented as dual task cost are presented in Table IVF. Our findings appear to indicate that the calculation of cost is less informative in this group of physically elite subjects than is often described in the literature on dual task interference in the elderly or those with mild cognitive impairment.[25]

Inertial sensor data

Demographics for subjects tested with inertial sensors for the ISAW-Grid task are found in Table IVF(2). Instrumented measures of turning revealed significant between group differences (Table IVF(3)). In both single and dual-task conditions, soldiers with post-concussive deficits demonstrated longer turn durations, increased step numbers to complete a turn, and decreased peak rotational velocities during turns. All of these turning variables are correlated to each other and calculated from the same data, thus would be expected to all distinguish. Variables related to gait velocity, step variability, centroid frequency and total sway area did not distinguish groups ($p>0.10$ for all variables).

Table IVF(1). Instrumented Stand and Walk – Grid Coordinates (ISAW-Grid)

	Scoring Reliability	**Known Groups Analysis***	**Correlations to Standard Neurocognitive tests**			
Metrics	Fort Bragg	HC	mTBI		ICC (95% CI), n, p-value	
	n = 26 19 mTBI, 7 HC	N=52 Mean (SD) Median (Range)	N=51 Mean (SD) Median (Range)	p-value		
	ICC (95% CI)				TOH, # of moves# moves	WRAT Reading (IQ)
Grid coordinates Single	0.97 (0.92-1)	6.7(1.7) 8 (3-8)	6.3 (1.8) 7 (3-8)	0.262	-0.19 (-0.38, 0.02) n=91 p=0.073	0.39 (0.21, 0.55) n=99, p<0.001*
Grid Coordinates Dual	0.98 (0.93-1)	7.0 (1.5) 8.0 (3-8)	5.9 (2.2) 6 (1-8)	0.008	-0.09 (-0.29, 0.11) n=93 p=0.378	-0.08 (-0.27, 0.11) n=103 p=0.416
Walk time Single	0.97 (0.96-0.99)	12.0 (2.1) 12.4 (6.9-16.3)	12.6 (2.2) (12.5 8.1-19.0)	0.206 t-test	0.03 (-0.18, 0.23) n=91 p=0.805	0.04 (-0.16, 0.24) n=99 p=0.697
Walk time Dual	0.95 (0.90-0.98)	12.0 (2.0) 12.4 (6.8-15.2)	12.5 (2.2) 12.2 (8.5-21.0)	0.634	0.04 (-0.17, 0.24) n=93 p=0.715	0.14 (-0.05, 0.33) n=103 p=0.145
*Known groups analysis with Mann-Whitney U unless otherwise noted						

Table IVF(2). Instrumented Stand and Walk – Grid Coordinates (ISAW-Grid)-Dual Task Costs

Metric	HC	mTBI	p-value
Median dual grid coord(chars) (52,52)	7.0(1.5) 8.0(3-8)	5.9(2.2) 6.5(1-8)	0.016, Mann-Whitney
Dual Task Cost grid (%) (52,52)	-12.6(42.6%) 0(-166.67-50.00)	4.12(36.8%) 0(-100.00-71.43)	0.059, Mann-Whitney
Median dual time(mins) (52,52)	12.0(2.0) 12.4(6.8-15.2)	12.5(5.0) 12.2(8.5-21.0)	0.647, Mann-Whitney
Dual Task Cost time(%) (52,52)	-0.21(5.4%) -0.25(-9.50-12.61)	0.60(5.3%) 0(-11.82-11.28)	0.349, Mann-Whitney
Completed task(52,52)	100%	100%	NA

Table IVF(3). Demographics for subjects tested with inertial sensors for ISAW-Grid task.

Characteristic	**Healthy Control (N=62)**	**Concussion/mTBI (N=42)**	**p-value**
Age (yrs) **(mean (SD), median (range))**	28.8 (5.5), 28.5 (19-42)	27.1 (5.4), 25 (19-42)	0.052
Sex-Male	45 (72.6%)	39 (92.9%)	0.011
Ethnic Background **Black** **Hispanic** **White** **Other (Asian, Native American, biracial)**	 19 (30.6%) 7 (11.3%) 31 (50.0%) 5 (8.1%)	 3 (7.1%) 9 (21.4%) 23 (54.8%) 7 (16.7%)	0.033
Education **HS** **Post-HS** **Bachelors** **Post-Grad/Professional**	 12 (19.4%) 22 (35.5%) 19 (30.6%) 9 (14.5%)	 6 (14.3%) 30 (71.4%) 6 (14.3%) 0	0.001
WRAT Reading Level (mean (SD), median (range)	11.9 (1.9), 12.7 (4.4-13)	10.8 (2.3), 11.4 (3.8-13)	0.002
Deployed to Iraq/Afghanistan	33 (53.2%)	32 (76.2%)	0.023
Sustained a concussion	10 (16.1%)	41 (97.6%)	0.001
Years of service	7.0 (5.7), 6.5 (0.3-23.3)	6.0 (5.1), 3.7 (0.8-23)	0.619
Do you feel "Ready to Deploy" to a combat zone in 72 hours?	57 (91.9%)	20 (47.6%)	<0.001
Hearing issue-self report	10 (16.1%)	41 (97.6%)	<0.001
# days since last concussion **N=9,23, a lot of missing data**	2264 (1168.3), 2023 (977-4030)	226.4 (140.1), 181.5 (58-632)	0.515

Table IVF(4). ISAW-Grid sensor variables during turn that distinguished groups.

Sensor Variable	Median HC	Median mTBI	p-value
Peak Turning velocity in single task condition	235.0 degr/sec	198.3 degr/sec	<.001
Peak Turning velocity in dual-task condition	229.3 degr/sec	202.0 degr/sec	<.001
Turn duration seconds in single task condition	1.57 sec	1.88 sec	<.001
Turn duration seconds in dual-task condition	1.62 sec	1.83 sec	<.001

Discussion

Analysis of ISAW-Grid using the Mann-Whitney U revealed significant between groups differences for the grid task memory component in the dual-task condition and not in the single task condition. This would support the concept of this dual-task evaluating a limited and shareable amount of brain resources as the grid coordinates distinguished groups in the dual-task condition only. The clinical measure of timed walk did not distinguish HC and mTBI groups. Using the inertial sensor findings to evaluate more subtle deficits, only the most dynamic testing condition (a 180 degree turn) was sufficient to discriminate between HC and SM with mTBI residual symptoms. SM were premorbidly high functioning Warrior athletes; it appears likely that this standing and walking with a turn with its inherently less challenging test conditions were likely less sensitive to between group differences perhaps as a result of a ceiling effect. Other studies use more challenging conditions such as narrowed stance or gait, single leg stance, standing on a compliant surface, standing with vision suppressed (ref). While specific mechanisms cannot be determined by the results of this study, it may be that peak turn velocity may be degraded by vestibular symptoms (e.g., diminished tolerance for rotation, impaired gaze or dynamic stability).

Recommendations

The ISAW-Grid task may likely be well tolerated in acutely concussed SM and should be evaluated in this population, specifically to determine if it can document recovery over time with the turning metrics using the inertial sensor and the cognitive component of number of recalled grid coordinates. As with all AMMP tasks, if this task is to be used to inform readiness to return-to-duty, a longitudinal study exploring the predictive validity, information on normative data on healthy controls (ultimately would want to establish cut-points for definite "Go" and "No Go" parameters). If it is to be used to measure progress for RTD, we need to evaluate responsiveness to change as a SM recovers spontaneously or responds to treatment. Further study is needed to evaluate the sensitivity and specificity of the ISAW-grid.

LOAD MAGAZINE-RADIO CHATTER

Introduction

In the "Load the Magazine-Radio Chatter" task, the subject loads M-16 dummy rounds from a bin of mixed size rounds as fast as possible. The dual-task condition requires monitoring radio communication about an upcoming training event and verbally announcing when key words are spoken by specific personnel. Metrics are the number of rounds loaded and the number of correct and incorrect responses to the radio chatter.

Description

The SM completes a relatively automatic manual task choosing from a bin of mixed size dummy rounds (5.56 and 7.62 caliber) and loading 5.56 caliber training rounds into magazines as fast as possible both in a single and a dual-task condition. The dual-task condition requires monitoring radio communication and verbally announcing when specific key words are spoken by specific personnel. This test takes approximately 22-24 minutes to perform including time for set up and subject instruction.

Rationale

The purpose of this task is to assess the cost of a cognitive task overlay requiring auditory processing on the speed of a relatively automated upper extremity manual task[26]. This task is intended to challenge attention allocation (divided attention), sustained attention, executive function, manual dexterity/speed, and auditory processing. White noise in the radio chatter recordings require close attention to auditory information which is operationally important while completing a motor task that has relevance to functional duty demands. Given that it is completed in sitting, this task does not require significant postural control.

Hypotheses/expectations

A dual-task paradigm requires an individual to perform two tasks simultaneously (in this project: a motor and a cognitive task), in order to compare dual-task performance with single-task performance. The interpretation assumes that human processing resources are limited and shareable; and that in concussion and other types of mild brain injury an overload in these processing resources is more easily reached. Dual-task performance is often measured as a "cost" relative to performance of each activity in a single domain condition. Dual-task effects include a) interference (cost) which is defined as performance under dual-task conditions results in a decrement relative to single task performance. A second dual-task effect is called b) enhancement (benefit) in which performance under dual-task conditions results in an improvement relative to single task performance.

The Load the Magazine-Radio Chatter task is a standard dual-task with the motor component requiring upper extremity function in a relatively rote manual dexterity task and no real postural control challenge. The expectation was for a dual-task cost in terms of number of correct and incorrect key words identified and the number of dummy rounds loaded in the dual-task condition over the single task condition. Given that this task requires sustained attention with some executive function, it was expected to correlate to standard neurocognitive tests of attention and memory including the Comprehensive Trail Making Test and the NAB Digits forward/Digits backward and NAB Numbers and Letters. A correlation with WRAT Reading was not necessarily hypothesized, however, the expectation would be that a subject who is of higher intelligence may be more able to develop a strategy for being successful at this task.

Method

As part of the AMMP validation study to evaluate inter-rater reliability, known-group discrimination and convergent and discriminate validity, the Load Magazine-Radio Chatter task was administered to SM with mild traumatic brain injury and healthy controls. Load Magazine-Radio Chatter task assessment relied on observational metrics, including number of rounds loaded (counted) and number of key words and distractors responded to in both single and dual-task conditions. Between-groups analyses for rounds loaded and keywords and distractor words reported in single and dual-task condition were conducted on 51 HC and 51 SM with mTBI.

In order to reduce a potential practice effect, subjects are given 2 timed trials to practice loading dummy rounds and 1 to 2 trials of listening to and responding to radio chatter before being tested on both number of rounds loaded and number of correct and distractor key words responded to in both single and dual-task conditions.

Results

Non parametric between groups analysis revealed significant differences in the dual-task condition for the number of correct responses to the radio chatter, and number of errors in responding to distractor words committed between HC and concussed personnel (Table IVG(1)). The correct and detractor responses to radio chatter keywords did not distinguish groups in the single task condition. Dual task costs were calculated and are are similar to direct groups comparisons, cognitive task interference demonstrated in the dual task condition (Table IVG(1)). The motor task of loading rounds also did not distinguish groups in either the single or dual-task condition. As discussed under Aim 2, there were significant correlations to the CTMT and to the WRAT Reading score in the dual-task conditions (Table IVG(1) and Aim 2, Table IIB).

Discussion

Subjects with mTBI had more difficulty than HC with the cognitive task (keyword and distractor word responses) specifically when the cognitive task was overlaid on the physical/motor task of loading rounds. This would support the concept of this dual-task evaluating a limited and shareable amount of brain resources as the radio chatter keyword responses distinguished groups in the dual-task condition only. It appears that the motor task of loading rounds was not of sufficient difficulty to elicit a dual-task effect in this Soldier population, possibly because it was a rote or well-trained task for these subjects or because subjects prioritized motor task over cognitive. The Load-Magazine-Radio Chatter task may potentially distinguish not duty ready SM with mTBI who have auditory processing issues including those who are irritated by loud sounds.

Recommendations

As with all AMMP tasks, if this task is to be used to inform readiness to return-to-duty, a longitudinal study exploring the predictive validity, information on normative data on healthy controls (ultimately would want to establish cut-points for definite "Go" and "No Go" parameters). If it is to be used to measure progress for RTD, responsiveness to change as a SM recovers spontaneously or responds to treatment should be evaluated. Further study is needed to evaluate the sensitivity and specificity of the Load-Magazine-Radio Chatter task.

Table IVG(1). Load Magazine-Radio Chatter Between Groups Comparisons and Correlations

	Scoring Reliability	Known Groups Analysis*			Correlations to Standard Neurocognitive tests	
Metrics	Fort Bragg	HC	mTBI		ICC (95% CI), n, p-value	
	n = 24 18 mTBI, 6 HC	n = 51 Mean (SD) Median (Range)	n = 51 Mean (SD) Median (Range)	p-value		
	ICC (95% CI)				CTMT Composite@	WRAT Reading (IQ)
Rounds loaded Single	Not evaluated	55.47 (9.9) 58 (32-77)	53.7 (8.6) 54 (39-86)	0.337 t-test	*	*
Rounds loaded Dual	Not evaluated	51.8 (9.3) 51 (30-72)	49.1 (9.4) 49(31-81)	0.16 t-test	*	*
Rounds difference Single-Dual	Not evaluated	3.7 (6.0) 4 (-13-19)	4.4 (6.8) 4 (-13-19)	0.730	*	*
Single Task Correct	0.997 (0.993-1)	7.7 (1.9) 8 (1-9)	7.4 (2.3) 8.5 (0-9)	0.797	0.15 (-0.06, 0.34) n=92 p=0.167	0.15 (-0.05, 0.33) n=102 p=0.139
Single Task Errors	0.995 (0.986-1)	2.2 (3.4) 1 (0-17)	2.7 (3.8) 1 (0-16)	0.797	-0.15 (-0.34, 0.06) n=92 p=0.157	-0.1 (-0.29, 0.1) n=102 p=0.318
Dual-task Correct	0.978 (0.949-0.999)	7.7 (1.6) 8 (1-9)	7.02 (1.8) 7 (0-9)	0.014	0.35 (0.15, 0.52) n=92, p=0.001*	0.35 (0.17, 0.51) n=102, p<0.001*
Dual-task Errors	0.947 (0.869-1)	2.2 (2.6) 2 (0-13)	3.4 (2.9) 3 (0-15)	0.006	-0.41 (-0.57, -0.22) n=92, p<0.001*	-0.35 (-0.51, -0.17) n=102, p<0.001*
Correct difference Single-Dual	*	-0.06 (2.2) 0 (-6-8)	0.34 (2.2) 1 (-7-5)	0.059	-0.12 (-0.32, 0.08) n=92 p=0.237	-0.14 (-0.32, 0.06) n=102 p=0.17
Rounds Cost%	*	6.1(10.7) 6.3 (-30.2-32.2)	7.7(12.6) 7.7(-30.2 – 35.4)	0.503 t-test	*	*
Correct Cost%		-19.4 (92.3) 0 (-600-88.9)	-14.9 (117.2) 11.1(-700 – 100)	0.027	*	*

*Known groups analysis with Mann-Whitney U unless otherwise noted; @Comprehensive Trail Making Test=CTMT

SECTION V: EXPLORATORY ANALYS

Introduction

Exploratory analysis includes three avenues of inquiry:

- Evaluation of participants who were negative outliers (did very poorly compared to the rest of the participants) on any of the task metrics that were able to distinguish between HC and mTBI.
- Characteristics of subjects with mTBI who responded 'NO' on their intake form to the question about readiness to deploy on a combat tour in 72 hours.
- Predictive modeling to classify HC and mTBI.

These analyses were undertaken in order to further elucidate our findings from specific task performance and to identify opportunities for continuing research.

OUTLIER ANALYSIS

Methods

Given the non-normality of the distribution of the metrics, we evaluated negative outliers for the mTBI group with respect to the HC group using the Tukey Interquartile Range (IQR) criteria of greater than or less than 1.5* IQR from either end of the minimum / maximum edges of the IQR for HCs. Task specific metrics included in this analysis were those that were significantly different when HC were compared to mTBI from known group analysis.

Results

A summary table is provided (Table VA). A total of 34 participants (10HC and 24 mTBI) were outliers on at least one task item that successfully distinguished groups.

<u>CQ Duty:</u> For total visits, 5 mTBI were classified as outliers relevant to the distribution of HCs compared to 2 for Task Performance. Total Visits appears to be a more sensitive measure for identification of outliers.

<u>ISAW-Grid:</u> For number of Grid Coordinates Correct, 6 mTBI were classified as outliers relevant to the distribution of HCs.

<u>Load Magazine-Radio Chatter:</u> For these metrics, 3 HC and 5 mTBI were outliers on number of keywords correct and 2HC and 5 mTBI were outliers on number of distractor errors. This task may be less sensitive in identifying mTBI outliers given the number of HC also identified.

<u>Patrol-Exertion:</u> For these metrics:

Vision end of task: 2 HC and 6 mTBI respectively were outliers
Reaction time - early: 6HC and 6 mTBI were outliers
Reaction time - late: 4HC and 11 mTBI were outliers

This task may be less sensitive in identifying mTBI outliers given the number of HC also identified. Reaction time late appears to better distinguish mTBI as outliers than early reaction time.

Summary over All Tasks

Participants with <u>greater than two</u> outlier items: 1HC and 8 mTBI
Participant with more than 1 task: 6 mTBI, 4 of whom were <u>not</u> ready to deploy

Conclusions

Another avenue for exploration for distinguishing mTBI from HC as well as readiness for deployment is utilization of outlier analysis. The mTBI groups were more likely to be outliers than HCs. A large number of service members would need to be tested in order to establish norms and cut points for each of the tasks.

Table VA. Negative outliers for the mTBI group with respect to the HC group using the Tukey Interquartile Range (IQR) criteria

Outliers ID	CQ # Visits	CQ Total Performance	ISAW # Grid Dual Task	Radio Chatter #Correct	Radio Chatter Errors	Patrol Vision Score	Patrol React Time Early	Patrol React Time Late	Total Items	Total Tasks	Group	Ready Deploy
42	1								1	1	mTBI	Y
51			1						1	1	mTBI	N
57			1						1	1	mTBI	N
67	1			1	1				3	2	mTBI	N
78			1						1	1	mTBI	N
79						1	1	1	3	1	mTBI	N
85							1		1	1	mTBI	Y
86					1				1	1	mTBI	N
88				1					1	1	HC	Y
92	1								1	1	mTBI	N
93				1					1	1	mTBI	Y
94								1	1	1	mTBI	Y
96								1	1	1	mTBI	N
97	1								1	1	mTBI	Y
99							1		1	1	HC	Y
100							1		1	1	HC	Y
107						1	1	1	3	1	mTBI	N
109							1		1	1	HC	Y
114				1	1	1		1	4	2	mTBI	N
116		1							1	1	mTBI	N
117				1	1				2	1	HC	Y
120							1	1	2	1	mTBI	N
122			1	1	1				3	2	mTBI	N
125			1	1	1		1	1	5	3	mTBI	N
126							1	1	2	1	mTBI	N
130							1	1	2	1	HC	Y
138						1		1	2	1	HC	Y
143						1	1	1	3	1	HC	N
144				1	1				2	1	HC	Y
152								1	1	1	mTBI	Y
154							1	1	2	1	HC	Y
164			1			1		1	3	2	mTBI	Y
165	1	1				1			3	2	mTBI	Y
166						1		1	2	1	mTBI	Y

READINESS TO DEPLOY

Methods

The Non-Parametric Wilcoxon U Test was used to compare those who reported themselves 'ready' or 'not ready' to deploy on a combat tour in the mTBI group, on those task metrics that distinguished groups as well as neurocognitive scores and relevant items on the intake forms. This related to a question on the intake form which asks subjects to provide a yes or no response to the question "Do you feel mentally and physically prepared to begin a combat tour 72 hours from now?"

Results

Table VB describes those items that distinguished ($p<0.05$) or nearly distinguished the two groups ($p<0.1$), ready or not ready to deploy.

- Two task items were significant, ISAW grid number remembered under dual task conditions (p-value= 0.045) and radio chatter number correct under dual task conditions (p-value= 0.029). Both of these items are related to memory as is NAB Digit Forward (p=0.075).
- Refer to Outlier Table V.A, for those participants with outliers in more than one task; 4 of 6 said they were 'NOT READY TO DEPLOY ON A COMBAT TOUR'.

Table VB. Metrics that Distinguish Groups: Subject Reported "Readiness to Deploy on a Combat Tour"

ITEM	Affect on 'NOT READY to DEPLOY'
Intake Form-Sleep Aide	Those using a sleep aide, more likely to repsond 'NOT READY',p=0.08
NEURO-NAB DIGIT Forward	Lower scores for those 'NOT READY' (p=0.075)
ISAW GRID # correct under dual task	Lower scores for those 'NOT READY'(p=0.045)
Radio Chatter # Correct under dual task	Lower scores for those 'NOT READY' (p=0.029)
Refer to Outlier table	

Conclusions: Memory may be a symptom that is readily self-identified in soldiers with mTBI, leading them to decide they are not ready to undertake a deployment to a combat zone.

PREDICTIVE MODELING

Predictive modeling is in the beginning stages of development. Preliminary results are reported.

Methods

Multiple Logistic Regression, Decision Tree (CHAID) and Discriminant Analysis were used to explore classification of HC and mTBI.

CHAID offers a method of efficiently searching for relationships between the independent variables and the categorical, dependent outcome measure. The output is a tree diagram that shows the category combinations that make the most significant difference in the outcome percentages. Thus, CHAID is an effective tool for identifying segments that maximize the prediction accuracy. In contrast to logistic regression where participant with missing data are dropped, CHAID keeps all subjects, using whatever data is available. SPSS V22.0 was used for this analysis.

For all methods, metrics that distinguished groups from each of the AMMP tasks were included. In addition, sensor data from the ISAW-grid coordinates task for peak velocity was included.

Results

Logistic Regression

Metrics from the CQ Duty, ISAW-Grid and Patrol-Exertion tasks are included in this optimized model (Table V.C.1). This model successfully predicted 80.8% of 73 participants included in the analysis, 88.4% of 43 HC and 70% of 30 mTBI. This low number of included participants was due to not having completed a task and/or missing data. Additionally, the Patrol-Exertion task did not include the first 19 participants with mTBI because the task was modified multiple times and only those subjects who completed the final version of the task were included.

Table VC(1). Logistic Regression Model

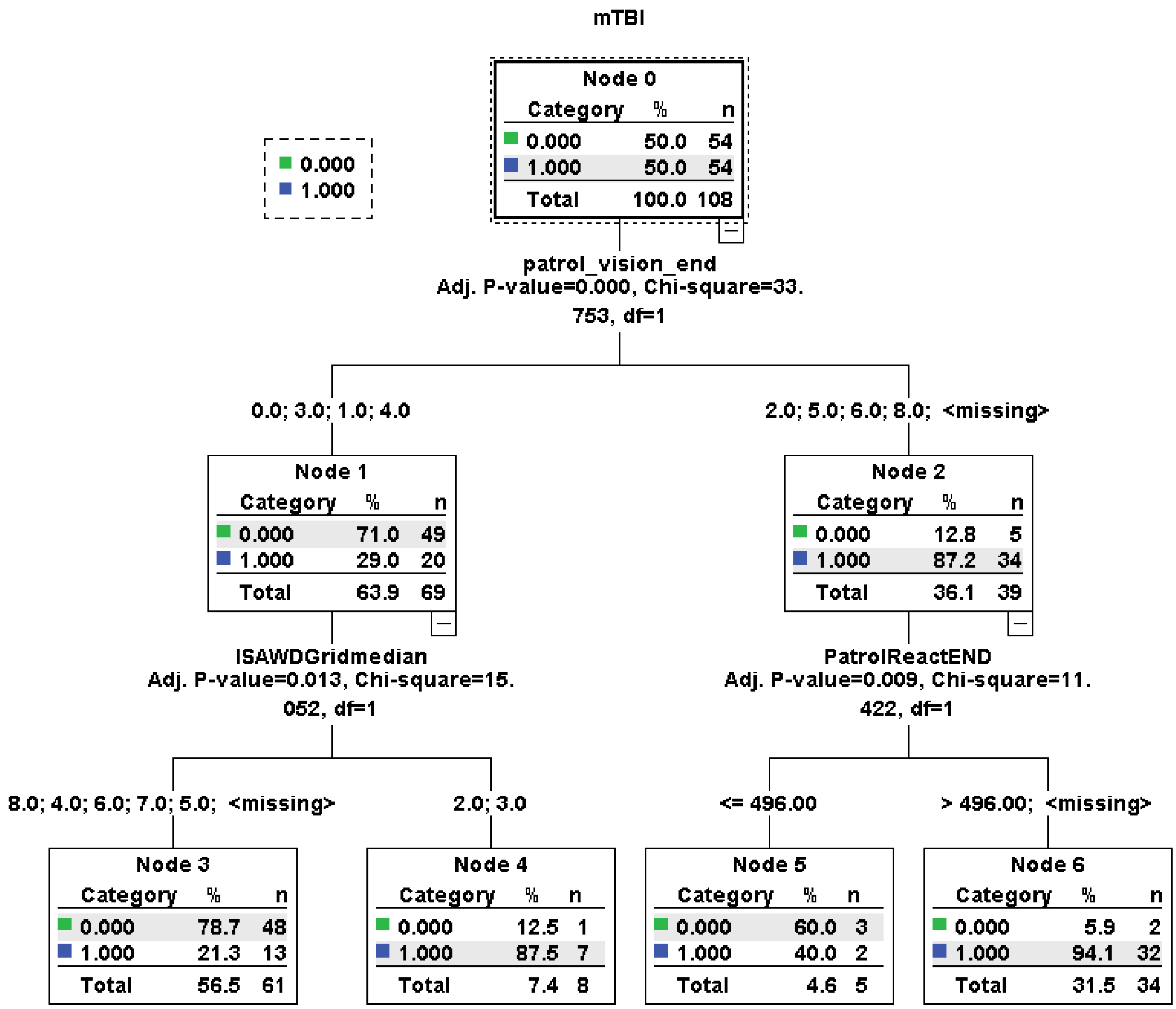
	B	SE	df	Sig	Exp(B)	95%CI Lower	95%CI Upper
CQ Duty # Visits	.166	.072	1	.021	1.180	1.026	1.358
ISAW-Grid; #Coordinates Remembered Dual task	-.298	.169	1	.077	.742	.533	1.033
Patrol Reaction Time End	.004	.002	1	.106	1.004	.999	1.009
Patrol Vision End	.938	.374	1	.012	2.554	1.227	5.319
Constant	-3.600	1.934	1	.063	.027		

CHAID

Task metrics from the ISAW-Grid (number of grid coordinates recalled under dual task condition) and Patrol-Exertion (vision end of task and reaction time end of task) were included in the CHAID model are shown in Figure 8 where mTBI is coded as ‘1’ and HC as ‘0’. Also included is readiness to deploy in 72 hours as a yes/no response. This model successfully predicted 85.2% of 108 participants included in the analysis, 85.2% of 54 HC and 85.2% of 54 mTBI, considerably better than results from the Logistic Regression model.

The vision at end of task (Patrol-Exertion) split is unusual because of the break in sequence where a value of 2 is grouped with 5, 6, and 8. The median value for the mTBI group is 1. The frequency distribution of the vision values demonstrated that ‘2’ was more likely to be associated with mTBI and therefore was included in the right branch. The other high values of 5, 6, and 8 were more likely to predict mTBI as compared to HC so they were also included on the right branch. Missing values for the mTBI group, where only 33 of 54 were available, may have skewed the results.

Figure 9. Logistic Regression Model



Discriminant Analysis

The approach included all variables entered in the previous two models, and also CQ total time, CQ rule breaks, and ISAW time under dual task condition as well as the total score for the PCL-C (PTSD screen). All variables were kept in the model. Readiness to deploy was not included because this method requires continuous variables. The additional CQ metrics were included to evaluate their contribution to the results given the nature of the task with its focus on cognitive function. Inclusion of the total PCL-C score for PTSD was hypothesized to provide a measure of classification. However, a final model that would be most useful would probably not include this metric since those soldiers with high scores would already be designated as not ready to return to duty. A total of 60 participants were included in this analysis due to missing data, 36 HC and 24 mTBI.

In this model, the PCL-C sum score contributed the most to classification. Table V.C.2 provides the coefficients associated with the model. Two approaches to classification used provided the following results:

- Modeling with all participants and then classifying: 33 of 36 HC (91.7%) and 20 of 24 mTBI (83.3%) were classified correctly for a total 88.3% correctly classified.
- Successive modeling, leaving each participant out of the model and then classifying them using the resulting model: 29 of 36 HC (80.6%) and 13 of 24 mTBI (54.2%) were classified correctly for a total of 70% correctly classified.

The second approach, an unbiased method of classification, yielded poor results; demonstrating the instability of the full model.

Table VC(2). Linear Discriminant Analysis Function

Variable	HC	mTBI
Constant	-527.03	-541.04
CQ Task Performance	8.23	8.45
CQ Total Rule Breaks	-0.64	0.30
CQ # Rules Broken	2.25	0.30
CQ Total Visits	4.16	4.45
CQ Total Time(mins)	0.52	0.65
ISAW Time Dual Task Condition	0.91	0.62
ISAW # Grid Coordinates Remembered Under Dual Task Condition	1.07	0.62
ISAW Peak Velocity	0.28	0.27
Patrol Vision End of Task	-0.46	0.10
Radio Chatter Correct Under Dual Task Condition	66.93	67.35
Radio Chatter Errors Under Dual Task Condition	42.16	42.51
Patrol Reaction Beginning of Task	0.04	0.04
Patrol Reaction End of Task	-0.04	-0.03
PCL-C Sum (PTSD Screen)	0.77	0.84

Conclusions

The results of exploratory modeling for classifying HC and mTBI were encouraging. A strategic plan for selection of tasks and on-going data collection accompanied with exploration of additional metrics can yield models that may be used for determining readiness for return to duty.

FUTURE RESEARCH RECOMMENDATIONS AND NEXT LINES OF INQUIRY

Next steps in research include both general "gap area" themes as well as specific research question to promote development and validation of individual AMMP tasks. Both are presented in this section however next steps in research will admittedly be informed by DoD/ stakeholder needs, availability of test subjects within FORSCOM or in medical readiness platforms in the MEDCOM. Research prioritization may also be a function of specific interests and expertise among clinical researchers in study design and administration related to the AMMP tasks.

<u>AMMP Battery</u>
We recommend creation of an AMMP Steering Committee during the bridge period following this current initial validation effort and next steps, to assist with monitoring and potentially coordinating further validation studies. Some focus areas include:

- **Gap 1: Tailoring AMMP Tasks to address different types of RTD decision making (Acute vs. Chronic Injury); Time since injury: Short (days) vs. Long (months**). The current AMMP battery includes performance tests that could be used to screen SM in austere, far forward settings (to inform early RTD decision making after acute injury) and other AMMP tasks likely better suited to measure performance in established practice environments (Hospital Settings). Follow on research should be pursued to identify optimal administration points in the continuum of care and to validate their use in appropriate practice environments. Considerations may include practical constraints to administration (space or maximal time requirements to set up and administer) or equipment factors (durability of instrumented systems (e.g., computers or accelerometers) to reliably function in austere environments).

- **Gap 2: Standardized Scoring**: In current form, each individual AMMP task is assessed based on participant performance on a series of task specific component metrics (e.g., time to perform, number of errors, number of items correctly identified, etc.). Thus, overall task performance is based on calculating performance on a series of sub-component metrics which have not been normalized to a standardized scoring system within the battery. Investigators see significant value in the development of a scoring system based on percentages or on a Likert based system that specifies: a) better than average, b) average, or c) worse than average, will contribute to the clinical utility of these assessment tasks. This approach would allow relative distinctions between performances on individual AMMP tasks and provide more specific feedback on a participant's relative strengths and challenges.

- **Gap 3: Phase II Discriminant Validity:** To meet with the primary RTD gap area of characterizing readiness to RTD, the research team would propose testing in a cohort consisting entirely of SM with history of concussion to discriminate between those who are duty ready (despite recent history of concussion) from non-duty ready personnel who may appear functional but are for some reason, non-duty ready (e.g.,: still symptomatic, subtly impaired in one or more physiologic systems; or unable to perform Warrior Tasks or Battle Drills to standard).

- Responsiveness to Change: If individual AMMP tasks are to be used to measure progress toward RTD readiness as a result of rehabilitation (intervention), research to evaluate metric responsiveness to change is essential. This will dictate the need for alternate forms of several of the AMMP tasks.

- Predictive modeling using AMMP task metrics should focus on predicting 'Successful Return to Duty'. Success for different RTD roles must be defined and studies that follow the Service Member's RTD experience must occur to generate the ultimate objective of the AMMP, to develop a predictive model for successful RTD. Factors which may be evaluated might include retention and promotion, annual evaluations, and use of health care resources for continuing mTBI symptoms.

<u>AMMP SPECIFIC TASK DEVELOPMENT</u>

- Two of the AMMP dual-tasks (ISAW-Grid and Load Magazine-Radio Chatter) may be considered for use in their current state on a limited basis in military rehabilitation settings to provide further information from military clinicians on their utility and relationship to RTD success/failure. Data from this clinical use should be evaluated to provide further validation of these dual-task metrics to provide useful clinical information on patient performance and progress.
- Develop, test, and validate alternate version(s) of the CQ Duty task to allow testing for responsiveness to change and response to treatment interventions focused on mTBI vulnerabilities including executive dysfunction and impaired attention and memory.
- Using the ISAW-Grid and a modification of the Illinois Agility-Word List task: Obtain serial measures of dual task cognitive load-dynamic stability performance in a cohort of SMs (Active Duty Cadets or acutely concussed Special Forces SM) pre- and post-concussion from boxing or other sports injury to establish recovery curves of static postural stability, dynamic stability, agility, attention and working memory in highly functional and highly motivated personnel (USMA)
    - ISAW-Grid task at baseline, 24 hours, 72 hours, 96 hours, 1 week, 9 and 14 days to follow recovery from acute concussion and once normal recovery curves are determined, to evaluate responsiveness to interventions such as the graded return to activity protocol.
    - Illinois Agility-cognitive task (like Grid-coordinates) at baseline, assuming asymptomatic (headache and dizziness resolved) and again at 5, 7, 9 and 14 days)
    - Validate similar dual-task performance study in civilian athlete cohorts (e.g., academia, NCAA, NFL).
- Specific AMMP tasks may have greater sensitivity in certain patient groups (e.g. ISAW Grid in acutely concussed personnel, rolling component of Run Roll Aim for those reporting post traumatic dizziness as a clinical complaint). Studies to identify AMMP task use based on patient complaint profile are needed.
- Using an up tempo video (this may be a custom developed or a ready-made video that provides a busier and more challenging cognitive load), evaluate the Patrol-Exertion task at point of RTD in established concussion care programs following rehabilitation (given exertion component and high face validity) (Candidate sites: WOMACK, NC; Fort Campbell KY). Additionally, develop, test, and validate alternate version Patrol-exertion videos to include more complicated scenarios requiring greater cognitive focus to allow use

of the Patrol-exertion task in testing for responsiveness to change and response to treatment interventions.

- Use Load Magazine- Radio Chatter test to measure performance in AD Soldiers under stressed temperature conditions (extreme hot/ extreme cold)- Cross validate other military functional tasks requiring bi-manual dexterity (USARIEM)
- Based on findings from the current inertial sensor data of the Illinois Agility-Packing List and Run Roll Aim tasks, consider further studies with inertial sensor instrumentation to evaluate the high level mobility and subtle mobility deficits of Warrior athletes potentially with a combination of motor tasks (floor to stand transitions and combat rolls) that .challenge vestibular vulnerabilities.
- Encourage additional studies to translate the use of Dual-task and Multitask assessments with face validity to civilian tests.

Conclusions

The successful completion and key finding of this study provides ample reason to support on-going research to refine and apply the AMMP battery for evaluating the SM with mTBI readiness for successful return to duty. We believe that tasks may be used as well in the civilian setting with minimal modification.

KEY ACCOMPLISHMENTS AND FINDINGS

1. Achieved clinically acceptable inter-rater reliability; all test metrics for each of the six tasks remaining in the AMMP battery have interrater reliability above 0.90 for dual-tasks and above 0.88 for multitasks except for several metrics on errors and cues which were then not used to evaluate between group differences.
2. Based on a minimum correlation of 0.3 for evaluation of hypothesized relationships between standard neurocognitive measures and AMMP task metrics; these hypotheses were supported. Although small (almost all below 0.4), expected correlations were demonstrated for most tasks with the exception of the Patrol-exertion task.
    a. Small correlations may be due to complexity of the tasks with multiple factors affecting performance. In addition, the mTBI group was not tested at the time of evaluating AMMP tasks for several assessments including Neurobehavioral Assessment Battery and Comprehensive Trail Making Test tests, which may have been a confounder given lag times between neurocognitive testing (obtained from Womack TBI Clinic chart) and AMMP battery testing.
    b. Dynamic Visual Acuity Testing (http://www.micromedical.com/Products/) was administered as a behavioral measure of gaze stability and a proxy for vestibular function testing. The DVAT identified only 3 subjects with mTBI who demonstrated clinically significant impairments in gaze stability (> 2 lines lost) during rapid head impulses ($\geq$ 120 degrees/sec) relative to static visual acuity during a head stationary condition. This clinical reference point was consequently insufficient for use as a correlational measure for AMMP metrics intended to target vestibular vulnerabilities.
3. Subjects with mTBI appear to have more difficulty than HC with cognitive tasks ***especially*** when overlaid on physical challenge:
    a. Dual-task interference for the cognitive task when tested during the motor task was able to distinguish HC from mTBI groups in the Load Magazine-Radio Chatter and Instrumented Stand and Walk-Grid Coordinates Dual Task.

b. Metrics focusing on executive function (cognitive) vulnerabilities demonstrated the ability to distinguish groups in the Charge of Quarters Duty task. A combination of exertional, cognitive and reaction time requirements in the Patrol-exertion task resulted in symptom report of reduced visual clarity and slower reaction time metrics which distinguished mTBI compared to HC.

4. Other than reduced peak velocities during 180 degree turns during normal walking as measured by inertial sensors, and reaction times during the mulitask, Patrol-exertion, AMMP physical performance metrics alone were insufficient to distinguish groups, leading to speculation that for the most part subtle differences may require inertial sensors or other laboratory equipment to identify physical performance dissimilarities in elite Warfighters that are healthy versus concussed.
5. Using 1) the AMMP task metrics that discriminate groups, 2) PCL-C scores (PTSD screen), and 3) self-assessment for readiness to return to combat duty, predictive modeling through logistic regression, discriminant analysis and decision tree analysis (CHAID) yielded successful classifications of HC and mTBI between 80.8% and 91.7% of cases. Accepting a number of limitations such as an inability to use cases with missing data, these methods show promise in identifying specific factors and AMMP metrics that provide the most information and that may be further investigated for RTD decision-making.
6. Exploratory analyses using time series analysis methodologies (principal component analysis (PCA)) is demonstrating the potential to correctly categorize healthy control and subjects with mTBI. These exploratory findings require further investigation with the current data set to develop a theoretical framework for their interpretation and association with known mTBI related vulnerabilities. .
7. There is likely an optimal balance of symptom report, impairment and functional metrics that can be modeled to optimally discriminate between ready and non-duty ready personnel.
8. An AMMP Training Manual and Training Modules (PowerPoint and Video) are included in appendices and under separate files. For each of the six AMMP tasks, these materials provide 1) Task Description and Set Up, 2) Examiner Instructions and Script, 3) Score Sheet, 4) Scoring Guide, 5) Task specific testing materials. The AMMP Training Manual and Modules are designed to enable prospective AMMP examiners to understand, visualize, and practice the administration of the 6 AMMP tasks.

REPORTABLE OUTCOMES

LIST OF MANUSCRIPTS, ABSTRACTS, PRESENTATIONS

Manuscripts (published)

Scherer M, Weightman M, Radomski M, Davidson L, McCulloch K. “Returning Service Members to Duty Following Mild Traumatic Brain Injury: Exploring the Use of Dual-Task and Multitask Assessment Methods”, *Phys Ther.* 2013; 93:1255-1267.

Smith, LB, Radomski, MV, Davidson LF, Finkelstein, M, Weightman, MM, Scherer, MR, McCulloch, K (2014). Development and preliminary reliability of a multitasking assessment following concussion. *American Journal of Occupational Therapy, 68*, 439-443.

Manuscripts (submitted or in preparation)

Weightman MM, McCulloch KL, Radomski MV, Finkelstein M, Cecchini A, Davidson L, Heaton KJ, Smith L, Scherer M. Further development of the Assessment of Military Multitasking Performance: Iterative Reliability Testing. Submitted to the *Journal of Rehabilitation Research & Development* (20 October 2015).

McCulloch, K, Cecchini A, McMillan H, Cleveland C, Davidson LF, Finkelstein M, Radomski M, Scherer M, Smith L, Weightman M, Military/Civilian Collaborations for mTBI Rehabilitation Research in an Active Duty Population: Lessons Learned from the Assessment of Military Multitask Performance Project, (2015 in preparation).

Presentations

Date of Presentation	Title, Name of Conference, and Location
November 6, 2013 (platform)	*Returning Service Members to duty following mild traumatic brain injury: Exploring the use of dual- and multitask assessment methods* (McCulloch & Scherer), Association of Military Surgeons of the United States, Seattle, WA
February 21, 2014 (poster)	*Assessing Motor Performance in Military Service Members Following mTBI Using Inertial Sensor Data* (McCulloch & Yu), Human Movement Science Student Research Day, Chapel Hill, NC
March 19-22, 2014 (poster)	*Preliminary inter-rater reliability for a novel dual-task & multitask assessment battery guiding return-to-duty in concussed Service Members* (Weightman, McCulloch, Davidson, Scherer, Smith, Finkelstein, Radomski), International Brain Injury Association, San Francisco, CA
April 11, 2014 (workshop)	*Development of a Dual-and Multitask Assessment to Inform Return to Duty after Concussion: Implications for Civilian Practice* (Weightman, Radomski), Minnesota Brain Injury Association, Minneapolis, MN
June 11-14, 2014 (symposium)	*State of the Art Military TBI Care: Latest Policies and Innovations in Return to Duty Assessment* (Scherer, McCulloch, Maxfield-Panker, MacMillan), American Physical Therapy Association (APTA) 2014 Annual conference, Charlotte, NC

August 18-21, 2014 (paper)	*A novel dual-task and multitask assessment battery guiding return-to-duty in concussed Service Members (*Smith, Scherer, Weightman), 3rd International Congress of Soldiers' Physical Performance, Boston, MA
October 8 – 12, 2014 (posters)*	*Development of the Run-Roll-Aim Task, a high level mobility task assessing physical skills related to military duty* and *Development of the dual-task Illinois Agility task, a component of the Assessment of Military Multitasking Performance,* McCulloch & Goldberg, American Congress of Rehabilitation Medicine (ACRM) Annual Meeting, Toronto, ON
February 5, 2015 (platform presentation)	*Inertial sensors detect subtle mobility differences in soldiers with persistent concussion symptoms: preliminary findings for the instrumented stand and walk* (Scherer, Finkelstein, McCulloch, Smith, Weightman), APTA Combined Sections Meeting, Indianapolis, IN
May 5, 2015 (poster)	*Inter-rater reliability of the Assessment of Military Multitasking Performance: A test battery for concussed Service Members,* Cecchini, McMillan, Cleveland, Weightman, McCulloch, Womack Army Medical Center Research Symposium, Fort Bragg, NC
September 2, 2015 (Report to DoD Return to Duty Symposium)	*Assessment of Military Multitasking Performance* (Weightman, Radomski, Scherer), Return to Duty Toolkit Working Group Symposium, Fort Detrick, MD
October 29, 2015 (symposia)	*Assessment of Military Multitasking Performance multi-task components: Informing return to duty after concussion* and *Assessment of Military Multitasking Performance dual-task components: Informing return to duty after concussion* (Weightman, Radomski, Scherer, McCulloch), ACRM Annual Meeting, Dallas, TX
October 28-30, 2015 (poster)*	*High level mobility task analysis after military mild traumatic brain injury identifies subtle motor control impairments* (McCulloch, Favarov, Balcilar), ACRM Annual Conference, Dallas, TX
October 28-30, 2015 (poster)*	*Instrumented stand and walk in single and dual-task conditions in Soldiers with persistent concussion symptoms,* (Weightman, Finkelstein, McCulloch, Scherer), ACRM Annual Conference, Dallas, TX
Accepted for February 2016 (symposium)	*Validation of the Assessment of Military Multitasking Performance for Mild TBI.* Federal Section, American Physical Therapy Association's Combined Section Meeting, (Weightman, Scherer, McCulloch), Anaheim, CA
Accepted for July 2016 (poster)	*Non-linear analyses of Agility Task Performance after military mild traumatic brain injury: An approach to identify subtle motor control impairments* (McCulloch, Favorov, Weightman), IVSTEP, Columbus, OH

Published abstracts
*These poster presentation abstracts will be published in a future Supplement to the Archives of Physical Medicine and Rehabilitation.

FUNDING APPLIED FOR BASED ON WORK SUPPORTED BY THIS AWARD

Study title: Return to Duty after Concussion with Exertional Symptoms: Physiologic and Functional Predictor
PI: Karen McCulloch, PT, PhD, NCS for proposal; Ft Bragg local PI CAPT Henry McMillan, PT, DPT, MBA
Funder submitted to and date of submission: CDMRP – Neurosensory call – invited to write full proposal following pre-proposal review; was recommended for funding as an alternate, was not funded. Will be rewriting this project with slightly modified research plan/aims for submission under the BAA. Full proposal submitted February 2015.
Specific Aims
- Describe patterns of symptom complaint, impairments and recovery for SM with persistent physical symptoms after mTBI.
- Confirm feasibility and safety of a graded return to activity program, describing efficacy and intervention duration for SMs with persistent exertional symptoms.
- Examine association of physiologic, functional and simulation-based measures that reflect RTD readiness; identify predictors of successful RTD for injured SMs.

Relevance
Given the focus of this proposed study was on exertional complaints following mTBI, we intended to use exertional tasks from the AMMP as a component of the study (including Run-Roll-Aim, Illinois Agility Test, Patrol-Exertion task). We also intended to be able to address responsiveness of these AMMP tasks given the longitudinal nature of the study, as well as validate AMMP findings to the clinical judgment about readiness to return to duty based on the current practice standards at Womack Army Medical Center.

Study title: Development, Reliability, and Equivalence of an Alternative Form for the CQ Duty Performance-based Measure
PI: Mary Vining Radomski, PhD, OTR/L
Funder submitted to and date of submission: USAMRMC BAA, Full Proposal August 2015
Specific Aims
- Develop an alternate form of the CQ Duty.
- Assure rater agreement across 2 raters.
- Evaluate equivalence of CQ Duty-Alternate Form.

Relevance
Performance-based assessments involving multitasking cannot be repeated because of significant learning effects. If we succeed in developing a CQ Duty-Alternate Form, the CQ Duty may be used to both identify executive dysfunction and quantify treatment outcomes in SM with mTBI. In addition, we may be able to demonstrate a potentially replicable process that could be used to develop alternate forms for other performance-based measures of high-level cognitive skills and abilities.

Study title: The *Front-Desk Duty* Multitasking Test for Adults with Mild Stroke: A Pilot study
PI: Mary Vining Radomski, PhD, OTR/L
Funder submitted to and date of submission: Courage Kenny Foundation, October 2015
Specific Aims
- Optimize all Front Desk Duty (FDD) materials received from Shenandoah University.

- Train 6 FDD research team occupational therapists (two from each of CKRI at Abbott Northwestern, Mercy, and United Hospitals) and evaluate competence in administering and scoring the FDD.
- Evaluate IRR of the FDD on 21 study participants.
- Determine between-groups discrimination of the FDD when administered to 34 individuals with mild stroke recruited from CKRI at Abbott Northwestern, Mercy, and United hospitals and 34 healthy individuals.
- Examine the relationship between FDD scores and that of neurocognitive measures of EF and self-reported EF in daily life.

Relevance

The Front Desk Duty assessment is a civilianized version of the CQ Duty, with the same task and scoring but within the context of a shift at the front desk of a motel. If funded, this study may capitalize on findings from the AMMP study to advance rehabilitation practice.

CONCLUSION

The Assessment of Military Multitasking Performance was developed as functional return to duty assessment battery in response to a critical gap in the DoD's mTBI management policy. The AMMP was developed in response to stakeholder requirements for face validity, clinical feasibility and the versatility to address a broad spectrum of known mTBI related vulnerabilities. Objective findings from this research project demonstrate that the AMMP is feasible with regard to equipment, setup time and space, time to administer, and scoring. Findings demonstrate that clinically acceptable interrater reliability of scoring was clearly demonstrated in all AMMP tasks. In the domain of discriminant validity, four of six tasks included component metrics that distinguished HC from mTBI groups. When instrumentation data are considered in addition to clinical outcomes, accelerometer data recorded in three tasks provided enhanced resolution on subtle kinematic performance differences between groups that may prove useful for informing duty readiness in more chronic, or less obvious RTD determinations. In general, more demanding, dynamic conditions were necessary to distinguish between HC and mTBI groups suggesting that the difficulty level of physical tests will continue to be a key consideration for testing in the premorbidly high functioning Warrior population.

Given the heterogeneous presentation of mTBI, and the imperative for "making the right call" to return a Warrior to full Duty (i.e., combat, during time of war) – there is a clinical research imperative to further explore and validate predictive modeling techniques to accurately discriminate between duty ready and non-duty ready personnel. Future validation efforts using AMMP tasks as regressors in such a model should be prioritized in conjunction with other clinical tests, symptom report scales, or other viable markers to account for the variance associated with duty readiness.

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APPENDICES

APPENDIX 1: LIST OF PERSONNEL RECEIVING PAY FROM THE RESEARCH EFFORT

Project Participants and Collaborating Organizations—Paid by Award			
Name	**Institution**	**Project Role**	**Principal Contributions**
Margaret M. (Maggie) Weightman PT, PhD	Courage Kenny Research Center (CKRC)/ Allina Health	Principal Investigator/ Project Director	Manage, oversee and contribute to all aspects of project. AMMP task development.
Mary Vining Radomski	CKRC	Co-Principal Investigator	Focus on development of training manual and videos; assist with project oversight. AMMP task development.
Marsha Finkelstein MS	CKRC	Co-Investigator	Oversee all aspects of data entry and data analysis
Amy Cecchini, PT, MS	CKRC –Contractor	Research Coordinator	Coordinate project and oversight at Fort Bragg including recruitment and testing of subjects
Caroline Cleveland BS	CKRC –Contractor	Research Assistant	Recruitment, consenting, and testing all subjects at Fort Bragg, REDCap data entry and verification
Albert “Skip” Rizzo	Institute for Creative Technologies, University of Southern California; CKRC –Contractor	Consultant	Development of videos for Patrol-Exertion task using Virtual Iraq-Virtual Afghanistan software
Daniel Nilsson	CKRC –Contractor	Engineer	Engineering Consultant, development of reaction time apparatus for Patrol-exertion task, assist with inertial sensor analysis ISAW-grid task
Rachel Ahn	CKRC–Contractor	Graduate student	Data entry and verification
Dane Bonath	CKRC –Contractor	Graduate student	Data entry and verification
John Hughes	University of MN, Biostatistics CKRC –Contractor	Consultant	Consult and assist with data analysis
Robert Kreiger	University of MN CKRC –Contractor	Consultant	Consult and assist with data analysis, exploratory analyses
Emily Shoemaker	CKRC	Technical writer	Assist with final report
Anthony Abeln	CKRC	Occupational Therapist	Pilot testing
Matt White	CKRC	Occupational Therapist	Pilot testing
Kristina Kath	CKRC	Administrative Assistant	Administrative assistance

Donald (Donnie) Musgrove	University of MN, Department of Biostatistics CKRC –Contractor	Graduate student	Assist with correlational analysis of data
Leslie Davidson	Riverbend Therapeutics, LLC	Co-investigator	Development of training videos and materials, AMMP task development.
Karen McCulloch	Division of Physical Therapy University of North Carolina (UNC)-Chapel Hill	Co-investigator	Subaward oversight for UNC-Chapel Hill, assist with oversight of Fort Bragg staff and data collection. AMMP task development.
Rich Goldberg,	Department of Biomedical Engineering, UNC-Chapel Hill	Biomedical Engineer	Oversight of BME graduate student in analysis of inertial sensor data for Illinois Agility and Run Roll Aim tasks
Oleg Favorov	Department of Biomedical Engineering, UNC-Chapel Hill	Biomedical Engineer	Analysis of inertial sensor data for Illinois Agility and Run Roll Aim tasks, oversight of BME graduate student
Deborah Kenner	Division of Physical Therapy UNC-Chapel Hill	Graduate student	Administrative assistance
Roger Yu	Department of Biomedical Engineering, UNC-Chapel Hill	Graduate student-biomedical engineering	Data collection, and analysis of inertial sensor data for Illinois Agility and Run Roll Aim tasks
Mary Beth Osborne	Division of Physical Therapy UNC-Chapel Hill	Assistant	Administrative assistance/ cover release time

Project Participants and Collaborating Organizations—*NOT PAID*, in kind contributions, and DoD collaborators			
Name	Institution	Project Role:	Principal Contributions
MAJ Matthew Scherer, PT, PhD	Andrew Rader US Army Health Clinic, JB Fort Myer- Henderson Hall, VA (previously USARIEM, Natick, MA)	Co-investigator	AMMP task development, IRB approval/supervision for USARIEM,
CPT Laurel Smith MA, OTR/L	United States Army Research Institute of Environmental Medicine, Natick MA	Co-investigator	AMMP task development, IRB approval/supervision for USARIEM,
Kristin Heaton PhD	United States Army Research Institute of Environmental Medicine, Natick MA	Neuropsychology consultant	Supervision of neurocognitive training and testing, data interpretation

CAPT Henry McMillan PT, DPT	Department of Brain Injury Medicine, Womack Army Medical Center, Fort Bragg, NC	Fort Bragg Principal Investigator	Oversight all components and Fort Bragg staff and Womack IRB
Muhammet Balcilar	Department of Biomedical Engineering, UNC-Chapel Hill	Graduate student	Analysis of inertial sensor data for Illinois Agility and Run Roll Aim tasks
Lars Oddsson PhD	Courage Kenny Research Center (CKRI)/ Allina Health	Consultant	Advisor on inertial sensor and biomechanical analysis
Various audiometry staff	US Army Aeromedical Research Laboratory, Fort Rucker, AL	Consultants	Consult and assist with development of radio chatter audio files.

APPENDIX 2
AMMP MANUAL – Overview
(See AMMP Manual in a separate file.)

The *Assessment of Military Multitasking Performance* (AMMP) is a recently-developed performance-based test battery that has been subjected to preliminary validation to evaluate inter-rater reliability and known-groups discrimination. The AMMP was developed by an interdisciplinary team of civilian and military rehabilitation researchers to help inform duty-readiness decision-making for Service Members (SM) who have sustained a concussion/mild traumatic brain injury.

Introduction to the AMMP Tasks

The six tasks that compose the AMMP were developed using either a dual-task or multitasking paradigm. All tasks employ observational metrics and some tasks also utilize inertial sensor data to characterize SM performance.

<u>AMMP Multitasks</u>
Charge of Quarter Duty
The SM is challenged to develop and execute a work plan for completing an array of interleaving tasks (supply inventory, PVC foot stool assembly, providing information to superiors, prospective memory tasks) associated with his/her hypothetical assignment to Charge of Quarters Duty.

Run-Roll-Aim
The SM completes a high level mobility task with multiple maneuvers while carrying a simulated weapon. Maneuvers are cued by a computer screen with a handheld remote controlled slide advancer. The task requires a rapid start, avoiding a "trip wire" obstacle, performing a 3-5 second rush, combat rolling, searching for visual targets through simulated weapon scope, rapid lateral dodging and back pedaling.

Patrol-Exertion
The SM is challenged to gather intelligence in a recorded video depicting a virtual Afghanistan patrol environment while reporting observed IED markers based on a briefing provided at the beginning of the video. The SM then uses the information to answer specific questions from memory at the end of the patrol video. The SM will perform continuous step-ups on an exercise step at an intensity of 65-85% of HR maximum throughout the activity while being monitored for effort level via a Polar HR monitor and performance observation. The SM will be wearing a combat helmet, eye protection, and be carrying a simulated M16 weapon equipped with a trigger switch connected via Bluetooth to a computer configured to record reaction time (RT). The SM is required to press the switch each time a beep tone stimulus is heard throughout the video as a measure of RT during a divided attention multitask.

<u>AMMP Dual-tasks</u>
Illinois Agility Test – Packing List
The Illinois Agility Test requires running distances of 30' with rapid direction changes and navigation of obstacles in a serpentine pattern during the middle part of the obstacle course. A memory task is also completed. Then both the agility task and the memory task are performed at the same time. Accuracy of memory recall and time to complete the agility task are measured in single and dual-task conditions.

Instrumented Stand and Walk – Grid Coordinates
The SM is challenged to perform the Instrumented Stand and Walk (ISAW) test (developed by APDM) which includes instrumented and timed assessment of quiet standing for 30 seconds, assessment of

dynamic stability during walking for two 7 m (23 foot) lengths with a 180 degree turn at midpoint. The SM will next memorize an 8 digit alphanumeric grid coordinate provided within the context of a simulated patrol mission brief and report the exact sequence back to the examiner after 45 seconds. Finally, both the ISAW and the grid memorization tasks will be performed simultaneously. Accuracy of grid coordinate recall, postural sway area, gait path variability, and time to complete the ISAW (i.e. gait speed) will be measured in single and dual-task conditions.

Load Magazine – Radio Chatter
SM completes a relatively automatic manual task choosing from a bin of mixed size dummy rounds (5.56 and 7.62 caliber) and loading 5.56 caliber training rounds into magazines as fast as possible both in a single and a dual-task condition. The dual-task condition requires monitoring radio communication and verbally announcing when radio chatter is relevant to scenario instructions.

Structure of the AMMP Manual
In this Manual, there is a chapter for each of the aforementioned AMMP tasks. The following sections compose each test-task specific chapter:

- Task Description and Set Up
- Examiner Instructions and Script
- Score Sheet
- Scoring Guide
- Materials

Guidance for Use of the AMMP Manual
Administration of the AMMP requires that examiners understand the theoretical foundation of the tasks and are competent in conducting and scoring the tasks.

- To understand the theoretical foundations of the AMMP, examiners should be familiar with papers that have been published on this test (e.g., Radomski et al., 2013; Scherer et al., 2013; Smith et al., 2014).
- To assure competence, examiners should first read the AMMP Manual in its entirety. Next, examiners should watch the AMMP Training Modules. After doing so, at least three practice administrations of each test task are recommended before administering the test task on a subject or patient. This will enable the examiner to become comfortable simultaneously reading the administration script, managing any equipment, and observing performance.

References

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Scherer, M. R., Weightman, M. M., Radomski, M. V., Davidson, L. F., & McCulloch, K. L.(2013). Returning service members to duty following mild traumatic brain injury: exploring the use of dual-task and multitask assessment methods. *Physical Therapy, 93*(9), 1254-1267.

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APPENDIX 3
AMMP TRAINING MODULES - Overview
(See AMMP Training Modules in a separate file.)

Description and Purpose of the AMMP Training Modules

The AMMP Training Modules are designed to enable prospective AMMP examiners to understand and visualize the administration of the 6 AMMP tasks. Careful study of the AMMP Manual and independent practice are the primary means by which researchers and clinicians learn to administer the AMMP; the AMMP Training Modules are intended to complement, not replace, the AMMP Manual and independent practice.

AMMP Training Modules Learning Objectives

After using the AMMP Training Modules and carefully studying the AMMP Manual, prospective AMMP examiners will be:

- Able to correctly administer and score all 6 AMMP test-tasks as detailed in the AMMP Manual;
- Familiar with common challenges associated with test-task set up, administration, and scoring;
- Aware of red flags to stop the testing session.

Structure of the AMMP Training Modules

There are 6 Training Modules (Powerpoint slide sets) that correspond to each of the AMMP Tasks. Each Module provides a brief description of the task, describes scoring metrics, and includes a brief video of test task performance.

Guidance for Use of the AMMP Training Modules

Administration of the AMMP requires that examiners understand the theoretical foundation of the tasks and are competent in conducting and scoring the tasks.

- To understand the theoretical foundations of the AMMP, examiners should be familiar with papers that have been published on this test (e.g., Radomski et al., 2013; Scherer et al., 2013; Smith et al., 2014).
- To assure competence, examiners should first read the AMMP Manual in its entirety. Next, examiners should watch the AMMP Training Modules. After doing so, at least three practice administrations of each test task are recommended before administering the test task on a subject or patient. This will enable the examiner to become comfortable simultaneously reading the administration script, managing any equipment, and observing performance.

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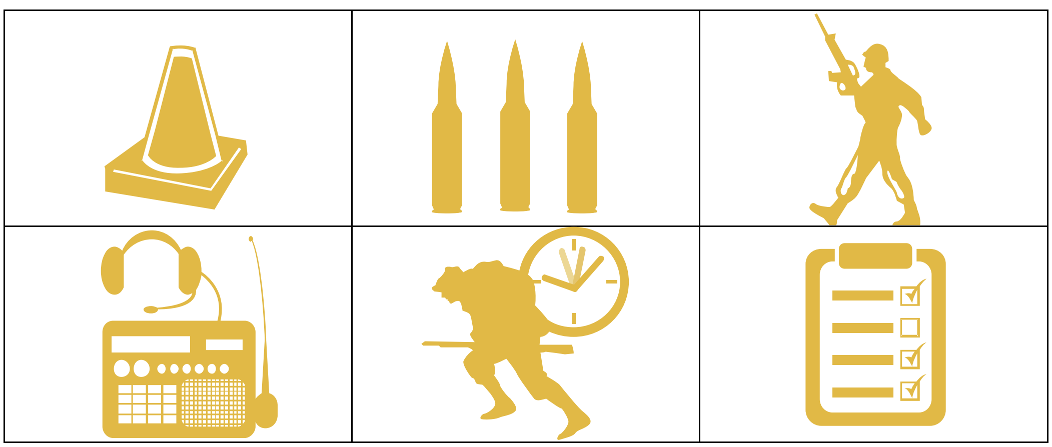
ASSESSMENT OF
MILITARY MULTITASKING
PERFORMANCE

ADMINISTRATION MANUAL

November 2015



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INTRODUCTION

Overview and Purpose of the *Assessment of Military Multitasking Performance (AMMP)*

The *Assessment of Military Multitasking Performance* (AMMP) is a recently-developed performance-based test battery that has been subjected to preliminary validation to evaluate inter-rater reliability and known-groups discrimination. The AMMP was developed by an interdisciplinary team of civilian and military rehabilitation researchers to help inform duty-readiness decision-making for Service Members (SM) who have sustained a concussion/mild traumatic brain injury.

Introduction to the AMMP Test Tasks

The six test tasks that compose the AMMP were developed using either a dual-task or multitasking paradigm. All test tasks employ observational metrics and some test tasks also utilize inertial sensor data to characterize SM performance. At present, there is no prescribed task administration order.

<u>AMMP Multitasks</u>

Charge of Quarter Duty

The SM is challenged to develop and execute a work plan for completing an array of interleaving tasks (supply inventory, PVC foot stool assembly, providing information to superiors, prospective memory tasks) associated with his/her hypothetical assignment to Charge of Quarters Duty.

Run-Roll-Aim

The SM completes a high level mobility task with multiple maneuvers while carrying a simulated weapon. Maneuvers are cued by a computer screen with a handheld remote controlled slide advancer. The task requires a rapid start, avoiding a "trip wire" obstacle, performing a 3-5 second rush, combat rolling, searching for visual targets through simulated weapon scope, rapid lateral dodging and back pedaling.

Patrol-Exertion

The SM is challenged to gather intelligence in a recorded video depicting a virtual Afghanistan patrol environment while reporting observed IED markers based on a briefing provided at the beginning of the video. The SM then uses the information to answer specific questions from memory at the end of the patrol video. The SM will perform continuous step-ups on an exercise step at an intensity of 65-85% of HR maximum throughout the activity while being monitored for effort level via a Polar HR monitor and performance observation. The SM will be wearing a combat helmet, eye protection, and be carrying a simulated M16 weapon equipped with a trigger switch connected via Bluetooth to a computer configured to record reaction time (RT). The SM is required to press the switch each time a beep tone stimulus is heard throughout the video as a measure of RT during a divided attention multitask.

AMMP Dual-tasks

Illinois Agility Test – Packing List

The Illinois Agility Test requires running distances of 30’ with rapid direction changes and navigation of obstacles in a serpentine pattern during the middle part of the obstacle course. A memory task is also completed. Then both the agility task and the memory task are performed at the same time. Accuracy of memory recall and time to complete the agility task are measured in single and dual-task conditions.

Instrumented Stand and Walk – Grid Coordinates

The SM is challenged to perform the Instrumented Stand and Walk (ISAW) test (developed by APDM) which includes instrumented and timed assessment of quiet standing for 30 seconds, assessment of dynamic stability during walking for two 7 m (23 foot) lengths with a 180 degree turn at midpoint. The SM will next memorize an 8 digit alphanumeric grid coordinate provided within the context of a simulated patrol mission brief and report the exact sequence back to the examiner after 45 seconds. Finally, both the ISAW and the grid memorization tasks will be performed simultaneously. Accuracy of grid coordinate recall, postural sway area, gait path variability, and time to complete the ISAW (i.e. gait speed) will be measured in single and dual-task conditions.

Load Magazine – Radio Chatter

SM completes a relatively automatic manual task choosing from a bin of mixed size dummy rounds (5.56 and 7.62 caliber) and loading 5.56 caliber training rounds into magazines as fast as possible both in a single and a dual task condition. The dual-task condition requires monitoring radio communication and verbally announcing when radio chatter is relevant to scenario instructions.

Structure of the AMMP Manual

In this Manual, there is a chapter for each of the aforementioned AMMP test tasks. The following sections compose each test-task specific chapter:

- Task Description and Set Up
- Examiner Instructions and Script
- Score Sheet
- Scoring Guide
- Materials

Guidance for Use of the AMMP Manual

Administration of the AMMP requires that examiners understand the theoretical foundation of the test tasks and are competent in conducting and scoring the test tasks.

- To understand the theoretical foundations of the AMMP, examiners should be familiar with papers that have been published on this test (e.g., Radomski et al., 2013; Scherer et al., 2013; Smith et al., 2014).
- To assure competence, examiners should first read the AMMP Manual in its entirety. Next, examiners should watch the AMMP Training Modules. After doing so, at least three practice administrations of each test task are recommended before administering the

test task on a subject or patient. This will enable the examiner to become comfortable simultaneously reading the administration script, managing any equipment, and observing performance.

References

Radomski MV, Weightman MM, Davidson LF, Finkelstein M, Goldman S, McCulloch K, Roy TC, Scherer M, Stern EB (2013). Development of a measure to inform return-to-duty decision making after mild traumatic brain injury. *Military Medicine*, *178*(3), 246-253

Scherer, M. R., Weightman, M. M., Radomski, M. V., Davidson, L. F., & McCulloch, K. L.(2013). Returning service members to duty following mild traumatic brain injury: exploring the use of dual-task and multitask assessment methods. *Physical Therapy*, *93*(9), 1254-1267.

Smith, LB, Radomski, MV, Davidson LF, Finkelstein, M, Weightman, MM, Scherer, MR, McCulloch, K (2014). Development and preliminary reliability of a multitasking assessment following concussion. *American Journal of Occupational Therapy, 68,* 439-443.

CHARGE OF QUARTERS DUTY

Charge of Quarters Duty
Task Description and Set Up

Description
The SM is challenged to develop and execute a work plan for completing an array of interleaving tasks associated with his/her hypothetical assignment to CQ duty.

Purpose
This multi-task provides an opportunity to observe and quantify planning and implementing a plan; specifically, how a SM with mTBI approaches an unstructured complex task when only task parameters and outcome are specified.

mTBI-related task challenges: Primary ● Secondary ○

Cognitive				Sensory			Physical			
Executive function	Memory	Attention	Reaction time	Eye gaze tracking	Scanning	Vestibular	Balance	Exertion	Bend-lift	Manual UE Speed
●	○				○				○	○

Source
Adapted from *Multiple Errands Test-Simplified Version* (Alderman et al., 2003)
Alderman, N., Burgess, P.W., Knight, C., & Henman, C. (2003). Ecological validity of a simplified version of the multiple errands test. Journal of the International Neuropsychological Society, 9, 31-44.

Materials and Supplies
<u>Set up and administration items:</u>

- Blue painters tape
- Tape-measure
- Clipboard
- Administration manual and scoresheet
- Stopwatch
- Pencils

<u>Test task items:</u>
Laminated signs to be posted in each work area (Assembly Area, Supply Closet, Bulletin Board, CQ Desk)
Wall clock
Assembly area –

- Table

Examiner sits or stands in a location to fully observe the table in order to observe rule adherence regarding number of PVC parts in the Assembly Area at any given point in time.

Supply closet

- Basket to carry items
- 5-drawer unit for footstool parts/tools with drawers labeled as follows –
    - Drawer/Bin 1 – 1” diameter PVC pipe (4, 12” in length; 6, 8” in length; 10, 4.5” in length)*
    - Drawer/Bin 2 – Elbow and T-Connectors (6, 1” diameter 90 degree elbow PVC connectors; 7, 1” diameter T- PVC connectors)
    - Drawer/Bin 3 – End Caps (4, 1” diameter external PVC endcaps)
    - Drawer/Bin 4 – 3-Way Connectors (8, 1” diameter 3-way elbow PVC connectors)
    - Drawer 5 – Other (sandpaper, masking tape, tape measure, labels, timer)
- Fully Stocked Inventory List sign posted over the 5-drawer unit
- Table on which to place 5-drawer unit is optional

The footstool inventory list is affixed to the side of the drawer unit so that it is not be visible while the subject is standing in any of the other work zones.

*PVC pipe, connectors may be purchased at local home improvement stores or ordered directly from Formufit, Inc. http://www.formufit.com/

Bulletin board

Signs posted on the wall: barrack lay-out, CQ duty roster, monthly calendar, diagram for foot stool assembly, 2 foils (information not relevant to the task) (see Figure 5 for layout). Blue tape must extend for the length of the posted materials and be ~ 4 feet from the wall (to prevent subjects from reading the contents from outside the designated area). **Select a space in which information posted in the Bulletin Board area cannot be read while the subject is standing in any of the other work zones.**

CQ desk

Table or desk
Chair
2 walkie talkies**
Basket for walkie talkies
Plastic hanging file box with 10 file folders labeled as follows:
Blank CQ Duty Reports
Completed CQ Duty Reports
Inventory Forms
Completed Inventory Forms
Incidence Reports
Blank CQ Duty schedules
Past CQ schedules (past 4 months)
Emergency contacts
2 blank folders
Laminated Contact List (placed such that it is visible/upright in the File box)
Laminated Communications Roster (positioned on desk top)
Laminated Walkie Talkie instructions (positioned on desk top)**

**Walkie talkies may be purchased at local home improvement stores. Laminated Walkie Talkie instructions include in the Manual pertain to the Cobra MicroTalk made by Cobra Electronics. Laminated instructions may need to be modified for other models.
https://www.cobra.com/products

Test Task Set Up
Space estimate: Approximately 6 feet by 11 feet area

The CQ Duty test task can be set up in whatever configuration aligns with the available clinical or testing space (Figure 1). Work area boundaries are established by the placement of blue painter's tape. The measurements in Figures 2 – 5 are estimates. Testers should use the Checklist below to make sure that tape placement assures that SM must step into the work area in order to complete relevant test tasks.

Figure 1. Example of how the CQ Duty test task might be set up in a clinical space.

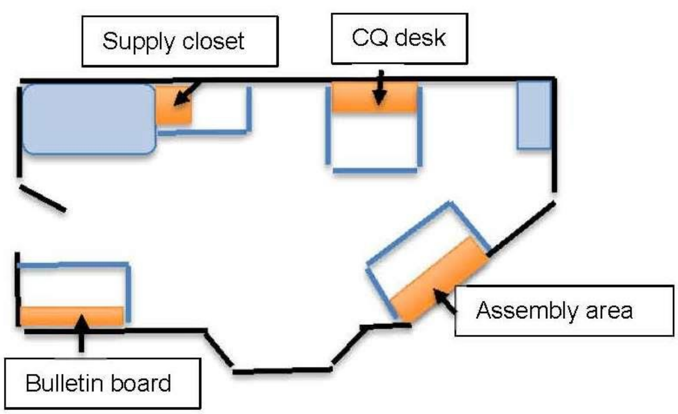


Figure 2. CQ Desk

Figure 3. Assembly area

Figure 4. Supply closet

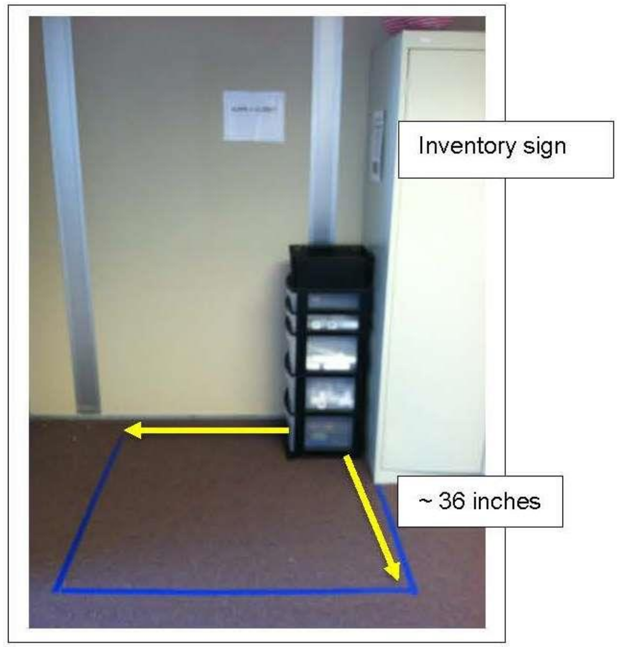
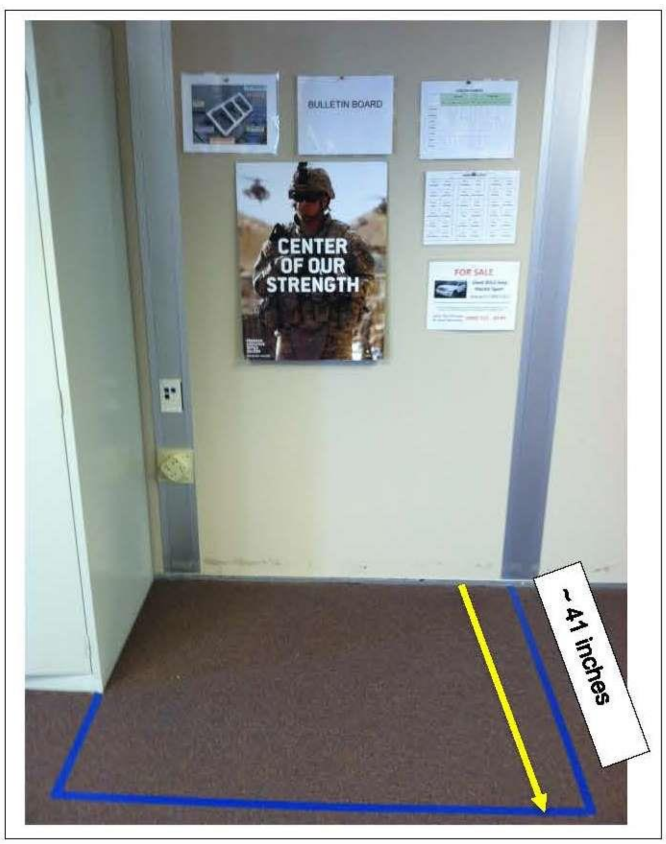


Figure 5. Bulletin board



Test Task Set Up Checklist:
____ Is the wall clock visible from all work areas?
____ Are the CQ duty schedule, barrack layout readable ONLY if standing inside the blue tape in the Bulletin Board work area? [If one or more can be read from outside the blue tape, move the tape further out.]
____ Is it impossible to view the footstool diagram (Bulletin Board) from the Assembly Area? [Select a location for the Bulletin Board in which SM cannot see the diagram from the Assembly Area.]
____ Is the Fully Stocked Inventory List readable ONLY if standing inside the blue tape in the Supply Closet work area? [If the sign can be from outside the blue taped area, move the tape further out.]
____ Is the Contact List and Communications Roster readable ONLY if standing inside the blue tape of the CQ Duty Desk work area? [If one or more can be read from outside the blue tape, move the tape further out.]

Charge of Quarters Duty
Examiner Instructions and Script

Before instructing the participant, turn on participant's walkie talkie and set to radio frequency 6 and place in the basket at the CQ desk; turn on the examiner's walkie talkie and set to radio frequency 10. Make sure a clock can be seen from all areas. During the task, sit or stand in a location that allows you to fully and easily observe the table in the Assembly Area (AA) in order to observe rule adherence regarding # of PVC parts in the AA at any given point in time.

INTRODUCTION
Provide participant with CQ Duty Report affixed to clipboard and state the following:

During this exercise, you must complete some assignments while pulling CQ duty. This is your copy of the CQ Duty Report. It describes task instructions, rules, and includes places for you to write notes. You can use it throughout the exercise along with whatever devices and techniques that you think will help you perform at your best. I will orient you to your assignments, the test spaces and the rules and you can ask questions.

INSTRUCTIONS
A. Description of assignments
Follow along as I describe your assignments.

- **Radio SPC Smith at the Guard Shack to report that you are taking over CQ duty.**
- **Assemble a PVC footstool for CPT James.**
- **After exactly 5 minutes, stop what you are doing and radio the First Sergeant to report the number of vacant barracks. Also ask if there are any additional tasks to be completed while on duty. If so, these must be added to your assignment list.**
- **On your CQ Duty Report, write down the following 4 items:**
  - **a) number of 3-way PVC connectors remaining in stock after the footstool is assembled;**
  - **b) Formufit's address (manufacturer of the footstool materials);**
  - **c) the telephone number of the Service Member who is scheduled for CQ duty next Wednesday;**
  - **d) the room # that PVT Sullivan is in.**
- **Write legibly. You will not receive full points if I cannot read your handwriting.**
- **Return all supplies and materials to their original locations and place the footstool on the CQ desk** (touch the desk surface) **at the end of the exercise.**
- **File your completed CQ Duty Report in the folder entitled, Completed CQ Duty Reports.**

- **After completing all of your tasks, radio SPC Smith at the Guard Shack and report that you've completed your assignments.**

Next, I am going to point out your Work Areas for this task. But first, do you have any general questions about your assignment so far? If yes, clarify. If no, begin orientation to testing space.

B. Orient participant to the testing space.

I will now orient you to the testing space. Everything you need to complete this exercise is located in the 4 work areas marked with blue tape.

B1.Walk to the areas with the participant to point out location of materials and area perimeter. Start by walking to the CQ Desk.

- **We are currently at the CQ Desk.**
- **Use this walkie talkie during the exercise. Push this button** (point) **to speak into the walkie talkie; push this button** (point) **to change radio frequency channels. Use these instructions if you need more help** (point).
- **Use this Communication Roster** (point) **to locate the correct radio frequency channels for various personnel that you need to contact during the task.**
- **Obtain and file required forms here** (point to file box). **Also note the pad of paper and pencil and a Contact List for those assigned to CQ duty** (point to list that sticks out of last folder).

B2. Walk over to Bulletin Board.

- **Here is the Bulletin Board. Here you will find information that you need to report to command including a map of the barracks, a CQ duty schedule, a clock, and a diagram regarding how to assemble the footstool. Note that this diagram is the only information you have about how to construct the footstool.**

B3. Walk to the Supply Closet.

- **This area is the Supply Closet. All the materials you will need for building the footrest are located in this area. Each drawer is labeled but keep in mind that there are some parts in the drawers that you do not need for the project. You may use any of the items in the last drawer** (point to drawer labeled Other). **Here is an inventory list that specifies how many parts we need to keep on hand and the address of Formufit to use for re-ordering supplies** (point to list). **Additionally, there is a basket you may use to carry items from one area to another.**

B4. Walk to the Assembly Area.

- **We are now in the Assembly Area. Assemble the footrest only in this area.**

Do you have any questions about the work spaces? (If yes, clarify. If no, continue.)

C. Review the task rules.

I will now explain the task rules. During this exercise, you must follow these rules (point out rules on CQ Duty Report).

- **You must carry out all of these tasks but may do so in any order.**
- **Assemble the footrest only in the Assembly Area.**
- **Bring only the number of PVC parts needed for the footrest from the supply closet to the assembly area.**
- **Do not move or remove any of the wall signs during the course of this exercise.**
- **In order to score the most points, your trips between work areas should be kept to a minimum. You should return to an area only if it is absolutely necessary to complete the task or follow the instructions correctly. You will get the most points if you can complete this exercise in 7 trips.**
- **Do this exercise as quickly as possible without rushing.**
- **You may not ask questions for further guidance about this exercise once the test starts.**

Do you understand these rules? If no, clarify. If yes, continue.

EXAMINER GUIDANCE:
If the SM asks whether he/she can use his alarm, phone, watch during the test, state: **"Use any strategy or device that you think will help you do your best."**
If the SM asks any questions about the test task and/or procedures BEFORE the test begins, answer the questions directly.

D. Verify that participant understands the instructions. Move outside of the designated work areas into a neutral zone. Using the CQ Duty Report, the Participant restates the task instructions and rules.

Now brief me on what you are being asked to do. Fill in any gaps that the participant may not have included.

After doing so and answering all questions about the task, place the subject on the start X outside of all taped areas. State: **Remember, you must complete all of the assigned tasks but may do so in any order. Start** and begin the timer.

[Participant begins the exercise.]

EXAMINER GUIDANCE: IF THE SUBJECT IS USING THE WRONG RF
If the SM tries to perform step 1 (radioing Guard Shack) but is not on the correct frequency, state: **I can't hear you on the radio.**
If the SM still does not figure out to change the rf, state: **you are on the wrong rf.**
See side 2 of score sheet for scoring instructions.

EXAMINER GUIDANCE: HOW TO RESPOND TO QUESTIONS ASKED DURING TESTING AND SCORE RULE BREAKS RE QUESTIONS

- Scoring: Every question asked = 1 rule break.
- If a subject asks a question during the test, state: **"Do what you think is best."**
- If the subject has not figured out a solution to his/her own question **within 1 minute**, point to the relevant information on his or her CQ Duty report and provide information to get him or her back on track. [Scoring: The item for which the subject needs this examiner assistance is scored a 0.]

E. Re-set examiner walkie talkie during task.

At the beginning of the test, the examiner's walkie talkie is set at frequency 10 (corresponding to Gate Guards/Guard Shack).

EXAMINER GUIDANCE: WALKIE TALKIE RESPONSE TO REPORT TO GUARD SHACK

Participant: "SPC Smith (or Guard Shack) this is XXX, Over"
Guard Shack: **"Xxx this is SPC Smith, go ahead over"**
Participant: "Beginning CQ duty"
Guard Shack: **"Good copy, over." Or "Roger that, Over."**
Participant: "Over"

After the subject radios to check in (**task 1** on score sheet), the examiner changes the radio to frequency 5 (corresponding to First Sergeant and **task 4** on score sheet).

[5 MINUTES INTO TASK]

F. Provide additional instructions when participant radios in after 5 minutes and asks about more tasks.

- **Get an Inventory Form from the files at the CQ desk.**
- **Inventory PVC supplies in SC using the form based on supply status once foot rest is assembled.**
- **Once this is done, file the order form in the "Completed Inventory Forms" folder at the CQ desk.**

EXAMINER GUIDANCE: WALKIE TALKIE DIALOGUE WITH FIRST SERGEANT

Participant: **"First Sergeant this is XXX, Over"**
First Sergeant: This is First Sergeant. Over.
Participant: Reporting vacant barracks as 9. Any additional assignments over?
First Sergeant:

1. **Get an Inventory Form from the files at the CQ desk.**
2. **After you complete the foot rest, inventory PVC supplies in SC using the Inventory Form.**
3. **File the form in "completed inventory forms" folder at CQ desk, how copy?"**

Participant: Repeats instructions, clarification made if error. If correct, "Good copy, Over"

After the subject completes **task 4,** the examiner resets the walkie talkie to frequency 10 (corresponding to task 18 on score sheet).

G. The task is discontinued when:

a) The Participant radio reports to the Guard Shack that he/she has finished the assignments OR;
b) The Participant states he/she does not want to continue OR;
c) Participant demonstrates behavioral contraindications as specified in IRB application OR;
d) The Participant is still performing the task at 30 minutes and does not appear to be within 2 minutes of completion.

Study ID:	Rater:	Date:	Order:

Did SM complete test task? _____Yes _____No (Examiner stopped) _____No (Subject requested to stop)

CQ Duty Score Sheet

Tasks 2= 100% accurate, no cues required 1= Completed but only partly correct OR *1 = Required cues (1, 3, 4, 6, 13 only*)*	**Task Score 0,1,2**	**Sub-totals**
1-Radio SPC Smith/Guard Shack and….[rf 10] STATE*: ***I can't hear you on the radio.***		
2 -Report that you are taking over CQ duty.		
3- Between 4 min 30 sec -5 min 30 sec, participant stops what he/she is doing* …. NOTE: IF THE SM DOES NOT STOP WHAT HE/SHE IS DOING BY 6 MINUTES & 30 SEC, STATE*: ***Stop and do what I instructed you to do 5 minutes into the task.***		
4- Radio 1SG* [rf 5] *CUE: I can't hear you on the radio.* NOTE: IF THE SM DOES NOT KNOW WHAT TO DO AT THE 5 MINUTE INTERVAL, STATE*: ***Check your CQ duty report to see what you are supposed to do now.***		
5- Report # of vacant barracks rooms. [9]		/10
6- Ask if there are any additional tasks to be completed while on duty*. NOTE: IF THE SM DOES NOT ASK THE QUESTION, STATE*: ***What else are you supposed to ask me?***		
7- Get an Inventory Form from the files at the CQ desk.		
8- Assemble PVC footrest		
9- Put the footrest on the CQ desk before completing the exercise.		/8
10- ***Inventory PVC supplies in SC using the form based on supply status once foot rest is assembled.***		
11- Files Inventory Form in "Completed Inventory Forms folder"		
12-Return all supplies and materials to their original locations before completing the exercise.		
13- Radio SPC Smith/Guard Shack …. [rf 10] *STATE*: I can't hear you on the radio.*		/10
14- Report task completion.		
15- Write down telephone # of SM scheduled next week at this time [Anderson @ 703-555-5564]		
16 Write down the # of 3-way PVC elbows in stock after assembling [6]		
17- Write down the mailing address of Formufit Inc. [15954 S. Mur Len Road #311 Olathe, KS 66602]		
18- Write down room # that PVT Sullivan is in [308]		
19- File completed CQ Report in "Completed CQ Duty Reports" folder		/10
Task performance total score	A._______/38	

Rules (see rule break definitions on back)	**Rule break (Y/N)**	**# of rule breaks**
Do not ask questions for further guidance about this exercise once the test starts.		
Assemble the footrest only in AA.		
Bring only the number of PVC parts needed for the footrest to the Assembly area [22 parts].		
Do not remove any of the signs from the walls of the work areas.		
Performance time: E.___min___sec	B.	C.

Scratch Pad for visits to WORK AREAs

SC, AA, BB, CQ Start (outside work areas) …
1.To ____
2.To ____
3.To ____
4.To _____
5.To_____
6.To ____
7.To ____
8.To_____
9.To _____
10.To _____
11.To _____
12.To ____
13.To _____
14.To_____
15.To _____
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28. To_____
29. To_____
30. To_____
31. To_____
32. To_____
33. To_____
34. To_____
35. To_____

D. Total # of visits to complete exercise: _____

Everything else must be scored in real time EXCEPT 10. 11. 15-19

Visit = any body part crosses into taped work area.

Rules	Rule break examples
Do not ask questions for further guidance about this exercise once the test starts.	1 rule break for **every question** asked. Making statements aloud ≠ rule break. [“Can you help me get this walkie talkie to work? What is the correct RF?” = 2 rule breaks]
Assemble the footrest only in AA.	Each time SM puts 2 parts together outside of AA = 1 rule break SM connects PVC elbow to 4.5” piece in SC = 1 rule break
Bring only the # of PVC parts that are needed for the footrest to the AA [only 22 PVC parts in AA at any point]	If SM has 24 PVC parts at AA = 2 rule breaks SM brings masking tape to AA = 0 rule break (not a PVC part)

Tasks	Scoring examples (1, 0)
1. Radio SPC Smith/Guard Shack and... [rf 10]	1 = radios Smith/Guard Shack after cue re rf 0= does not do this task at all **OR** requires further cueing re rf
2. Reports taking over CQ duty	1= reports something other than that he/she is taking over duty 0=does not do this task at all
3. Between 4 min 30 sec -5 min 30 sec, participant stops what he/she is doing ….	1= stops what he/she is doing between 5 min 30 seconds and 6 min 30 seconds 0= called before 4 min 30 sec **OR** didn’t radio in by 6 min 30 sec **OR** examiner instructs to stop what he/she is doing now
4.Radios 1SG [rf 5]	1 = radios 1 SG after cue re rf 1 = radios after being cued by examiner to check CQ Report 0 = even with cue, SM doesn’t know to radio 1SG and is instructed to do so
5. Report # of vacant barracks rooms. [9]	1= reports incorrect # of vacant barracks 0= doesn’t report this information at all
6. Ask if there are any additional tasks to be completed while on duty*.	1=asks if there are additional tasks to be completed after being cued 0= even with cue, SM does not ask the question and the examiner simply provides the 3 additional instructions (7,10, 11)
7. Obtain an inventory form from the files at CQ desk	1=obtains the wrong form from CQ desk 0= doesn’t get any form from CQ desk
8. Assemble PVC footrest	1= constructs footrest but made errors related to 1 – 2 parts 0 = does not do this task at all **OR** attempted with errors on 3 or more parts
9. Put the footrest on the CQ desk before completing the exercise.	1=puts the footrest on a table or desk other than the CQ desk 0 = puts footrest on the floor
10. *Inventory supplies remaining once the footrest is assembled*	1= takes inventory but some of the values are incorrect 1=takes inventory but answers are not legible 0= does not take inventory
11. *Files Inventory Form in “Completed Form” folder*	1=files the form but in the wrong folder **OR** form in hanging file but not in folder 0= does not file the form
12. Returns all supplies and materials to their original locations before completing the exercise.	1=returns some but not all supplies and materials to original locations 0= does not return any of the supplies and materials to their original locations before radioing that he/she is done with CQ duty
13. Radio SPC Smith/Guard Shack. [rf 10]	1 = radios Guard Shack after cue re rf 0= does not do this task at all **OR** requires further cueing re rf
14. …to report task completion.	1=reports something other than task completion **OR** calls in <u>before</u> completing task (ie filing CQ duty report as instructed) 0=does not do this task at all
15. Write down telephone # of SM scheduled next week at this time [Anderson @ 703-555-5564]	1= fills in name of Anderson but not phone # 1= fills in wrong phone number 1=fills out form but answers are not legible 0 = does not fill in this part of CQ duty report

16. Write down the # of 3-way PVC elbows in stock after assembling foot rest [6]	1=fills in the wrong # of 3-way PVC elbows
	1=identifies # but answers are not legible
	0= does not fill in this part of the CQ duty report

18. Write down the room # for PVT Sullivan [308]	1=fills in this part of CQ Report but with wrong room #
	1=identifies room # but not clearly legible
	0=does not fill in this part of CQ Report

19. File completed CQ Report in the “Completed CQ Duty Reports” folder	1=files the form but in the wrong folder **OR** form in hanging file but not in folder 0= does not file the form

Task performance is over immediately after the subject radios Guard Shack and reports task completion. Stop timer and record the performance time. **SM scores a “0” for any task completed <u>after</u> radioing Guard Shack to report task completion.**

estion asked. Making statements
you help me get this walkie talkie to
: RF?” = 2 rule breaks]

Charge of Quarters Duty
Scoring Guide

Examiner scoring supplies/materials:

- 1 stopwatch
- Clipboard
- Pencil
- Subject score sheets
- Radio / walkie talkie

Definitions of key underlying concepts:

Rules – Instructions that specify HOW a task test is to be completed which could be broken > 1 time during test-task performance. These rules may be adhered to or broken.

Task performance -The extent to which the subject independently and accurately completed each task element as instructed.
Performance time - The number of minutes and seconds between when the examiner says, "Start" and when the participant a) reports to SPC Smith/Guard Shack that he/she is finished with the task OR b) reports that he/she does not want to continue.
Visit – A visit occurs whenever any body part crosses into a taped Work Area. Visits are an observable metric for work efficiency.

Scoring procedures for performance subscores:

Before starting the task
Fill out the following:

- Subject's study ID
- Your Rater ID
- Today's date
- Where in the test order the subject is performing this test-task

At task start

Performance dimension	Scoring procedures	Performance subscore
Performance time	The examiner starts stopwatch when all task questions have been answered and immediately after he/she states, "Start". After starting the task, the examiner does not cue the subject or answer questions (see Rule 1).	(See "E" below)

During task

<table>
<tr><th>Performance dimension</th><th>Scoring procedures</th><th>Performance subscores**</th></tr>
<tr><td>A. Task performance</td><td>There are 19 tasks listed on the score sheet.

All task must be scored in real-time as the subject performs the task <u>except 10, 11, 15-19</u> (which may be scored after the subject has completed the task but before set up for the next participant).

The examiner assigns a 0, 1, or 2 for each of the 19 tasks based on observations of subject performance.

2 = 100% accurate, no cues required
1= Completed but only partly correct OR 1 = Required cues (1, 3, 4, 6, 13 only)
0 = Did not complete or perform
<u>Note:</u> Subjects are not cued during task performance except for tasks 1, 3, 4, 6, 13.

Refer to Side 2 of the score sheet for examples of performance warranting scores of 0 or 1 for each of the 19 tasks.</td><td>A = Task performance total score

Scores are summed for the 19 tasks and recorded on the score sheet.

A=________/38 possible points</td></tr>
<tr><td>B. Rule breaks</td><td>There are 4 rules:
Do not ask questions for further guidance about this exercise once the test starts.
Assemble the footrest only in the AA.
Bring only the number of PVC parts needed for the footrest to the AA [22 parts].
Do not remove any of the signs from the walls of the Work Areas.
If the subject breaks rule # 1, a Y is placed in the corresponding “Rule break” column of the score sheet. If he/she does not break the rule during any part of the task, an N is placed in that column.

Same for rule # 2, 3, and 4.

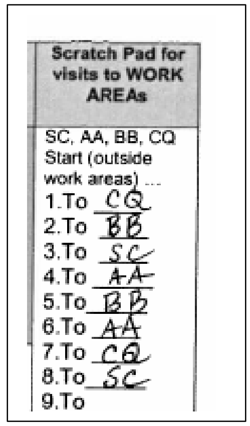
Refer to Side 2 of the score sheet for examples of commonly broken rules.</td><td>B = Total # of rules broken

Sum the # of Ys in the Rule break column

B=______/4 possible rules broken</td></tr>
<tr><td>C. # of rule breaks</td><td>Each time a rule is broken, the examiner puts a check-mark in the corresponding column labeled “# of rule breaks”.

For example: If the subject asks the examiner 4 questions during task performance, there would be 4 check- marks in “# of rule breaks” column for rule # 1.</td><td>C = Total frequency of rule breaks

For each rule broken, the examiner counts the # of check-marks and records the total in the corresponding “# of rule breaks” column. Next, the examiner sums these</td></tr>
</table>

		columns to determine C. (total frequency of rule breaks).
D. Task organization, planning, efficiency	The subject begins the task positioned in the Neutral Zone (outside of the designated work areas). The examiner sequentially writes down each Work Area the subject enters throughout the task (see below), beginning with the first Work Area the subject enters after the examiner instructs him or her to “start”. A visit occurs whenever any body part crosses into a taped Work Area. For 1. To_____ write the abbreviation of the first work area the subject enters after the examiner says, “start”. For 2. To_____ write the abbreviation for the work area that the subject visits next (and so on). Supply closet = SC Assembly area = AA Bulletin board = BB CQ desk = CQ  Scratch Pad for visits to WORK AREAs SC, AA, BB, CQ Start (outside work areas) ... 1.To CQ 2.To BB 3.To SC 4.To AA 5.To BB 6.To AA 7.To CQ 8.To SC 9.To	D = Total # of visits to work areas to complete the task

At task completion

Performance dimension	Scoring procedures	Performance subscore
E. Performance time	When the subject radios SPC Smith/Guard Shack OR he/she states that he/she does not want to continue, the examiner stops the stopwatch and records the length of time for task completion.	(E)Total task performance time – Time in minutes/seconds that it takes for the subject to complete the task after verifying/clarifying all instructions until he/she notifies examiner of task completion.

After subject has completed task

If you have not done so already, score tasks 10, 11, 15-19 and include those scores in (A) Task performance total score.

Also, see the Answer Sheet for the Inventory Form for correct answers.

CQ Scoring Frequently Asked Questions

Task Performance (A)

How should I score performance if the subject makes errors using the walkie talkie (such as setting it on the wrong radio frequency)?

If the SM tries to perform Task 1, 4, 13 (radioing Guard Shack) but is not on the correct frequency, state: **I can’t hear you on the radio. [Score 1]**

If the SM still does not figure out to change the rf, state: **you are on the wrong rf. [Score 0]**

Why am I required to provide cues for tasks 1, 3, 4, 6, and 13 but not the rest of them?

The performance of each of these tasks is essential to ~~the~~ completing subsequent steps in the CQ Duty. Therefore, cueing may be necessary to allow the subject to complete the entire activity.

What if I can't read the subject's handwriting on the CQ Duty Report or the Inventory Form?

During your instructions, the subject was told: **Write legibly. You will not receive full-points if I cannot read your handwriting.**

Each task requiring a written answer (15, 16, 17, 18) that is not legible is scored a 1.

Rules (B & C)

What if the subject asks me a question after the test begins? What should I say and how should the rule break be scored?

Every question asked = 1 rule break. If he/she asks a question, state, "do what you think best" and record "Y" under the Rule break (Y/N) column and a slash mark for every instance in which 1 question is asked.

If the subject has not figured out a solution to his/her own question within 1 minute, point to the relevant information on his or her CQ Duty report and provide information to get him or her back on track. [Scoring: The item for which the subject needs this examiner assistance is scored a 0.]

Rules (see rule break definitions on back)	Rule break (Y/N)	frequency of rule breaks
Do not ask questions for further guidance about this exercise once the test starts.	Y	//
Assemble the footrest only in AA.	N	0
Bring only the number of PVC parts needed for the footrest to the Assembly area [22 parts].	N	0
Do not remove any of the signs from the walls of the work areas.	N	0
Performance time: E.__min__sec	B. Total 1	C. Total 2

How will I know how many PVC parts the subject brings to the AA?

Position yourself so that you can count the # of parts on the table as the subject works. Or observe if there are parts on the table leftover after the footstool is assembled. For each part in excess of 22 in the AA, the subject receives 1 rule break.

Rules (see rule break definitions on back)	Rule break (Y/N)	frequency of rule breaks
Do not ask questions for further guidance about this exercise once the test starts.	N	0
Assemble the footrest only in AA.	N	0
Bring only the number of PVC parts needed for the footrest to the Assembly area [22 parts].	Y	III
Do not remove any of the signs from the walls of the work areas.	N	0
Performance time: E.___min___sec	B. Total 1	C. Total 3

Visits (D)

Scratch Pad for visits to WORK AREAs
SC, AA, BB, CQ
Start (outside work areas) ...
1.To BB
2.To CQ
3.To BB
4.To SC
5.To AA
6.To AA

What if the subject starts to leave a Work Area (with one foot inside the taped area and one foot outside) but remembers something else to do, turns around so that both feet are now in the Work Area?

This person never left the Work Area – no "visits" are recorded for setting 1 foot outside of the taped area.

What if the subject is able to reach into the drawers of the SC to get PVC parts without stepping across the tape into the SC Work Area?

A visit occurs any time a body part crosses the tape into a Work Area and so reaching into the SC constitutes a visit.

What if one of the PVC parts falls off the table and rolls outside the AA and the SM goes to retrieve it? Does this count as a "visit" when he walks back into the AA to continue assembling the footrest?

Yes. Every time a SM crosses the tape into a Work Area, a visit is recorded – regardless of the reason for doing so.

Performance Time (E)
What if the subject radios the Guard Shack to report task completion and then files the CQ Duty report at the CQ desk? At what point do I stop the stopwatch to record performance time?

Stop the stopwatch immediately after he/she reports that he/she completed the task and record as the performance time. Subject scores a "0" for item 9, *(Files Inventory Form in "Completed Inventory Forms" folder*) because it was not performed during the task.

ANSWER SHEET FOR EXAMINERS

[Parts inventory once the footrest has been assembled]

Inventory Form		
Item	**Current Stock**	**Needed**
3 way Elbow PVC Connectors	6	2
T- PVC Connectors	3	4
90 degree Elbow Connectors	4	2
External PVC End Caps	2	2
12” PVC pipe	4	0
8” PVC pipe	2	4
4 ½ ” PVC pipe	2	8
Sandpaper	1	0
Tape measure	1	0

CQD Forms

<table>
<tr><td colspan="2">CQ DUTY REPORT</td><td colspan="2">SUBJECT NUMBER:</td></tr>
<tr><td rowspan="2">ORGANIZATION OR INSTALLATION</td><td rowspan="2">LOCATION</td><td colspan="2">PERIOD COVERED</td></tr>
<tr><td>FROM</td><td>TO</td></tr>
<tr><td colspan="2">You should do the following:
• Radio SPC Smith at the Guard Shack and report that you are taking over CQ Duty
• Assemble a PVC footstool for CPT James.
• File the CQ Duty Report in folder marked “Completed CQ Duty Reports”.
• Return all supplies and materials to their original locations before completing the exercise.
• Place the footstool on the CQ desk at the end of the exercise.
• Radio SPC Smith at the Guard Shack when you’ve completed the exercise.
Exactly 5 minutes after you start the exercise:
• Radio the 1SG and report the number of vacant barracks.
• Ask about any additional tasks you’re to complete on your shift.</td><td colspan="2">RULES
• You should carry out all of these tasks but may do so in any order.
• Assemble the footrest only in the Assembly Area.
• Bring only the number of PVC parts needed for the footrest from the Supply Closet to the Assembly Area.
• Do not remove any signs or instructions from the walls in the work areas.
• Figure out how to complete the exercise in 7 transits or less. In order to score the most points, your trips between zones should be kept to a minimum.
• Take as little time to complete this exercise as possible without excessively rushing.
• Do not ask questions for further guidance about this exercise once the test starts.</td></tr>
<tr><td colspan="2">You should obtain the following information during the exercise:</td><td colspan="2">Write the information here.</td></tr>
<tr><td colspan="2">How many 3-way PVC connectors are left in stock after the footrest has been assembled?</td><td colspan="2"></td></tr>
<tr><td colspan="2">What is the mailing address for Formufit Inc. (manufacturer of footstool parts)?</td><td colspan="2"></td></tr>
<tr><td colspan="2">What is the telephone number of the Service member who is scheduled for CQ Duty next Wednesday?</td><td colspan="2"></td></tr>
<tr><td colspan="2">What room number is PVT Sullivan in?</td><td colspan="2"></td></tr>
</table>

Subject #

Inventory Form		
Item	**Current Stock**	**Needed**
3 way Elbow PVC Connectors		
T- PVC Connectors		
90 degree Elbow Connectors		
External PVC End Caps		
12” PVC pipe		
8” PVC pipe		
4 ½ ” PVC pipe		
Sandpaper		
Tape measure		

CQD Signs and Handouts

Communications Roster

Radio Holders	Radio Frequency
Military Police	7
Guard Shack	10
Staff Duty Officer	2
Troop Medical Clinic	4
Emergency Room	9
Commander	6
1SG	5
Chaplain	1
Orderly Room	8

FULLY STOCKED FOOTSTOOL
PARTS INVENTORY

Quantity	Parts
8	1” diameter 3-Way PVC Connectors
7	1” diameter T- PVC Connectors
6	1” diameter 90 Degree Elbow PVC Connectors
4	1” diameter External PVC End Caps
4	1” x 12” PVC pipe
6	1” x 8” PVC pipe
10	1” x 4 ½” PVC pipe
1	Sandpaper
1	Tape measure

Formufit Inc.
15954 S. Mur Len Rd # 311
Olathe, KS 66602

Contact List for CQ Duty

Name	Contact Number
SGT Michaels	212-756-4594
SPC Anderson	703/555-5564
SPC Jones	812/464-9804
SGT Zavala	812/484-9493
PFC Davis	410/776-2762
SGT Rains	812/278-9473
SPC Jacobs	561/957-4899

HOW TO USE THE WALKIE-TALKIE*

1. Push down the MODE button and hold it down to TURN ON.
2. Use the CHANNEL BUTTON to select the radio frequency.
3. Hold down the SIDE BUTTON and talk into the walkie talkie.

Relevant only for pictured version of Cobra MicroTalk.

CQ DUTY SCHEDULE

	THIS WEEK							NEXT WEEK						
	MON	TUES	WED	THUR	FRI	SAT	SUN	MON	TUES	WED	THUR	FRI	SAT	SUN
SGT Michaels					X			X						
SPC Anderson			X							X				
SPC Jones						X						X		
SGT Zavala				X					X					
PFC Davis		X									X			
SGT Rains	X													X
SPC Jacobs							X						X	

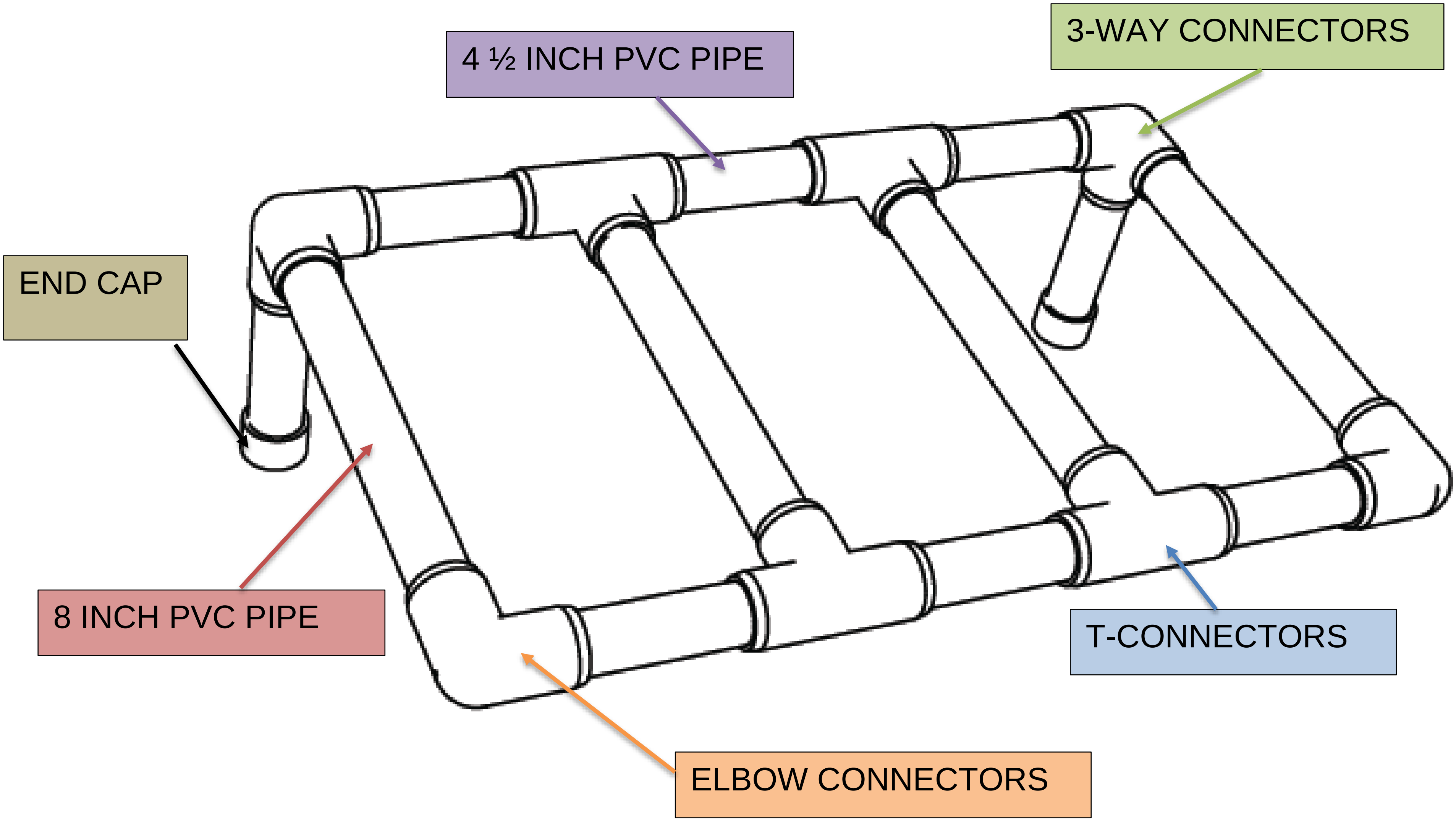
BARRACKS LAYOUT

RM 101 **PVT SMITH**	RM 102 **PFC Wright**
RM 103 **SPC Moore**	RM 104 **SPC Munroe**
RM 105 **Vacant**	RM 106 **PVT Daniels**
RM 107 **PVT Hernandez**	RM 108 **SPC Belanger**
RM 109 **PVT Thomas**	RM 110 **Vacant**
RM 111 **SPC Saunders**	RM 112 **PFC Jones**

RM 201 **SPC Mitchell**	RM 202 **Vacant**
RM 203 **PFC Jefferies**	RM 204 **SPC Alexander**
RM 205 **PFC DeLeon**	RM 206 **Vacant**
RM 207 **Vacant**	RM 208 **PFC Jefferies**
RM 209 **SPC Carlisle**	RM 210 **SPC Donohue**
RM 211 **PFC Jacobs**	RM 212 **PVT James**

RM 301 **PVT Manning**	RM 302 **Vacant**
RM 303 **SPC Bridge**	RM 304 **Vacant**
RM 305 **PFC Lowery**	RM 306 **PVT Peterson**
RM 307 **PFC Cooper**	RM 308 **PVT Sullivan**
RM 309 **Vacant**	RM 310 **SPC Mahoney**
RM 311 **Vacant**	RM 312 **PFC Zavela**

PVC FOOTREST PARTS AND ASSEMBLY



ASSEMBLY AREA

SUPPLY CLOSET

BULLETIN BOARD

CQ DESK

RUN-ROLL-AIM (RRA)

Run-Roll-Aim (RRA)
Task Description and Set Up

I. Description: The SM completes a high level mobility task with multiple maneuvers while carrying a simulated weapon. Maneuvers are cued by a computer screen with a handheld remote controlled slide advancer. The task requires a rapid start, avoiding a "trip wire" obstacle, performing a 3-5 second rush, combat rolling, searching for visual targets through simulated weapon scope, rapid lateral dodging and back pedaling.

II. Purpose: This task requires the SM to demonstrate high level balance and mobility skills not unlike those required in a battlefield situation, alternating between quick position changes and focused visual search through a weapon scope. Rapid head and body position changes stimulate the vestibular system, so SMs with vestibular impairment may have particular difficulty with this task.

III. mTBI-related task challenges: Primary ● Secondary ○

Cognitive				Sensorimotor				Physical		
Executive function	Memory	Attention	Reaction time	Eye gaze tracking	Scanning	Vestibular	Balance	Bend - lift	Exertion	Manual UE Speed
		○	○	●		●	●		○	

IV. Source: This task was created by AMMP team members as a way to challenge high level mobility skills in a situation simulating combat.

V. Materials and Supplies

- Clipboard and Score sheet
- Stopwatch
- Simulated weapon
- Scope designed for bird/insect viewing mounted to weapon
- Adjustable headband and waistband to mount inertial sensors (strapped onto each)
- 2 NexGen inertial sensors* and wireless access point for data collection with computer laptop
- Power point presentation of targets and cues
- Remote to advance Powerpoint visual cues/targets during task
- 5'x10' floor mat for landing in after 3-5 second rush, visual scanning component, and combat rolls (mat should be secured as necessary to the floor so that it doesn't move easily)
- 2, 12" cones to set up "trip wire" obstacle (obstacle created by taut cord stretched between the two cones)
- Taped stripe down the middle of the floor mat to indicate landing zone after 3-5 second rush and taped X on right and left (3½ feet from either side of the center) to mark approximate end point for combat rolls

*****I2M Sensors can be found at this website http://www.nexgenergo.com/ergonomics/I2M-IMUs.html

Inertial sensors are placed (1) on an adjustable headband slightly to the opposite side of the forehead from the subject's eye used for sighting through the weapon scope and (2) on an adjustable waist band fitted tightly around the subject with the sensor in the mid lumbar area.

VI. Test Task Set Up

Space estimate: Wide hallway or treatment room with space that will accommodate a course including minimum 10' width and 45' length (allow a ~30' run to floor mat with stimulus laptop positioned ~12' away from front edge of mat, with short distance for deceleration at start/finish). Width of area for trip wire placement and combat rolls on mat is 10' at a minimum. See Figures 1-3 for further specification.

Note: Positioning of the computer and mat must be checked to assure that it is possible to clearly view the numbers on the computer screen through the scope that has a limited focal range, but not be viewable with the naked eye. It may be necessary to modify the size of the visual stimuli on the computer screen if there is insufficient space to allow the computer to be placed 12' away from the floor mat.

Figure 1. Layout of Run-Roll-Aim task

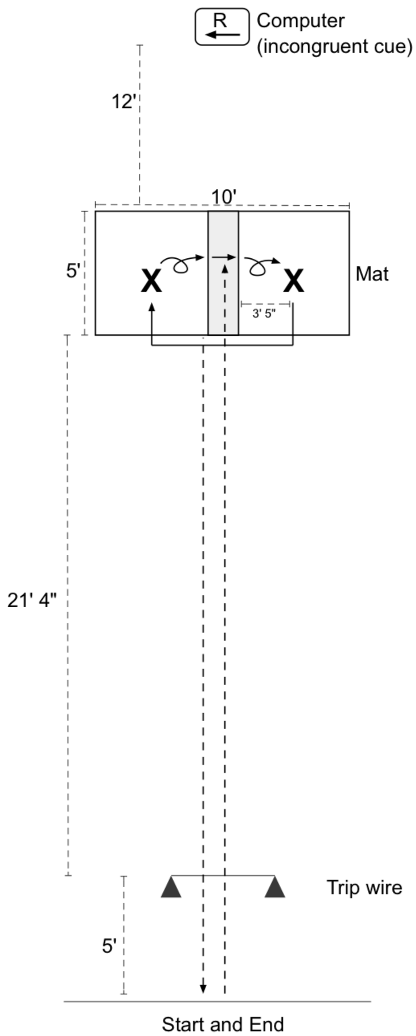


Figure 2. Initiation of Run-Roll-Aim task – a taut cord is stretched between two medium sized cones (12”) in height, taped to each cone to serve as a “trip wire”.

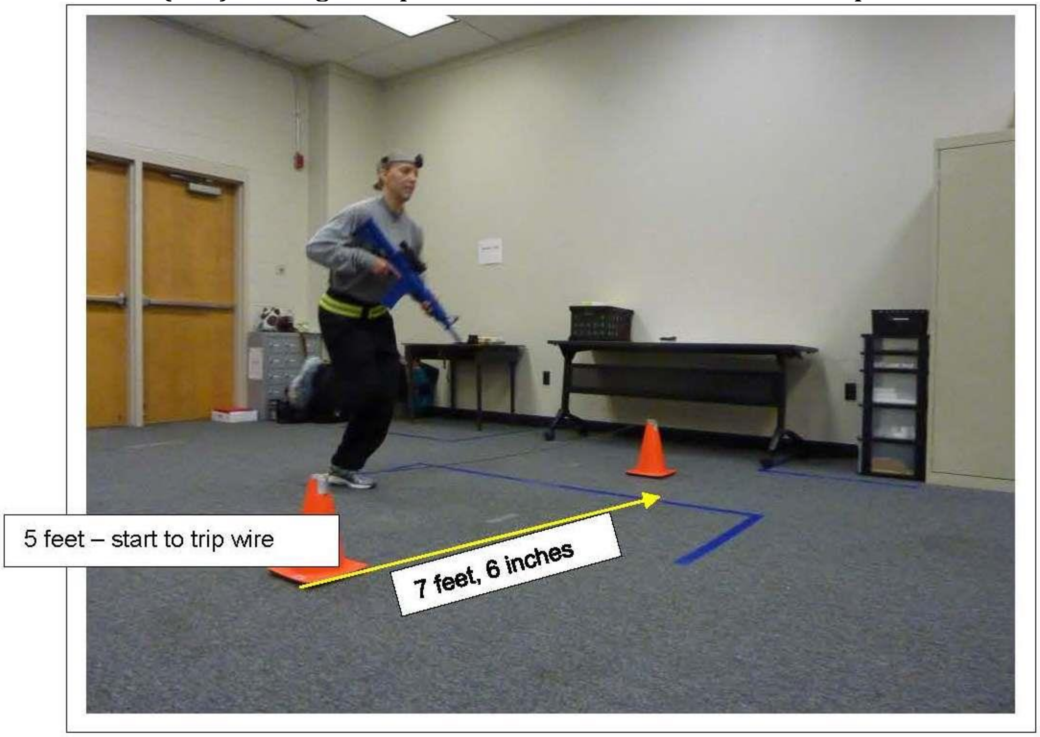


Figure 3. Service member during visual search after combat roll to the right. Note she is positioned on the right X after the combat roll. Tape stripe down the middle of the mat indicates target for initial prone landing after 3-5 second rush.


3 feet 5 inches from center of mat to either X marking end of combat roll
10 feet mat width

Run-
Roll-

Run-Roll-Aim (RRA)
Examiner Instructions and Script

This task is cued by a series of PowerPoint slides advanced by a slide advancing remote. The slide deck includes slides you can use to illustrate the task as you are providing instructions during the walk-through, followed by two practice trials. Use one practice trial with everyone, use the second practice trial only if the subject has difficulty in smoothly completing the task on the first practice trial (e.g. requires cues, gets confused about the sequence, and makes errors in the task). Before administering the test, practice using the slide set and advancing each slide at the appropriate time during the task. The slide for direction of the roll should be advanced as the subject is moving into the prone position on the mat. Other cueing slides can be advanced as the subject is doing the prior component of the movement sequence.

INTRODUCTION

This test is called Run Roll Aim. It looks at your agility, speed, and ability to find visual targets during simulated military maneuvers. It is important to be quick but also to be accurate in identifying visual targets.

INSTRUCTIONS

A1. Walk-Through the Task

- **Each part of the task will be cued by slides on the computer at the end of the course, to keep you moving through the task.** Point to computer.
- **Notice how the course is laid out in a T. You will begin at this end line facing the center of the T.** Point to the mat positioned in front of computer.
- **At the start of each trial, you will see this "READY?" slide. Once you confirm that you are ready, then I will say "Set, Go". At the same time, the screen will also indicate "GO".**
- **Let's walk through the parts of the task so you get familiar with them.**
- **Move quickly stepping over this trip wire and perform a 3-5 second rush, landing prone with your chest on the center of the mat on the floor** (as indicated by the tape). Have the subject get into the prone on the mat.
- **Each time you do the task, you will see a letter indicating which direction you should ROLL. If you see an "L", you should roll to your left. If you see an "R", you should roll to your right.**
- **Let's say you see an "R" on the screen. Do a combat roll to your right. You should end with your chest on the "X" marked on the mat** (as indicated by tape).
- **After you roll, 10 numbers will appear on the screen. There are 5 odd and 5 even numbers on each screen. Before each trial I will tell you whether you will be looking for ODD or EVEN numbers.**
- **Look through the scope now to focus it so that you can see the numbers clearly.** Have participant read 5 even or odd target numbers to ensure scope is properly focused.
- **During each trial, you will say the target numbers out loud so that I can hear you. Keep track of the numbers so you say each number ONLY ONCE and you know when you get all 5 numbers.**
- **Once you say all 5 numbers, stand and SIDE SHUFFLE to the other side of the mat and land in prone again on the X marked on the opposite side of the mat. It is**

important that you position yourself on the X so that the scope will be focused correctly.

- **You will see a new screen of numbers. If you looked for ODD numbers on the first side, you will look for ODD numbers on the other side. Call out all 5 target numbers again.** Have the participant call out target numbers again.
- **Once you say all 5 numbers, ROLL back to the center.**
- **Stand and BACKPEDAL to the starting point as quickly as you can, but avoid the trip wire on the way back.**
- **Do you have any questions?**

A2. Practice Trial

Now let's do a practice trial so you can put all the parts of the task together.

Have the subject perform a practice trial.

Respond to questions, and provide cues as needed.

- **As you get familiar with the sequence, you do not have to wait for the next screen to cue you. If you get mixed up during the task or forget something, I may give you a cue so you do not get stuck. In general just do the best you can, going as quickly and accurately as possible.**

CUEING

Cueing during the practice trial(s) and before the first trial:

- **This time you're looking for ____** (even or odd) **numbers.**
- **Remember that the letter on the screen tells you which direction to roll.** Provide this cue for both practice trials and the first test trial OR in response to an incongruent trial (i.e. the subject rolled in the wrong direction).
- **Ready, Set, Go.**

If during the practice trial the subject does the entire movement sequence WITHOUT HESITATION or ERROR, move on to testing. If the subject is confused or requires cues, conduct a second practice trial. Record performance of these trials on the score sheet. If the subject does not appear to be clear on what is an odd or even number, complete both practice trials.

Cueing for second through fourth trials (if previous trial was without errors in roll directions):

- **This time you're looking for ____** (even or odd) **numbers.**
- **Ready, Set, Go.**

Cues during task when subjects have difficulty:

In general, provide cues if the subject needs some input to continue and complete the task successfully. If the subject identifies 4 numbers and then hesitates, so that you can provide a cue for "**one more**", do so to prompt the subject to search for the fifth number. However, if the subject identifies 4 numbers and begins to side shuffle or roll, allow the error to occur without a cue. (I.e. Do not cue the subject in the middle of the side shuffle or roll so that they must return to target position.)

If the subject does the first visual search and identifies ALL incorrect numbers (i.e. identifies all ODD numbers when the target was EVEN numbers), provide a cue before the next visual search by saying "**Your target is ____** (even or odd) **numbers**".

If the subject asks if their target is even or odd after the trial has begun, provide guidance, but mark as requiring a cue.

During visual search, if number identification includes a delay greater than a few seconds (this sometimes happens after 3 or 4 targets have been identified), cue the number of additional numbers that are missing. If a cue for "**one more**" results in the subject identifying an incorrect number or one that has already been identified, provide an additional cue by saying "**OK**" and progress to the next segment of the task. Do not insist on the number identified being correct.

Note all errors in the error column. Errors include skipped numbers, incorrect (even or odd) numbers that are identified, and numbers that are not included on the slide at all. The latter error of commission sometimes occurs when the subject has a visual acuity problem.

10-29-12
Rev 7-24-2013
Rev 9-9-2013
Rev 10-12-2013
Rev 12-2-2013
Rev 1-13-2014
Rev 2-14-14
Rev 4-1-14
Rev 6-2015

Study ID:	Rater:	Date/Time:	Order:

RUN-ROLL-AIM TEST
Score Sheet

Did the subject complete the task? ☐ Yes ☐ No **If No:** ☐Examiner stopped ☐Subject stopped
Reason: ____
Test session start time: ___________ **Dominant eye** ___Left ____Right

Practice trial – R congruent/even	**Time (min:sec:100th sec):**		
	Correct responses	Errors*	Cues*
a. Avoids obstacle (trip wire)	fwd: ☐ bkwd:☐	fwd: ☐ bkwd:☐	
b.Stroop [mark responses]	**rolls R**☐	hesitate☐self-correct ☐ rolls L ☐	
c. Visual target ID A	**14 20 38 46 52** ☐ ☐ ☐ ☐ ☐	19 27 31 45 53 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
d. Visual target ID B	**10 68 76 82 94** ☐ ☐ ☐ ☐ ☐	17 63 71 89 95 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
e. Follows other instructions: side shuffle, backpedal	All correct: ☐	☐ ☐ ☐ (e.g. rolls when shouldn't)	☐ ☐ ☐
f. Total trial scores	f.1.Total boxes marked above___/14	f.2.Total boxes marked above:____	f.3.Total boxes marked above: ____

If requires more than one cue during practice trial 1, include second practice.

Practice trial – L congruent/odd	**Time (min:sec:100th sec):**		
	Correct responses	Errors*	Cues*
a. Avoids obstacle (trip wire)	fwd: ☐ bkwd:☐	fwd: ☐ bkwd:☐	
b.Stroop [mark responses]	**rolls L** ☐	hesitate☐self-correct ☐ rolls R ☐	
c. Visual target ID A	**19 27 31 45 53** ☐ ☐ ☐ ☐ ☐	14 20 38 46 52 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
d. Visual target ID B	**17 63 71 89 95** ☐ ☐ ☐ ☐ ☐	10 68 76 82 94 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
e. Follows other instructions: side shuffle, backpedal	All correct: ☐	☐ ☐ ☐ (e.g. rolls when shouldn't)	☐ ☐ ☐
f. Total trial scores	f.1.Total boxes marked above___/14	f.2.Total boxes marked above:____	f.3.Total boxes marked above: ____

Observations/Comments:

Study ID:	Rater:	Date/Time:	Order:

Trial 1 – L incongruent/odd	**Time (min:sec:100th sec):**		
	Correct responses	Errors*	Cues*
a. Avoids obstacle (trip wire)	fwd: ☐ bkwd:☐	fwd: ☐ bkwd:☐	
b.Stroop [mark responses]	**rolls L** ☐	hesitate☐self-correct ☐ rolls R ☐	
c. Visual target ID C	**29 37 43 51 65** ☐ ☐ ☐ ☐ ☐	24 30 48 56 62 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
d. Visual target ID D	**13 29 75 81 97** ☐ ☐ ☐ ☐ ☐	12 28 74 86 90 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
e. Follows other instructions: side shuffle, backpedal	All correct: ☐	☐ ☐ ☐	☐ ☐ ☐
f. Total trial scores	f.1.Total boxes marked above___/14	f.2.Total boxes marked above:____	f.3.Total boxes marked above: ____

Observations/comments:

Trial 2 – R congruent/even	**Time (min:sec:100th sec):**		
	Correct responses	Errors*	Cues*
a. Avoids obstacle (trip wire)	fwd: ☐ bkwd:☐	fwd: ☐ bkwd:☐	
b.Stroop [mark responses]	**rolls R**☐	hesitate☐self-correct ☐ rolls L ☐	
c. Visual target ID A	**14 20 38 46 52** ☐ ☐ ☐ ☐ ☐	19 27 31 45 53 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
d. Visual target ID B	**10 68 76 82 94** ☐ ☐ ☐ ☐ ☐	17 63 71 89 95 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
e. Follows other instructions: side shuffle, backpedal	All correct: ☐	☐ ☐ ☐	☐ ☐ ☐
f. Total trial scores	f.1.Total boxes marked above___/14	f.2.Total boxes marked above:____	f.3.Total boxes marked above: ____

Observations/comments:

Study ID:	Rater:	Date/Time:	Order:

Trial 3 – L congruent/even	**Time (min:sec:100th sec):**		
	Correct responses	Errors*	Cues*
a. Avoids obstacle (trip wire)	fwd: ☐ bkwd:☐	fwd: ☐ bkwd:☐	
b.Stroop [mark responses]	**rolls L** ☐	hesitate☐self-correct ☐ rolls R ☐	
c.Visual target ID B	**10 68 76 82 94** ☐ ☐ ☐ ☐ ☐	17 63 71 89 95 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
d.Visual target ID C	**24 30 48 56 62** ☐ ☐ ☐ ☐ ☐	29 37 43 51 65 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
e. Follows other instructions: side shuffle, backpedal	All correct: ☐	☐ ☐ ☐	☐ ☐ ☐
f. Total trial scores	f.1.Total boxes marked above___/14	f.2.Total boxes marked above:____	f.3.Total boxes marked above: ____

Observations/comments:

Trial 4 – R incongruent/odd	**Time (min:sec:100th sec):**		
	Correct responses	Errors*	Cues*
a. Avoids obstacle (trip wire)	fwd: ☐ bkwd:☐	fwd: ☐ bkwd:☐	
b.Stroop [mark responses]	**rolls R**☐	hesitate☐self-correct ☐ rolls L ☐	
c.Visual target ID A	**19 27 31 45 53** ☐ ☐ ☐ ☐ ☐	14 20 38 46 52 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
d.Visual target ID D	**13 29 75 81 97** ☐ ☐ ☐ ☐ ☐	12 28 74 86 90 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐
e. Follows other instructions: side shuffle, backpedal	All correct: ☐	☐ ☐ ☐	☐ ☐ ☐
f. Total trial scores	f.1.Total boxes marked above___/14	f.2.Total boxes marked above:____	f.3.Total boxes marked above: ____

Observations/comments:

***Scoring guidance:**
Errors = contact with trip wire, incorrect/repeated/skipped/commission number(s) recited, hesitation, self-correction and/or wrong direction roll in Stroop, roll instead of side shuffle, out of sequence movement(s) during task
Cues =provided DURING trial for completion of task (e.g. “one more” number, confirmation of odd/even, instruction about side shuffle vs. roll, etc.)
Each ROW must have at least one box (or more) marked. Tally number of X in each column in row f.
Reinstruction BETWEEN trials is not marked as an error OR cue.

Run-Roll-Aim
SCORING GUIDE

Examiner scoring supplies/materials:

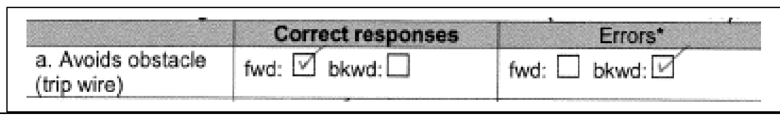
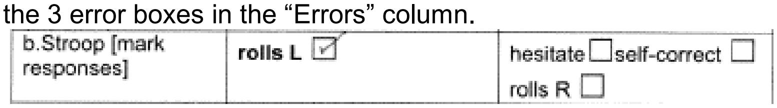
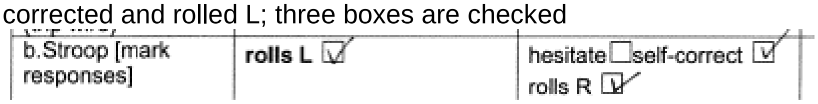
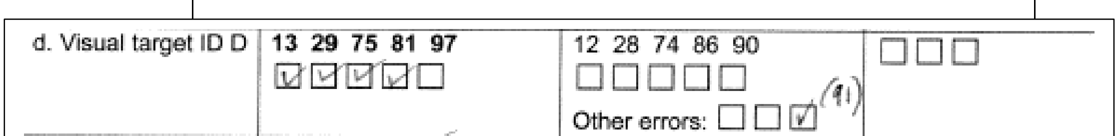
- Stopwatch
- Remote to operate stimulus slides on computer
- Clipboard
- Pencil
- Score sheet

Definitions of key underlying concepts:
Time – time to complete the Run Roll Aim trial from GO signal to when the first foot crosses the finish line.
Items correct – number of visual targets correctly identified during each trial
Items in error – errors made in obstacle avoidance, Stroop response, visual target identification (odd when even targets, e.g.), repeated correct items in a set, lack of following of task instructions. Specific criteria during the components of the trial are described below.
Cue – examiner prompts or instruction reminders provided during the trial (e.g., "one more" number, confirmation of odd/even before number identification begins, cue about odd/even in between number identification sets when first set was wrong target, instruction about side shuffle vs. roll etc.)
Scoring procedures for performance subscores
Before starting the task
Ask service member which eye he/she uses to aim with weapon site. Place inertial sensor ~~close~~ just off center on the **opposite** side to avoid it getting in the way during the task.
If using inertial sensor(s) for data collection, record the start time to allow match to sensor time codes in recorded trials.
Fill out the following:

- Subject's study ID
- Your Rater ID
- Today's date
- Where in the test order the subject is performing this test-task
- Inertial sensor location(s), if applicable

Scoring for each trial uses the same procedure, so the specifics will only be described once. All that varies is the direction of the roll that is cued, whether they are to call out odd or even numbers and if there is a congruent or incongruent Stroop cue.
Before each trial, circle the word even or odd as a cue to yourself to inform the participant which they are to call out during the trial. Reinstruction between trials is not marked as an error or cue. Also, see Scoring Guidance box at end of score sheet.

During each trial:

Performance dimension	Scoring procedures	Performance subscore
Time	Hand time each trial, starting the stopwatch when you advance the slide to GO and say GO at the same time. End timing when the participant's first foot crosses the end line. In the event that there is a mistrial, and a condition must be repeated, record time codes for each trial to indicate which are to be retained (from inertial sensor trials on computer).	N/A – no subscore
a. Avoided obstacles	Error = contact with trip wire Check "fwd" and bkwd" boxes in either "Correct responses" or "Errors" column based on whether or not SM had contact with trip wire during run toward or away from the mat.  Correct responses / Errors* a. Avoids obstacle (trip wire) / fwd: ☑ bkwd: ☐ / fwd: ☐ bkwd: ☑	N/A – no subscore.
b. Stroop response	Error = hesitation, self-correction, or wrong direction rolled Indicate whether or not the SM rolled in the correct direction by checking the box in the "Correct Response" column or checking 1 of the 3 error boxes in the "Errors" column.  b.Stroop [mark responses] / rolls L ☑ / hesitate ☐ self-correct ☐ rolls R ☐ Hesitation occurs when SM takes 1 second or longer to initiate the roll. Completion of a roll or any part of it to the wrong direction is checked. In this example, the SM rolled to the R partly, but then corrected and rolled L; three boxes are checked  b.Stroop [mark responses] / rolls L ☑ / hesitate ☐ self-correct ☑ rolls R ☑	N/A – no subscore
c. & d. Visual targets ID [X]	Errors = incorrect, repeated, skipped numbers, or reporting a number that is not on the screen (commission) Check the boxes corresponding to numbers on the computer screen that the SM calls out. Some or all will be in the "Correct responses" column or "Errors" column, which should include reporting numbers other than those presented on the screen. In the "cues" column, check a box for each time a cue was offered regarding visual target (e.g.,"one more" – indicating there is one more number that needs to be recited before they reach the target ones).  d. Visual target ID D / 13 29 75 81 97 ☑☑☑☑☐ / 12 28 74 86 90 ☐☐☐☐☐ Other errors: ☐ ☐ ☑ (91) / ☐☐☐	N/A – no subscore

	If the SM recites odd when even is the target, provide a cue that odd is the target before they do the second set, marking cue in the third column for the next set.	
e. Follows other instructions: side shuffle, back pedal	Errors = running forward versus back pedaling as instructed; side shuffling versus rolling as instructed If the SM follows instructions to side shuffle and back pedal, check "All correct" box in the "Correct responses" column. For each error made (e.g., runs forward back to finish line) Check a box in the "Errors" column each time the SM does not perform as instructed (e.g. runs forward back to finish line, does not correct roll made in wrong direction, rolls when he should side shuffle).	N/A – no subscore
Observations-comments		N/A – no subscore

<u>At task completion</u>

Performance dimension	Scoring procedures	Performance subscore
f. Total trial scores	Count the number of boxes checked in the "Correct responses" column for rows a, b, c, d, e (of 14 possible)	f.1 = total number of boxes checked in the "Correct responses" column
	Count the number of boxes checked in the "Errors" column for rows a, b, c, d, e	f.2 = total number of boxes checked in the "Errors" column
	Count the number of boxes checked in the "Cues" column for rows c, d, e	f.3 = total number of boxes checked in the "Cues" column

RRA Scoring Frequently Asked Questions

Avoids obstacle

What if the subject's foot lightly touches the trip wire during the forward rush?

This constitutes an error.

<u>Correct scoring:</u>

	Correct responses	Errors*
a. Avoids obstacle (trip wire)	fwd: ☐ bkwd: ☐	fwd: ☒ bkwd: ☐

Stroop responses

Are there trials in which SM are more prone to rolling in the wrong direction?

Hesitation is more likely for trial 1 and 4 with incongruent cues. However, count any hesitation as an error.

How will I know if I see a hesitation?

A hesitation occurs when the subject is viewing the directional screen and waits for more than 1 second before initiating the roll to either direction.

Identifies visual target

How should I score if the subject asks if the target is even or odd after the trial has begun?

Provide guidance, but mark as requiring a cue.

How would I score errors and cues provided in the following situations?

*The subject identified 4 numbers and then hesitates. I provided a cue for "**one more**" and the subject then reported the 5th number.*

Correct scoring:

	Correct responses	Errors	Cues
C. Visual target ID B	**10 68 76 82 94** ☒ ☒ ☒ ☒ ☒	17 63 71 89 95 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☒ ☐ ☐

The subject identifies 4 numbers and begins roll (in the correct direction). I did not provide a cue because it was in the middle of the roll.

Correct scoring:

	Correct responses	Errors	Cues
b. Stroop [mark responses]	**rolls L** ☒	hesitate ☐ self-correct ☐ rolls R ☐	
c. Visual target ID B	**10 68 76 82 94** ☒ ☒ ☒ ☒ ☐	17 63 71 89 95 ☐ ☐ ☐ ☐ ☐ Other errors: ☐ ☐ ☐	☐ ☐ ☐

Follows other instructions: side shuffle, back pedal

How should I score it if the SM rolls after the first visual target identification set instead of standing to side shuffle?

If the SM completes the roll quickly (doesn't appear to realize the error), let the trial continue and advance to the next visual target ID slide. After that trial, review the sequence and encourage him/her to watch the slides for the side shuffle cue on the next trial. Mark the error and don't mark "all correct". If the SM hesitates for more than one second or begins to roll and it's possible to provide a cue to correct it, cue about standing to side shuffle, and mark a cue on the scoresheet. If they complete the stand/side shuffle, mark all correct.

Correct scoring:

	Correct responses	Errors	Cues
e. Follows other instructions: side shuffl[e] backpedal	All correct: ☐	☐ ☐ ☐	☒ ☐ ☐

RRA PowerPoint Slides

READY?

GO!

L or R

14

45

22

50

46

19

53

27

31

38

SIDE SHUFFLE TO OPPOSITE SIDE, TO PRONE

14

45

22 50

46

19

53

27

31

38

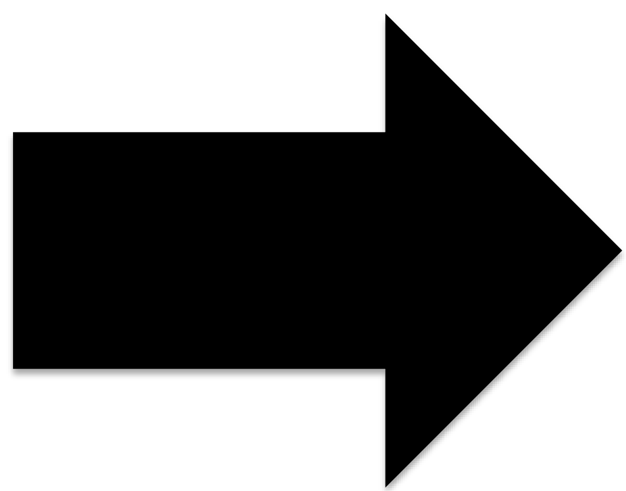
BACK PEDAL TO START

Practice Trial 1

READY?

GO!

R



14

45

22

50

46

19

53

27

31

SIDE SHUFFLE TO OPPOSITE SIDE, TO PRONE

63

10

17

89

82

94

68

95

76

71

ROLL to CENTER

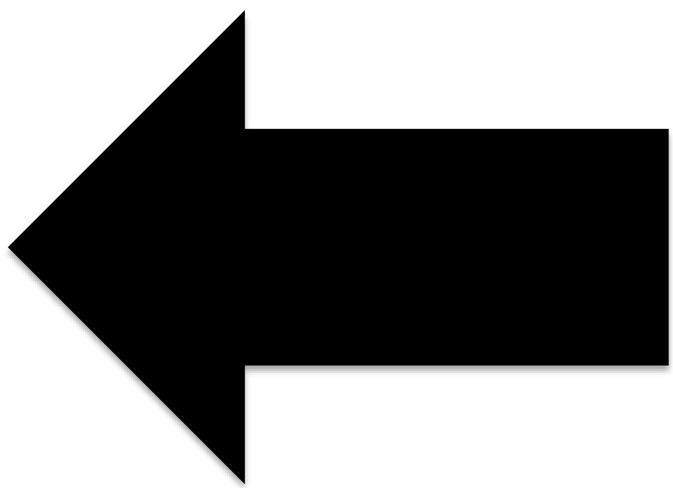
BACK PEDAL TO START

Practice Trial 2

READY?

GO!

L



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46

19

53

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38

SIDE SHUFFLE TO OPPOSITE SIDE, TO PRONE

63

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17

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94

68

95

76

71

ROLL to CENTER

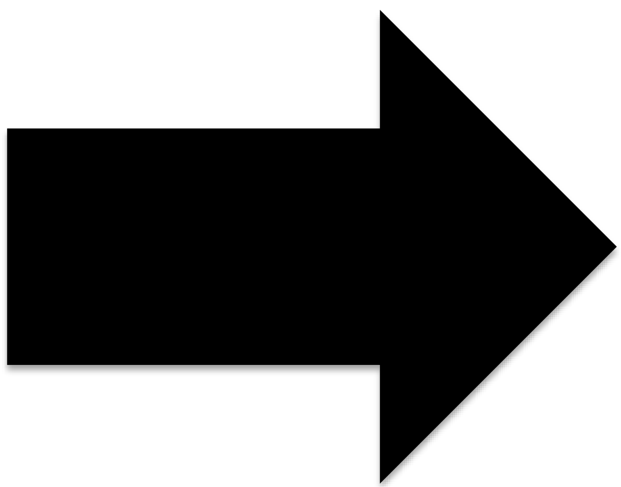
BACK PEDAL TO START

L incongruent -O

READY?

GO!

L



24

51

62

48

37

29

65

56

43

30

SIDE SHUFFLE TO OPPOSITE SIDE, TO PRONE

81

12

75

29

28

86

74

97

90

13

ROLL to CENTER

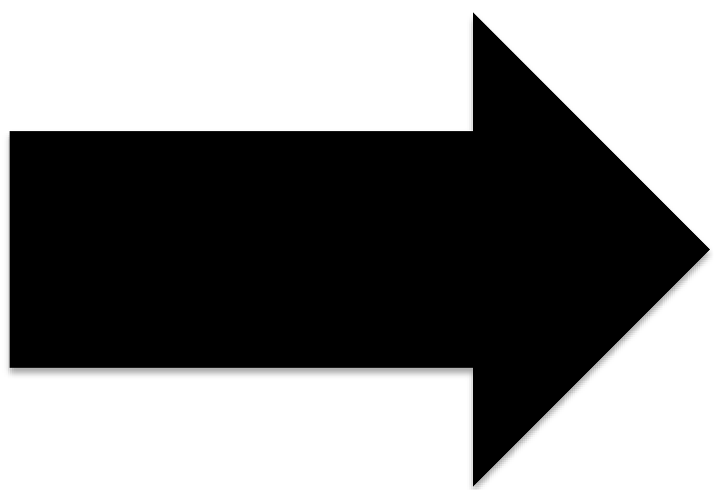
BACK PEDAL TO START

R congruent E

READY?

GO!

R



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SIDE SHUFFLE TO OPPOSITE SIDE, TO PRONE

63

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82

94

68

95

76

71

ROLL to CENTER

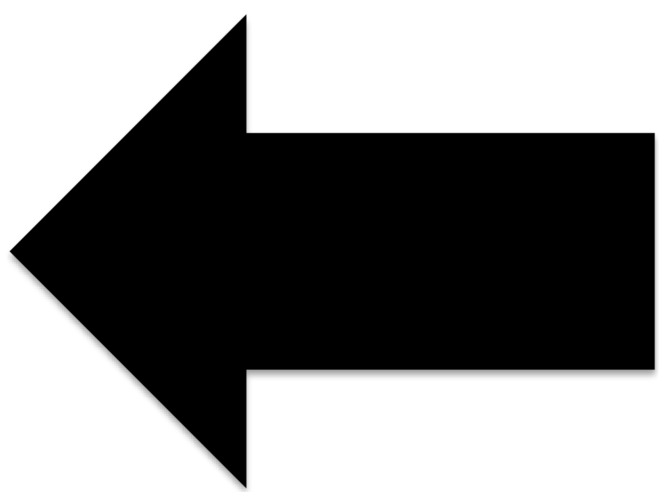
BACK PEDAL TO START

L congruent - E

READY?

GO!

L



63

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76

71

SIDE SHUFFLE TO OPPOSITE SIDE, TO PRONE

24

51

62

48

37

29

65

56

43

30

ROLL to CENTER

BACK PEDAL TO START

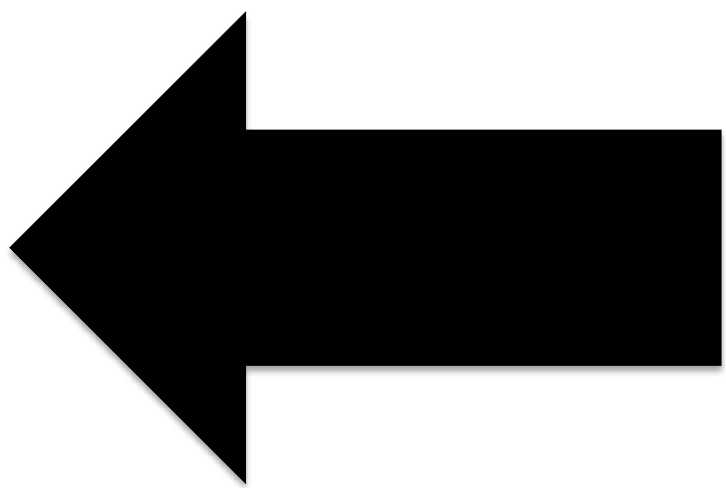
ROLL to CENTER

R incongruent -O

READY?

GO!

R



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20

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31

38

SIDE SHUFFLE TO OPPOSITE SIDE, TO PRONE

81

12

75

29

28

86

74

97

90

13

ROLL to CENTER

BACK PEDAL TO START

PATROL- EXERTION

Patrol/Exertion
Task Description and Set Up

I. Description: The SM is challenged to gather intelligence in a recorded video depicting a virtual Afghanistan patrol environment while reporting observed IED markers based on a briefing provided at the beginning of the video. The SM then uses the information to answer specific questions from memory at the end of the patrol video. The SM will perform continuous step-ups on an exercise step at an intensity of 65-85% of HR maximum throughout the activity while being monitored for effort level via a Polar HR monitor and performance observation. The SM will be wearing a combat helmet, eye protection, and be carrying a simulated M16 weapon equipped with a trigger switch connected via Bluetooth to a computer configured to record reaction time (RT). The SM is required to press the switch each time a beep tone stimulus is heard throughout the video as a measure of RT during a divided attention multitask.

II. Purpose: Visual scanning skills, attention, memory, RT, and decision-making under exertional conditions are often impaired following mTBI. This task places demands on divided and alternating attention, prospective memory, visual attention and scanning, gaze stability, and multimodal (i.e., auditory, visual, and vestibular) processing in conjunction with simultaneous exertional demands.

III. mTBI-related task challenges: Primary ● Secondary ○

Cognitive				Sensorimotor				Physical		
Executive function	Memory	Attention	Reaction time	Eye gaze tracking	Scanning	Vestibular	Balance	Bend - lift	Exertion	Manual UE Speed
○	●	●	●		●	○			●	

IV. Source: This task was created by AMMP team members as a way to challenge visual and auditory processing, reaction time, cognitive processing and attention skills in a situation involving moderate and simultaneous exertional demand.

V. Materials and Supplies

<u>Materials:</u>

- 4-5" high exercise step,
- heart rate monitor (sports type monitor with a chest strap and wrist watch component to allow examiner to monitor exercise heart rate),
- Table with elevated platform for positioning video monitor at eye level when subject is stepping
- laptop with Patrol video and RT programs
- video monitor with external speakers
- recording device for recording SM responses to post Patrol questions,
- standard helmet and eye protection,
- Simulated M-16 rubber weapon configured with RT switch,
- Antifog wipes for eye protection,
- Disinfecting wipes for cleaning HR monitor, helmet, eye protection and weapon between subjects

VI. Test Task Set Up

Space estimate: Approximately 6x8 foot area

Patrol Task – Exertion with Reaction Time
Examiner Instructions and Script

Open the Patrol Task application on the laptop, make a profile for subject. Use the subject ID number and click “create profile.” Turn on the switch on the blue gun.

INTRODUCTION

This task involves repeated stepping onto this exercise step while you watch a virtual patrolling video set in a rural countryside. We will monitor your heart rate in order to keep you exercising at a moderate pace. How old you are so we can calculate your exercise heart rate?

Write age and calculate APMHR.

INSTRUCTIONS

A. Don Equipment

- **Please put this heart rate monitor on under your shirt at the breastbone. You will need to wet this part a little.**

Hand subject the sports HR monitor and point to the contact area on the underside of the POLAR label, that they should get a little wet, and turn the wrist watch monitor to EXE (note it takes a 10-15 seconds to start indicting HR).

You have to stay within 5 feet of the subject with the watch part; it works to clip in on to the top of your clipboard.

- **You will wear a helmet, eye protection, and carry this blue weapon.**

Hand all equipment to subject. Allow the subject to choose the size helmet he/she wants to wear. If the subject is wearing glasses, additional eye pro is not necessary.

B. Symptom Assessment

Before we start, please rate two things for me.

Point to RPE scale.

- **Using this chart from 6 (which means no feeling of exertion) to 20 (very, very hard exertion), rate how hard you are working while standing still.**

Point to vision chart.

- **Using this chart where 0 means “you see clearly or normally” and 10 means “the worst or most unstable my vision could be,” rate your vision as it is now.**

I am going to ask you to rate those two items again for me while you are stepping up and down.

C. Practice Reaction Time

- **During this task we will test your reaction time. When you hear this tone**

Trigger the sound of the stimulus using the computer mouse several times—click on the BEEP icon.

- **Press this small switch as quickly as you can.**

Point to switch on blue rubber weapon, just below trigger.

- **Let's practice this a couple of times.**
- **Each time you hear the beep,** Trigger stimulus on computer by pushing the "beep" icon, **push the switch as fast as you can.** Allow subject to practice pushing the switch to manual stimulus several times.
- **Do you have any questions?**

<u>D. Test Reaction Time in standing</u>

- **Now let's record your reaction time. The computer will randomly trigger the "BEEP" sound a few times in the next 30 seconds.**
- **READY to push that switch as fast as you can?**

Start the RX time trial. The computer will play 2 beep sounds at 2 random times in 30 seconds; it will be at least 8 seconds for the first tone sound.
Record RT (in msec) from the computer screen on to score sheet (1a and 1b).

- If the numbers are greater than 400, try one additional trial and say **"Let's practice once more… Push the switch as fast as you can after you hear the sound."**
- Record the 2nd trial below the first on the score sheet.

<u>E. Tactical pauses and Reporting</u>

- **Now I will describe the video to you. The video will provide instructions and a review of common IED MARKERS that you should be looking for during each of 4 tactical pauses.**
- **Each pause begins when the patrol leader says "initiating tactical pause". The video will show a virtual 360 degree turn. You will continue stepping during the pause. During each turn, call out ANY IED MARKERS you see based on the instructions you were given. The tactical pause will end when the patrol leader says "OK, tactical pause complete, let's keep moving"**
- **At the end of the video, I will hand you a recorder and ask questions that may include intelligence concerning your unit's location, relevant times and date within the virtual scenario, as well as details about individuals, equipment, or activities you observe while on the video patrol.**

Show subject the hand held recorder.

- **The details for the final questions must be answered from memory so pay close attention to important information during the video for this final report.**

F. Rules and Brief-Back

- **You must follow these rules:**
  - **Push the switch every time you hear the beep.**
  - **Call out the IED markers ONLY during the tactical pauses where the patrol leader says "Initiating Tactical Pause" to start, and "Tactical Pause COMPLETE" to end.**
  - **Save all other tactical observations for the questions at the end.**
  - **Step continuously throughout the video until I tell you to stop.**
  - **What are the 4 tasks you will do during this task?**

  Subject should say:
  1) Press switch in reaction to beep,
  2) Identify IED markers observed during tactical pauses,
  3) Answer questions at the end of the video
  4) Step continuously.
- **Do you have any questions? I want you to know that you won't be shooting at anyone and no one will shoot at you, and nothing blows up during this video. It is important for you to react as fast as you can and to report everything as well as you can. DO YOUR BEST!!**

G. Reaction Time during stepping

- **Now we will test your reaction time with the beeps ~~again~~ when you begin stepping.**
- **Ready? Begin stepping**
- Start the reaction time trial again.
- Record RT (in msec) from the computer screen onto score sheet (1c and 1d).

B (repeat). Symptom Assessment while stepping

Point to RPE scale.

- **Using this chart again from 6 to 20, rate how hard you are working now.**

Point to vision chart.

- **Using this chart from 0 to 10, rate your vision now.**

- **I'm going to start the video now. Keep stepping until I tell you to stop. The beep will sound multiple times during the video. Make sure you respond quickly every time you hear it.**

DURING THE TEST

Monitor HR throughout to keep in range which you take off the chart (APMHR).

Goal is 65% of APMHR (age predicted maximum heart rate) by the time the Courtyard patrol scene starts so if he/she isn't close after the first 2 minutes of instructions on video, say **Step a little faster** when nothing important is showing on the video. Rarely if the subject is over 85% of APMHR, you may have to say "**slow down a bit."** Record the HR in the HR column next to each tactical pause, as well as below the RPE score at the bottom of the score sheet.

Turn your recorder on at about the "SWITCH TO YOUR NODS" statement on the video.

END OF THE TEST

B (repeat) Symptom Assessment: Ask the Workload and Gaze stability questions again right at the end of the video while subject is stepping. Point to the wall charts when you ask these questions. Say:

- **Keep stepping and rate how hard you are working.**
- **How stable is your vision?**

Have subject stop stepping and ask post video questions (see score sheet). Press the "record" button.
State: **"Recording Patrol Report with DRAGON XXX NOW"** (where XXX is the subjects ID number) and then hand recorder to subject. Press the "STOP" button on the recorder when done with post patrol questions.

EXAMINER GUIDANCE:
IMMEDIATELY AFTER THE TEST:

- ~~R~~Record the msec of the 11 reaction times at the end of the score sheets. NOTE that if they do not react or if it takes them longer than 2 seconds, then the screen will have "-1" which should be recorded in the appropriate blank~~.~~
- Turn the speaker switch off on the BLUE WEAPON at the end of the task.
- The battery should be changed when the battery indicator on the screen states 75% or less.
- Clean the helmet, eye pro, HR monitor and strap, and blue weapon and use the antifog wipes on the eye pro after each subject.

OTHER ADMINISTRATION TIPS

- If the eye pro fogs up, have the subject take them off during the PATROL Task.
- Close and reopen the PATROL Application between subjects. If it locks up, close and open the application again and re-do profile. Open the PATROL Application prior to turning on the switch on the blue weapon.
- There are separate instructions for the instrumented blue weapon software.

Study ID:	Rater:	Date:	Order #:

SM Completed Task? ____Yes____No (examiner stopped) ____No (subject stopped)

PATROL TASK with exertion Score Sheet

AGE__________ 220- Age = ______APMHR 65%____________ APMHR 85% ______________

Initial Reaction time (1a)_____ms (1b)______ms (stand)(1c)_____ms (1d)______ms (stepping)

NOTES:____

RATER: Place check mark in box to indicate correct response (No negative for extra observations)

Heart Rate	#1	OBSERVATION / IED Marker	IDENTIFIED (1 Point Ea)
	FOOT BRIDGE (NEAR SIDE)	Rock linefar side of creek that point down along the river road. (at 30°)	
		Trash Pile #1 (across bridge at 0°)	
		Conspicuous Box (at 270°)	
		Overturned earth (at 270°)	
	TOTAL # CORRECT		A. /4
	#2	OBSERVATION / IED Marker	IDENTIFIED (1 Point Ea)
	GROVE ENTRANCE	3 parallel line marks low on the wall (at 30°) (Also: "chalk marks")	
		Red prayer flag (under rock inside wall-at 330°)(Also: red cloth, flag, material…, red rug; "prayer…" or "red….")	
	TOTAL # CORRECT		B. /2
	#3	OBSERVATION / IED Marker	IDENTIFIED (1 Point Ea)
	MID GROVE	Broken tree branch (at 90°)	
		Small line of rocks just below broken branch (at 90°)	
		Small pile/bundle of sticks (also: logs, twigs, branches(at 270°)	
	TOTAL # CORRECT		C. /3
	# 4	OBSERVATION / IED Marker	IDENTIFIED (1 Point Ea)
	END GROVE	Stick bundle stacked vertically on R side of gate (at 30°)	
		3 parallel line marks low on the wall (at 330°); or "chalk marks"	
		Small line of rocks (at 330°)	
		Overturned earth (at 0 or 360° depends on when they see it)	
	TOTAL # CORRECT		D. /4
	SCANNING SUB-SCORETOTAL # CORRECT (A+B+C+D)		X.= /13
	*COMMENTS (extra items/objects reported)/*SYMPTOMS*:*		

Post Patrol Questions	Correct answer (Examples)	# Correct
	1 pt each unless indicated	
What enemy vehicles did you see?	Motorcycle, cycle, moped, bike, MC, Harley, any word that indicates motorcycle (1)	**/1**
What were the last grid coordinates reported?	EB 2682 (2 pt for all correct) 1 pt each for letters or numbers correct, must be exact (0, 1, or 2)	**/2**
What color clothing were the kids in the grove wearing?	White (1)	**/1**
What surveillance equipment did you see?	"binoculars", "scope", "binos", "observation device" (1)	**/1**
What weapon did the individual on the motorcycle have?	Knife, blade, sword, dagger, janbiya or khanjar (1) Accept any term that indicates they identify a type of knife	**/1**
What time did the patrol enter the grove?	Tolerances: 1700-1705 hours (1)	**/1**
What was the date that this activity occurred?	Tol: 20 June 2013 (month/day only is acceptable) (1)	**/1**
What items did you see throughout the scenario that could be used to create, arm or detonate an IED?	Tolerances: "Jugs, containers, IEDs, gas cans, water cans, red caps, fuel tanks, yellow jugs, daisy chain" (1)	**/1**
	Tolerances: "Wire", "cord", "fuse", "Det cord" (1)	**/1**
	Tolerances: "Battery", "9 volt", "power cell" (1)	**/1**
PATROL QUESTIONS SUBSCORE		**Y.= /11**
Anything else that you noticed that I should include in my report? **(Write comment(s) free form)**		
SCANNING SUBSCORE (A + B + C + D)=X	**Copy from bottom of table front side**	**X.= /13**
PATROL SUB-SCORE	**Copy from above**	**Y.= /11**
TOTAL POINTS (SCANNING +SALUTE) (X + Y)	**Total**	**Z.= /24**
Reaction time (2)_____ms (3)_____ms (4)_____ms (5)_____ms (6)_____ms (7)_____ms (8)_____ms (9)______ms (10)______ms (11)_______ms (12)_________ms		

Patrol-Exertion
Scoring Guidelines

Examiner scoring supplies/materials:

- Clipboard
- Pencil
- Subject score sheets and administration instructions
- Wall signs for RPE (rate of perceived exertion) and Vision Clarity (Likert Scales)
- Hand held voice recorder, heart rate monitor, Instrumented blue mock M-16 weapon with Reaction time software/hardware, helmet, eye protection.
- Computer and Monitor for playing PATROL video and to run reaction time program.
- Patrol video cued up, turn on speakers, turn on switch on blue weapon (for Rx time component)

Before starting the task, the rater fills out the following:

- Study ID, rater, date and test order (1^{st}, 2^{nd}, …6^{th} of the test tasks)
- Age
- Calculate the age predicted maximum heart rate
- Determine 65% and 85% range of APMHR for exercising—calculate or use the chart
- Enter the subject ID number into the computer program on laptop and click "*Create Profile*" (This is the program for running the baseline Reaction Time software.

1) In the left hand column of the score sheet under "Heart Rate", indicate the approximate time into the video when cues are given to the subject to "speed up" or to "slow down" in order to keep the subject's exercise HR in the 65-85% APMHR range per protocol.
2) Reaction time—Record the initial reaction time while standing (2a and 2b) and while stepping (2c and 2d). Read off computer screen after initial trial and write the milliseconds down in the appropriate spaces.
3) While standing, while initially stepping before the video starts and at the end of stepping before the post-video questions, record the subject reported number for rate of perceived exertion (RPE) from the 6-20 and vision clarity from 0-10 in the appropriate box on the score sheet. Record any other comments or reported symptoms in the appropriate blank space below the RPE and vision clarity questions.
4) Tactical pause 1-4 (AKA SPOT reports) —make a check mark in each box that the subject correctly identifies and write down in the blank space any extra words or comments that subject~~s~~ makes during the tactical pause or while patrolling.
5) Add up points for each tactical pause in blanks A through D and record the total (out of 13) in box X; also record on the back side of the score sheet in box X.

6) Mark the box for each component of the Post Patrol Questions using a 1 or 2 as appropriate per the examples.
7) Add up each section of the Post Patrol Questions and record total under Y (out of 11 maximum points) and also copy the score below in the subscore section Y.
8) Add up the subscore summary boxes for the Scanning (SPOT Reports) - X, Post Patrol Questions- Y and fill in the TOTAL in Box Z.
9) Copy the Reaction time numbers (in msec) off the computer screen into Reaction time blanks 2-12 on the bottom of the page.

Patrol Scoring Guidelines/Tolerances

1. Tactical Pause: Any "items of interest" reported on the IED marker list will be credited regardless of ***when*** they are identified (during the tactical pause or after). In general, the participant should provide the examiner feedback during or immediately after the tactical pause so be prepared.

2. Erroneous identifications (markers, motorcycle track, etc.) and IED component materials (battery, jugs, and detonation cord) offered during the tactical pause (e.g. craters, out of place dirt mounds, etc.) will not be counted as errors of commission (no points deducted).

3. Description of rock lines or stick piles must denote deliberate placement by enemy forces (e.g. rock line or stick pile deliberately placed, rock cairn, etc.) not just "rocks and branches"

4. During 1st Tactical pause, subject should identify the box on the near side of the river (not the brick on the far side).

5. Post Patrol Questions—see the middle column on the scoresheet labelled "Correct answer (Examples)" for expected answers. Write any additional comments in the blank spaces. No penalty is given for additional words or answers; they are just recorded in score sheet blanks.

Patrol- Exertion
Materials

BORG RPE Scale

6	NO EXERTION AT ALL
7	
	EXTREMELY LIGHT
8	
9	VERY LIGHT
10	
11	LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD (HEAVY)
16	
17	VERY HARD
18	
19	EXTREMELY HARD
20	MAXIMAL EXERTION

VISION

0 1 2 3 4 5 6 7 8 9 10

Normal, Clear, & Stable Vision

Extremely Blurry or Jumpy Vision "The Worst It could be"

System Description

The PATROL Reaction Test measures reaction time events during a video of a patrol mission scenario. When the pre-set time event is reached in the video, reaction from the subject is prompted by an audible cue from the Trigger module. The Subject is asked to react to the audible cue by pressing a button located on the pistol grip. When the button is pressed, the reaction time is measured as the delay from the audible cue to when the button is pressed. The reaction time is calculated and logged by the PC software. Hardware as installed on rubber duck can be seen in Figure 1.

Figure 1 - Trigger installed on rubber duck

Trigger Module

The trigger module is mounted at the bottom of the magazine on the blue rubber duck, as seen in Figure 2 and consists of a bluegiga ble112 Bluetooth Low Energy module, a buzzer and a momentary push button powered by a CR2032 3V Lithium battery.

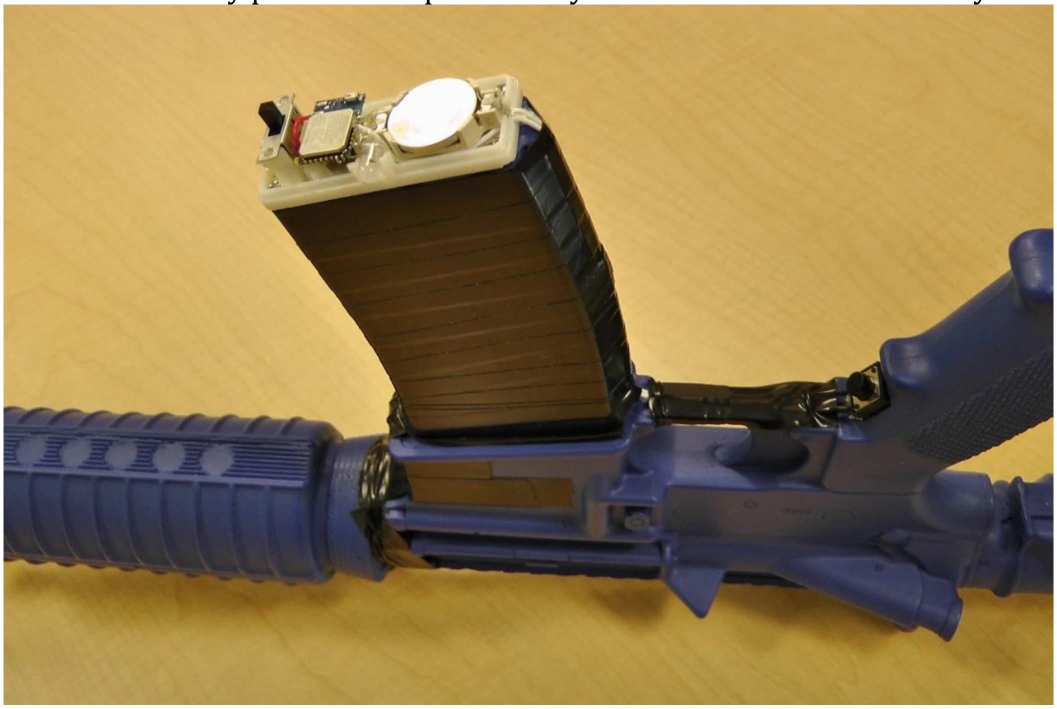


Figure 2 - Trigger module mounted on rubber duck

Electronics Design

The electronics are all wired and soldered to the ble112 module according to the schematics in Figure 3.

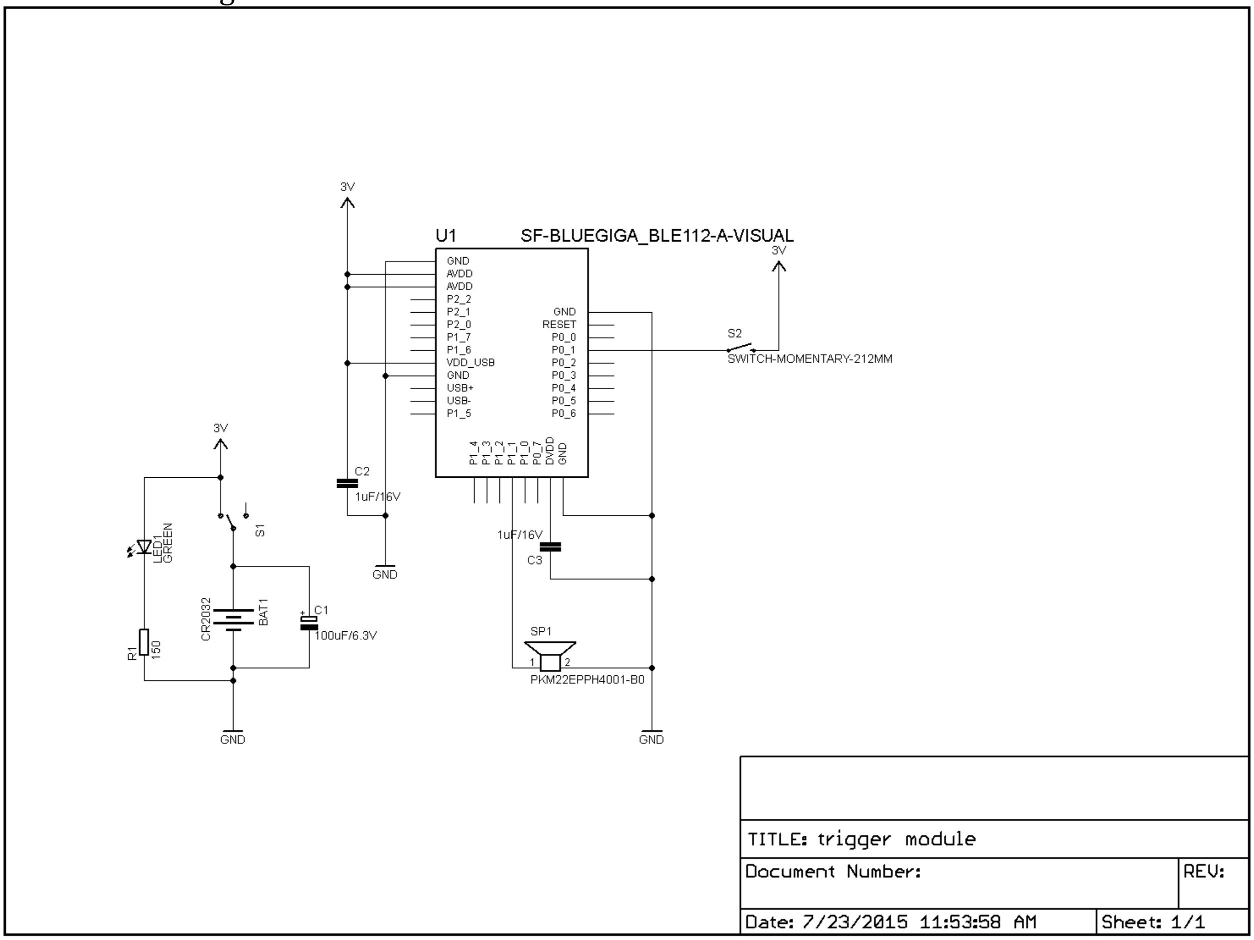


Figure 3 - Electrical schematic

Appendix A – Installation Instructions

Installation of software on PC

Make sure the latest java version is installed on the PC. The PC software in its existing folder structure should be copied to a folder on the PC, for example “C:\Patrol”. Copy rxtxSerial.dll to the JAVE_JRE/bin folder. Run the software through PATROL.jar.

User Instructions for PATROL Test

The system consists of the Trigger Module (located on the blue gun), the Dongle (mounted in a USB port) and the PATROL Software.

Setup Instructions

Preparing the system for a test involves the following steps:

1) Start the PC running the PATROL Software
2) Make sure that the Dongle is mounted in the correct USB port (the front most port on the right hand side of the PC). Any USB port used must be 2.0 compatible.
3) Turn on the Trigger Module and look for the green light to come on
   a) If the green light does not come on, please read the Troubleshooting guide on how to replace the battery
4) Start the PATROL Software located on the Desktop of the PC
5) The first dialog that comes up prompts you to select the COM-port that the Dongle is connected to, press OK
6) The Software will now try to connect to the Trigger Module, which will result in a beep from the Trigger Module.
   a) If the beep is not heard and an error dialog pops up, please read the Troubleshooting guide on how to connect the Trigger Module

Operating Instructions

As the system is set up and the Trigger Module is on with a green light and the PC running the PATROL Software. Follow these steps to run the test:

1) Use the Beep button to test the beep sound and the connection to the Trigger Module
2) Create a new profile by entering the Profile ID in the corresponding text box
3) Press Create Profile
4) Run Reaction Test and Run PATROL Test are now available
5) Press Run Reaction Test to run the reaction test, the results will populate the Results text box when the test has finished
6) Press Run PATROL Test to run the video and the automated test sequence
   a) At any time during the PATROL Test, the test can be paused by pressing SPACE
   b) At any time during the PATROL Test, the test can be aborted by pressing ESC
7) After the finished test, the results will populate the Results text box
   a) Write down the results
   b) A backup of the test results will also be saved to the hard drive of the PC
8) When done testing, TURN OFF the Trigger Module to conserve battery and exit the Software

Troubleshooting

Replacing the Trigger Module battery

The battery in the Trigger Module is a 3V CR2032 with about 200mAh capacity. The battery should last for about 10 hours of testing, please follow these steps to replace a depleted battery:

1) Turn the Trigger Module off
2) Open the bottom casing with a flat object by inserting it in the slot on the opposite side of the green light.
3) Twist the flat object so that the casing pops off
4) Use the flat object to pry the battery out of its holder
5) Insert the new battery with the positive facing towards you
6) Snap the lid back on to the Trigger Module
7) Power on and confirm that the green light comes on
    a) If the green light does not come on after replacing the battery, please contact support

Re-connecting the Trigger Module

At times, the PATROL Software will not recognize the Trigger Module. The following can be reasons for the Trigger Module not being recognized:

- The Trigger Module is not started before the Software is started
- A new Trigger Module is used
- Interference during the connection phase
- Hardware malfunction, please contact support

The following steps will describe how to connect the Trigger Module at the event of a connection failure:

1) Make sure the Trigger Module is on, the green light must be on
2) Open the configuration dialog
3) In the configuration dialog, press Discover
4) The list above the Discover button will be populated with available devices to connect to
5) Select the "PATROL Trigger" and press Connect, this should result in a beep from the Trigger Module
6) Save and Close to store the new settings
7) The configuration dialog will exit and a beep from the Trigger Module will confirm the connection.
8) If this does not work, please contact support

Rx Time Project AMMP Conceptual Design

Reaction time measuring during the PATROL scenario. The subject will be exposed to 11 auditory cues throughout the scenario and will respond by pressing a trigger in proximity to a "blue gun". The system will consist of software running on a PC and a separate Trigger Module that can output auditory cues as well as measure the delay between the cues and trigger reactions from the subject. The interface between the PC and the Trigger Module will be wireless to allow flexible mounting as well as not to interfere with the subject's movement. The Trigger module must on its own measure the time, since a PC cannot be considered a reliable real-time system, this is especially true considering communication with an external trigger button.

PC Software

The software will encapsulate the video showing the PATROL scenario. Researcher can configure software to set the time of the triggers. Configuration should be done in a configuration file. The software will track video frames and transmit a command to the Trigger Module when a pre-selected frame is reached.

Trigger Module

Trigger module will receive a command from the PC software to start an auditory cue. The on-board microcontroller will start a timer when the cue is started. The subject will press a trigger that will stop the timer and the time interval is calculated by the microcontroller. The time interval is transmitted to the PC software. The PC software presents reaction times at the end of the video.

Hardware

A PC running the software, wireless USB-dongle (or built-in Bluetooth), wireless module, microcontroller board, digital trigger button, piezo speaker (or similar), battery, battery charging circuit (or replaceable battery) and LED.

Specific Example

The PC software could be developed in C#/.NET which with existing libraries would make this process quick. The PC could have built-in Bluetooth capabilities or a separate dongle is used. The Trigger module would be a custom design optimized for size and weight. A lower-range MSP430 16-bit microcontroller would be mounted on a custom PCB together with a SMD trigger button, a Bluegiga Bluetooth RN-42 module, a status LED, a power button and a pizeo speaker. Contingent on calculations for power needs, the battery would probably be a lithium 3V coin cell battery. A custom plastic enclosure will only expose the power switch, status LED and trigger button to the user.

These recommendation are mostly based on my experience with the aforementioned technologies, depending on the developer's experience, other environments might be more familiar and preferred.

			Patrol Trigger Module		
	Contact	Daniel Nilsson			
		dasnilsson@gmail.com			
		612-702-2919			
Line #	Qty	Ref	Manufacturer/Distributer	Manufacturer Part #	Description
1	1	U1	bluegiga	BLE112-A-v1	Bluegiga BLE 112-A BLE module
2	1	SP1	Murata	PKM22EPPH4001-B0	Piezo 4kHz Buzzer
3	1	S2	Sparkfun(dist.)	COM-09190	12 mm Momentary pushbutton switch
4	1	S1	Sparkfun(dist.)	COM-00102	SPDT Mini power switch
5	1	BAT1	Renata	SMTU2032-LF	CR2032 Battery Holder
6	1	LED1	Sparkfun(dist.)	COM-09592	Green 5mm LED
7	1	R1	Yageo	MFR-25FRF52-150R	Resistor 150 ohm
8	1	C1	Panasonic	EEU-FC0J101B	Aluminum Electrolytic capacitor 100uF/6.3V
9	2	C2, C3	TDK	FK28X5R1C105K	Ceramic Capacitor 1uF/16V

ILLINOIS AGILITY TEST (IAT) – PACKING LIST

Illinois Agility Test
Description and Test Set up

I. Description: The Illinois Agility Test requires running distances of 30' with rapid direction changes and navigation of obstacles in a serpentine pattern during the middle part of the obstacle course. A memory task is also completed. Then both the agility task and the memory task are performed at the same time. Accuracy of memory recall and time to complete the agility task are measured in single and dual-task conditions.

II. Purpose: This task requires higher level mobility (rapid performance on an agility course) while performing a cognitive task (7 word list memory task) at the same time. This testing protocol is similar to the Walking and Remembering Test, which has been validated in both older adults and individuals with moderate to severe brain injury.

III. mTBI-related task challenges: Primary ● Secondary ○

Cognitive				Sensorimotor				Physical		
Executive function	Memory	Attention	Reaction time	Eye gaze tracking	Scanning	Vestibular	Balance	Bend - lift	Exertion	Manual UE Speed
	●	○					●		○	

IV. Source: Getchell B. Physical Fitness: A Way of Life (2ed). New York: Wiley and Sons, Inc. 1979.

V. Materials and Supplies

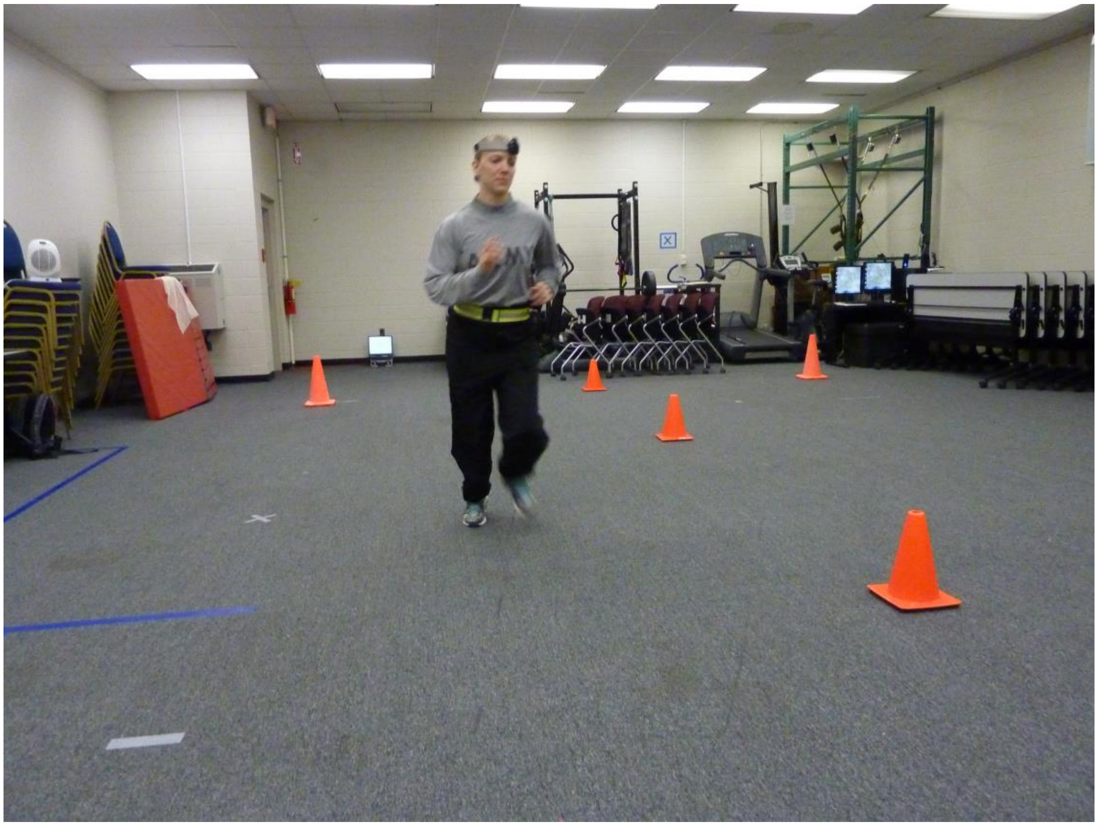
- Colored masking tape to mark start and end points of agility course
- Clipboard and Score sheet
- Stopwatch
- 6 cones
- Adjustable headband and waist band
- NexGen inertial sensors* and wireless data collection port and laptop.

*I2M Sensors can be found at this website http://www.nexgenergo.com/ergonomics/I2M-IMUs.html
Inertial sensors are placed (1) on an adjustable headband slightly to the opposite side of the forehead from the subject's eye used for sighting through the weapon scope and (2) on an adjustable waist band fitted tightly around the subject with the sensor in the mid lumbar area.

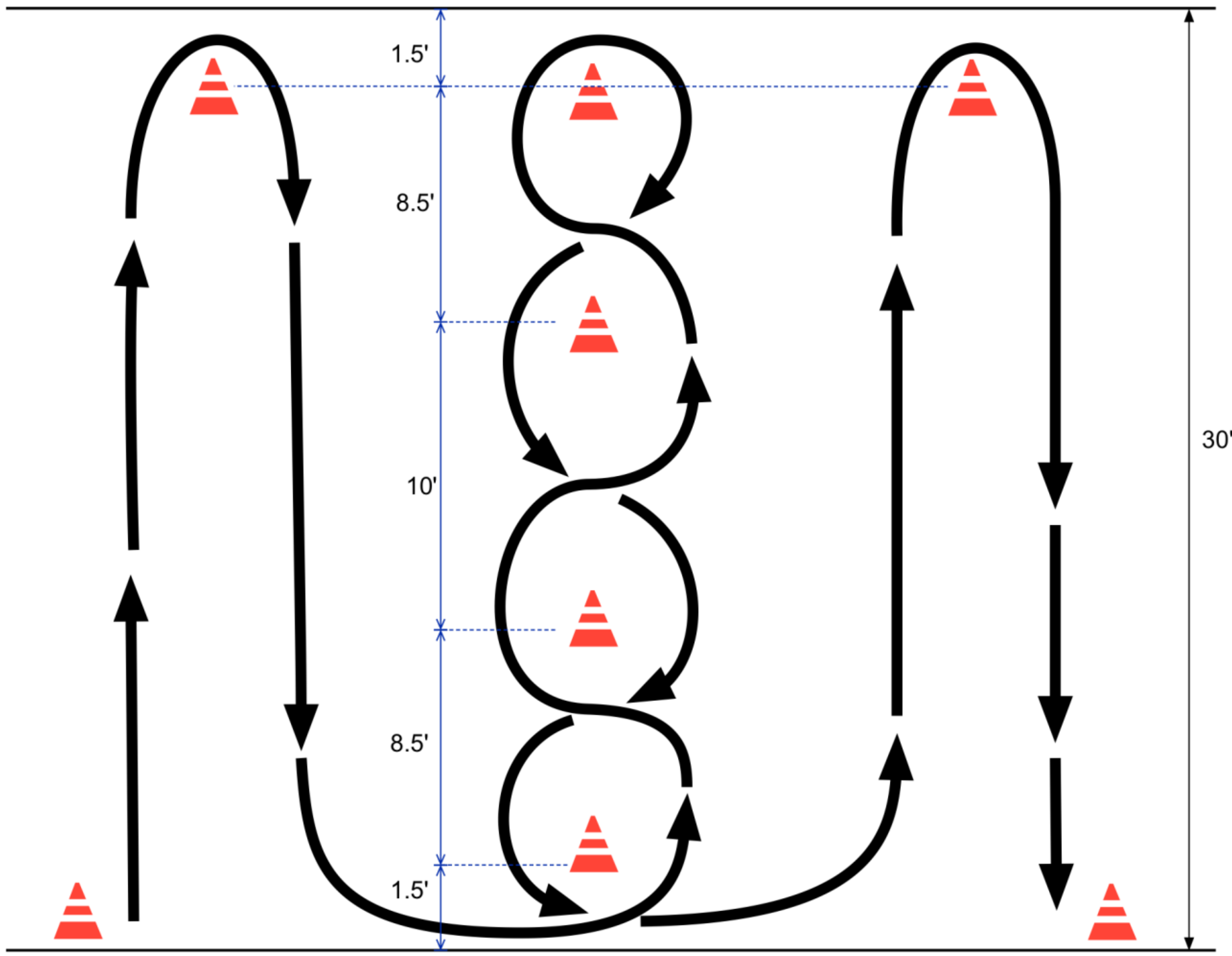
VI. Test Task Set Up
<u>Space estimate:</u> Wide hallway space that is 40' long and 12' wide at a minimum to allow for agility course set up and acceleration/deceleration during the agility task.

Figures 1 and 2 illustrate task set up.

Figure 1 Task set up example



<u>Figure 2</u> The starting position for the task is with the service member prone with his/her hands at the level of the starting line. The cones in the middle of the course are placed to allow sufficient room on the ends to circle the cones comfortably (in this example allowing 1.5' between end cone and far line and start/finish line, to avoid having to slow to avoid nearby obstacles just beyond the course).



STARTING POSITION

COURSE END

Illinois Agility Test
Examiner Instructions and Script

Before testing, roll a die to determine the order of the word lists that will be used with the subject. Also indicate sequence of priority conditions based on the subject ID number. Trial 1 is single task word list. Trial 2 is dual-task condition without instructions. Trials 3 and 4 are priority conditions. Odd ID number subjects' priority order is words 3/agility 4. Even ID number subjects' priority order is agility 3/words 4.

INTRODUCTION

This task is called the Illinois Agility Test. It will assess your speed and agility while moving on an obstacle course, as well as your ability to recall a short list of words.

INSTRUCTIONS

Single Task Condition – Walk Through Agility Task

Show schematic of the course (on page 4 of this script).

- **You will begin here lying prone with your hands at the level of this piece of tape.**
- **When I say go, stand up and run as quickly as you can around the large cone at this end.** Trace path on schematic. **Go around it, without touching it, then move to the cones in the middle. Run serpentine, alternating around one side and then the other, through the four cones in the middle of the course both UP and BACK.** Trace path on schematic.
- **Round the fourth cone in the middle and then run on the INSIDE of the large cone on the far right, before running quickly back to the finish.** Trace path on schematic.
- **If you get the sequence mixed up, try your best to correct it by going back to where you made the mistake. If you stop during the trial, we will need to repeat it.**
- **Go as quickly as you can, but avoid touching any of the cones.**
- If space is limited, then add: **Take care that you don't go so fast that it is hard to stop at the end of the course, since space is limited in this room.**
- **Do you have any questions?**

A. Single Task Condition – Practice and Timed Agility Task

- **Now let's have you jog through the course once to make sure you have the sequence right.**
- **Now let's try a timed trial.**
- **Do you have any questions?**

Record performance time. If there are errors, the subject must repeat the timed trial a second time.

B. Single Task Condition – Word List Task / Cognitive Task

Both the examiner and subject sit for this part of the task.

- **Now I am going to read a list of 7 words to you. These are things you might pack if you were going to deploy.**

- **Listen carefully, because you need to remember them for a short delay before you repeat them back to me. The delay is the length of time it took you to complete the agility task.**
- **I will say the 7 words, then I will say "Delay".**
- **When I say "Now" tell me the words you remember. You can say the words in any order.**
- **Do you have any questions?**

Answer all questions before proceeding. Use the number of words remembered in the single task condition as the span in the dual-task condition, if the number recalled is 5 or greater. If the subject recalls fewer than 5 words, use a list of 5 words in the dual-task condition.

Read the word list from the score sheet that corresponds to the number on the first die that you rolled before testing. Read words at a rate of one per second, dropping voice inflection slightly on the last word in the sequence. When "Delay" is said, start the stopwatch. Say "Now" when the time for completion of the agility task is met. Record the order of word recall on the word list sheet for those that are correct. If a new word is added to the list, then write it down verbatim for that trial. Record errors by adding missed words (error of omission) and added words (error of commission) together.

<u>C. Dual-Task Condition – WITHOUT priority instructions</u>
The subject can remain seated through task instructions.

- **Now we are going to combine the agility task with remembering words. The start position will be the same, in prone with your hands at the level of this piece of tape.**
- **Each time we repeat the task it will be with a different list of** ___ (number) **words. You can forget the words that you have heard previously. Just focus on remembering the words you have heard last. We will do this task a few times.**
- **Once you have heard the last word, there will be a short delay so you can get the last word in your head. Then I will say "Ready, go".**
- **Remember the words as you run the course. When you finish, tell me the words you remember, in any order.**
- **Complete the agility course as quickly as you can, but take care not to touch any cones.**
- **Do you have any questions?**

With the subject in the starting position, read the word list from the score sheet that corresponds to the number on the second die that you rolled before testing. Read words at a rate of one per second, dropping voice inflection slightly on the last word in the sequence. Record the time it takes the subject to complete the course, and record the words recalled for each trial. Use a repeat trial if the subject does not follow instructions or stops before completing the trial.

If the subject confuses the agility course sequence and does not correct it (i.e. the subject does not follow the serpentine pattern in middle of the course in both directions) so that the motor task time is less than the single task time, then repeat the trial. If the participant recognizes and corrects the error, then record the time and make a notation that an error was made in the course path. Any contact with cones during a trial should also be marked as an error.

If errors are made in word recall (i.e. commissions, or partial recollection of compound words), then mark those responses as errors. If the subject misunderstands how a word is pronounced, then write what he/she says verbatim. If it does not match the word recited exactly, then it is an error.

Offer a drink of water or brief rest prior to completing the remaining trials. If, after completing the agility course, the subject's respiratory rate is increased, or if the subject reports exertional symptoms of headache or dizziness, then allow him or her to normalize before a new trial.

D.1. Word List Priority This task is first for subjects with odd ID numbers.

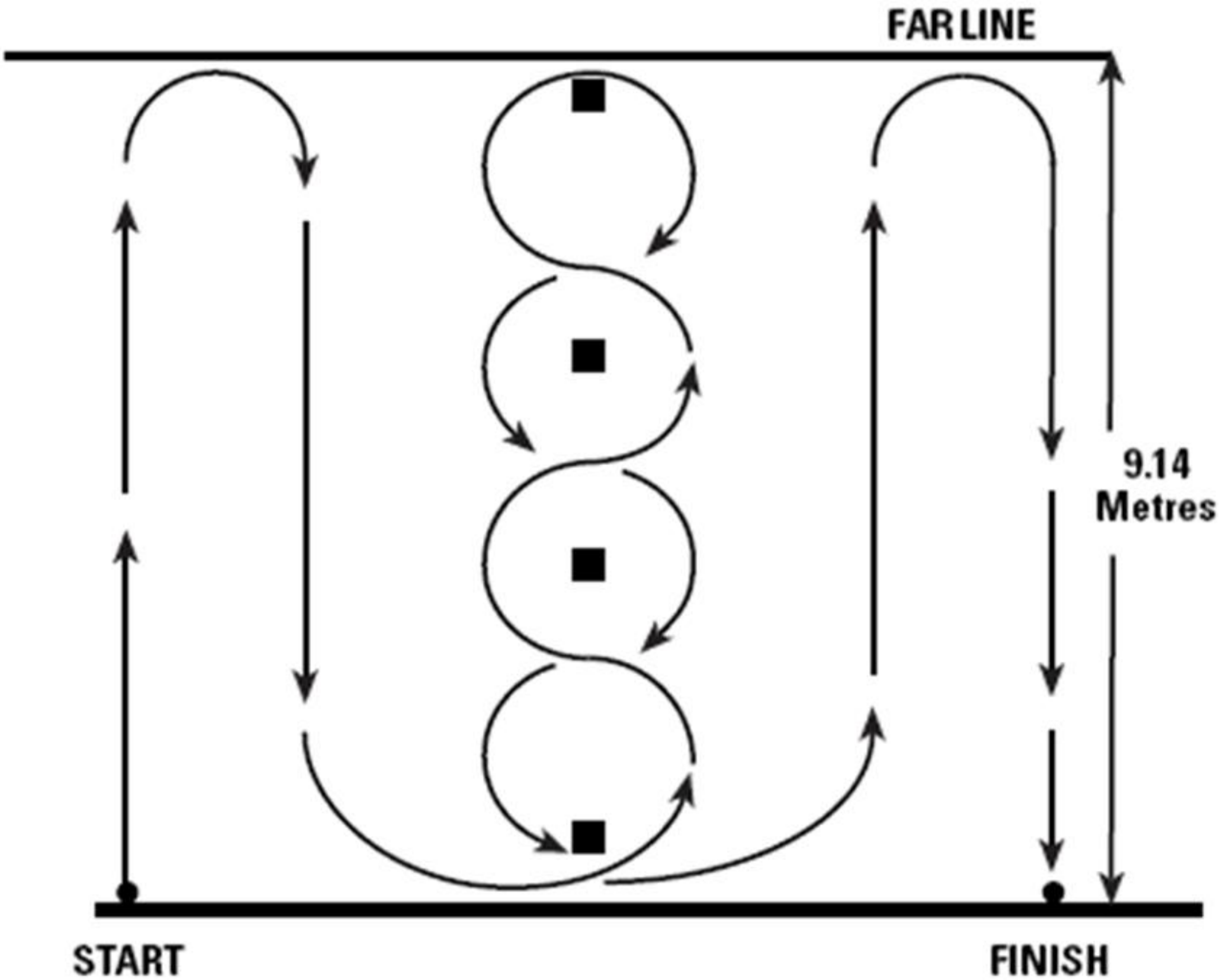
- **You are going to remember words and run again.**
- **This time I want you to focus on remembering as many words as you can while running the agility course.**
- **Let's see if you can remember all ___** (number) **words this time.**
- **Are you ready?**

Read the word list from the score sheet that corresponds to the number on the die that you rolled before testing. Read words at a rate of one per second, dropping voice inflection slightly on the last word in the sequence. Record the time it takes the subject to complete the course, and record the words recalled for each trial. Use a repeat trial if the subject does not follow instructions or stops before completing the trial.

D.2. Agility Priority This task is first for subjects with even ID numbers.

- **For this trial of words and running, I want you to focus on doing the agility task as quickly as you can while also doing the memory task.**
- **Let's see if you can beat your fastest time.**
- **Are you ready?**

Read the word list from the score sheet that corresponds to the number on the die that you rolled before testing. Read words at a rate of one per second, dropping voice inflection slightly on the last word in the sequence. Record the time it takes the subject to complete the course, and record the words recalled for each trial. Use a repeat trial if the subject does not follow instructions or stops before completing the trial.


FAR LINE
9.14
Metres
START
FINISH

Study ID:	Rater:	Date/Time:	Order:

ILLINOIS AGILITY TEST
Score Sheet

Did the subject complete the task? ☐ Yes ☐ No
If No: ☐ Examiner stopped task ☐ Subject stopped task

Did inertial sensor(s) malfunction? ☐ Yes ☐ No
If Yes: ☐ Head ☐ Trunk

<u>A. Single Task Condition – Agility Testing</u>
Trial 1: **Time __________** (sec) Repeat if errors in path.
Trial 2: **Time __________** (sec)

<u>B. Single Task Condition – Word List Task / Cognitive Task</u>
Complete this first word list task with a delay equivalent to the single agility task time. Then use the span of words remembered in this single word list task in future dual-task conditions.
Number of words remembered to be used in dual-task: ______

<u>C. Dual-Task Condition – WITHOUT priority instructions</u>
Mark correct words by number (i.e. 1, 2, 3) as they are recalled. Mark errors of omission from a list with an X. Record errors of commission (words added) to the list with an X. Words must be said verbatim or else it is an error. Note any errors from the agility course (i.e. incorrect path, contact with cones).

<u>D1 & D2. Dual-Task Condition – WITH priority instructions</u>
Same as C. above.

List 1: Trial # ___ ☐ single ☐ dual If dual: ☐ WITH instr. ☐ WITHOUT instr. ☐ word priority ☐ agility priority	**List 2: Trial # ___** ☐ single ☐ dual If dual: ☐ WITH instr. ☐ WITHOUT instr. ☐ word priority ☐ agility priority
1. Rifle	1. Helmet
2. Camelbak	2. Ammo
3. Socks	3. Tourniquet
4. Notebook	4. Pen
5. Tape	5. Eye pro
6. Knee pads	6. Ruck
7. Compass	7. Chemlight
Words Recalled Correctly: ______ **Word Errors: ______** **Agility Test Time: __________** **Agility Course Errors: ______**	**Words Recalled Correctly: ______** **Word Errors: ______** **Agility Test Time: __________** **Agility Course Errors: ______**

Study ID:	Rater:	Date/Time:	Order:

List 3 Trial # ___ ☐ single ☐ dual If dual: ☐ WITH instr. ☐ WITHOUT instr. ☐ word priority ☐ agility priority	**List 4 Trial #** ___ ☐ single ☐ dual If dual: ☐ WITH instr. ☐ WITHOUT instr. ☐ word priority ☐ agility priority
1. Radio	1. Protractor
2. Flashlight	2. Knife
3. Goggles	3. Bandoleer
4. Poncho	4. Watch
5. Magazine	5. Jacket
6. Bandage	6. DEET
7. Marker	7. Lanyard
Words Recalled Correctly: ______ **Word Errors:** ______ **Agility Test Time:** __________ **Agility Course Errors:** ______	**Words Recalled Correctly:** ______ **Word Errors:** ______ **Agility Test Time:** __________ **Agility Course Errors:** ______
List 5 Trial # ___ ☐ single ☐ dual If dual: ☐ WITH instr. ☐ WITHOUT instr. ☐ word priority ☐ agility priority	**List 6 Trial #** ___ ☐ single ☐ dual If dual: ☐ WITH instr. ☐ WITHOUT instr. ☐ word priority ☐ agility priority
1. E-tool	1. Ear pro
2. Boots	2. Batteries
3. Pistol	3. Sleeping bag
4. Duffel bag	4. Rope
5. Canteen	5. Cap
6. Gloves	6. Holster
7.Iodine	7. Scissors
Words Recalled Correctly: ______ **Word Errors:** ______ **Agility Test Time:** __________ **Agility Course Errors:** ______	**Words Recalled Correctly:** ______ **Word Errors:** ______ **Agility Test Time:** __________ **Agility Course Errors:** ______

10-29-12
Rev 7-24-2013
Rev 9-9-2013
Rev 10-12-2013
Rev 12-2-2013
Rev 1-13-2014
Rev 2-14-14

Illinois Agility & Equipment List Dual Task
Scoring Guide

Examiner scoring supplies/materials:

- A die or other means of randomly choosing word list order
- Stopwatch
- Clipboard
- Pencil
- Scoresheet

Definitions of key underlying concepts:

Words Recalled Correctly – the number of word list items that the subject correctly reports at the end of each trial

Word Errors – the number of intrusions (new words added) or words missed from the list used in a trial

Agility Test Time – time to complete the agility course from GO signal to when the first foot crosses the finish line (to the hundredth of a second).

Agility Course Errors – the number of times within a trial that the person does not adhere to course and/or requires cues to do so) [contacts a cone during the course, misses the second serpentine pattern and stops him/herself to correct it, e.g.]

Scoring procedures for performance subscores:

Before starting the task

Fill out the following:

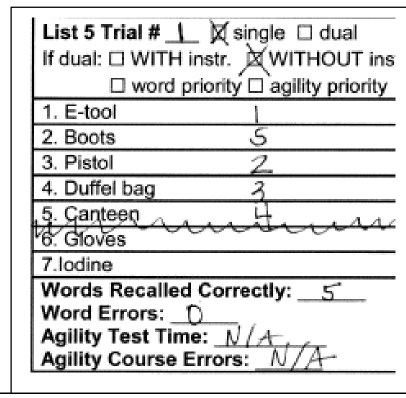
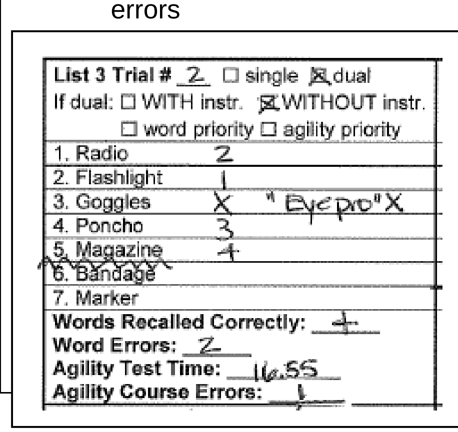
- Subject's study ID
- Your Rater ID
- Today's date
- Where in the test order the subject is performing this test-task
- Inertial sensor location(s), if applicable
- Item list order (determined by rolling die – if roll number 5 first, will use that word list for the first memory task trial)

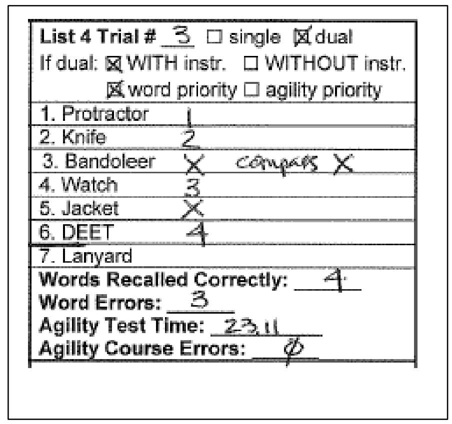
At task start

Roll a die to determine the order of the word lists that will be used with the subject; fill in the Trial # accordingly. Trial 1 is single task word list. Trial 2 is the WITHOUT instruction dual-task condition. Trials 3 and 4 are WITH Instruction priority conditions: for odd ID number subjects, Trial 3 is word priority and Trial 4 is agility priority; for even ID number subjects, Trial 3 is agility priority and Trial 4 is word priority.

During task

Performance dimension	Scoring procedures	Performance subscore
A. Single Task Condition – Agility Testing	The examiner starts the stopwatch when the participant is ready (at start line in prone position) and coincident with the "GO" cue.	Trial 1: Time = Time (in seconds) on stopwatch when the participant's first foot crosses the end line.

	If participant makes an error in the running path during the initial trial, repeat the trial in the single task conditions (A. Trial 2).	Trial 2: Time = Time (in seconds) on stopwatch when the participant's first foot crosses the end line.
B. Single Task Condition – Word List Task/Cognitive Task (Trial # 1)	Use the single task agility time from the last single task agility test as the "delay" for single task word list testing condition. After you present 7 words from the randomly chosen list, start the stopwatch. When the time for the agility task appears on the stop watch, ask for the participant to repeat the words he/she remembers. Record the words presented in order they are reciting. Write in any incorrect words that are recalled.	If SM recalls 5 or fewer words in this task, use 5 words in remaining dual-task trials. If SM recalls 6 or 7 words in this task, use that number in remaining dual-task trials. Mark this number on the first page of the scoresheet in the blank recorded for it. **Use this number as the word list length for dual-task trials. Mark this maximum word list length for each relevant trial as a reminder to stop at the correct number (e.g., only 5 words presented).**  List 5 Trial # 1 ☒ single ☐ dual If dual: ☐ WITH instr. ☒ WITHOUT ins ☐ word priority ☐ agility priority 1. E-tool 1 2. Boots 5 3. Pistol 2 4. Duffel bag 3 5. Canteen 4 6. Gloves 7. Iodine Words Recalled Correctly: 5 Word Errors: 0 Agility Test Time: N/A Agility Course Errors: N/A
C. Dual Task Condition – WITHOUT priority instructions (Trial #2)	The examiner presents the word list to the participant, pauses for 1 second, then starts trial with "Ready, set, Go" instruction. Start the stopwatch coincident with "GO". End the trial when the participant's first foot crosses the end line. After the agility task is completed, the participant reports as many words as he/she can remember from the list. In the box associated with Trial # 2, place a number next to each word in the order in which the subject reports back. Record any erroneous words that are reported as well. Count these as errors, meaning it is possible for the number of correct words and errors to add to more than the number of words provided.	In the box associated with Trial #2, fill in the following based on the definitions provided earlier in this scoring guide. • Words recalled correctly • Word errors • Agility test time (to the hundredth of a second) • Number of agility course errors  List 3 Trial # 2 ☐ single ☒ dual If dual: ☐ WITH instr. ☒ WITHOUT instr. ☐ word priority ☐ agility priority 1. Radio 2 2. Flashlight 1 3. Goggles X "Eyepro" X 4. Poncho 3 5. Magazine 4 6. Bandage 7. Marker Words Recalled Correctly: 4 Word Errors: 2 Agility Test Time: 16.55 Agility Course Errors: 1

D1. And D2. Dual Task Conditions WITH priority instructions (Trials # 3 & 4)	The priority for each condition is described before the word list is shared. The examiner presents the word list to the participant, pauses for 1 second, then starts trial with “Ready, set, Go” instruction. Start the stopwatch coincident with “GO”. End the trial when the participant’s first foot crosses the end line. After the agility task is completed, the participant reports as many words as he/she can remember from the list. In the boxes associated with Trials # 3 & 4, place a number next to each word in the order in which the subject reports back. Record any erroneous words that are reported as well.	In the boxes associated with Trials #3 & 4, fill in the following based on the definitions provided earlier in this scoring guide. • Words recalled correctly • Word errors • Agility test time (to the hundredth of a second) • Number of agility course errors  List 4 Trial # 3 ☐ single ☒ dual If dual: ☒ WITH instr. ☐ WITHOUT instr. ☒ word priority ☐ agility priority 1. Protractor 1 2. Knife 2 3. Bandoleer X compass X 4. Watch 3 5. Jacket X 6. DEET 4 7. Lanyard Words Recalled Correctly: 4 Word Errors: 3 Agility Test Time: 23.11 Agility Course Errors: Ø

IAT Scoring Frequently Asked Questions

Word lists

How should I score word list recall if the subject reports back a word with a similar meaning as the correct word?

Word list recall must be exact to be counted as correct.

What if a SM remembers a word from the list after they’ve said the words they remember and you’ve written their responses down?

As long as they recall the word correctly before you go on to the next trial, count the recall as correct.

Agility course

How should I score Agility Course Errors if subject forgets to serpentine back toward the finish line but then self-corrects?

Count this as a single error. This often will slow their time on the agility course significantly, so the error will be accounted for in time in addition.

INSTRUMENTED STAND AND WALK-GRID COORDINATES (ISAW-Grid)

Instrumented Stand and Walk (ISAW) – Grid Coordinates
Description and Task Set Up

Description: The SM is challenged to perform the Instrumented Stand and Walk (ISAW) test (developed by APDM) which includes instrumented and timed assessment of quiet standing for 30 seconds, assessment of dynamic stability during walking for two 7 m (23 foot) lengths with a 180 degree turn at midpoint (Mancini et al 2012). The SM will next memorize an 8 digit alphanumeric grid coordinate provided within the context of a simulated patrol mission brief and report the exact sequence back to the examiner after 45 seconds. Finally, both the ISAW and the grid memorization tasks will be performed simultaneously. Accuracy of grid coordinate recall, postural sway area, gait path variability, and time to complete the ISAW (i.e. gait speed) will be measured in single and dual-task conditions.

Purpose: This task will assess balance and gait stability as well as working memory under sub-maximal exertion conditions. The ability to learn and retain operationally relevant information such as that provided in this task while moving to an assigned mission location has relevance to functional duty demands.

mTBI-related task challenges: Primary ● Secondary ○

Cognitive				Sensorimotor				Physical		
Executive function	Memory	Attention	Reaction time	Eye gaze tracking	Scanning	Vestibular	Balance	Bend-lift	Exertion	Manual UE Speed
	●	○				○	○			

Source: ISAW methods based on the work of Mancini M, King L, Salarian A, Holmstrom L, McNames J, and Horak F, Mobility Lab to Assess Balance and Gait with Synchronized Body-worn Sensors. J Bioengineer & Biomedical Sci 2012

Materials and Supplies

- Blue painter's tape to mark the initial standing position of subject's feet, the turn point at the end of the walkway and a box to stand in which is just past the start position for subject to stop in at the end of the walk (See Figure 1).
- Clipboard with Score sheet that has Grid coordinate lists
- Pencil
- Stopwatch
- Opal or NexGen inertial sensor, MobilityLab (Opal) software, and wireless data collection port with computer, Opal hand held controller. www.apdm.com/mobility

The Opal system, which is used to quantify participant position changes, velocity and acceleration, consists of three, wrist watch-sized wearable inertial sensors attached to participants at the waist and on each lower leg. These sensors record data obtained during testing, which is down loaded onto a dedicated laptop computer for analysis and output.

Test Task Set Up

- 30' x 5' testing area
- Laptop and set up table positioned ~ 5 feet from the activity start point for ease of monitoring and set up.
- Refer to the set-up manual from *MobilityLab User's Guide* for the specific set up/floor markings and distances (Figure 2).

Figure 1. Subject walking towards box to stand in.

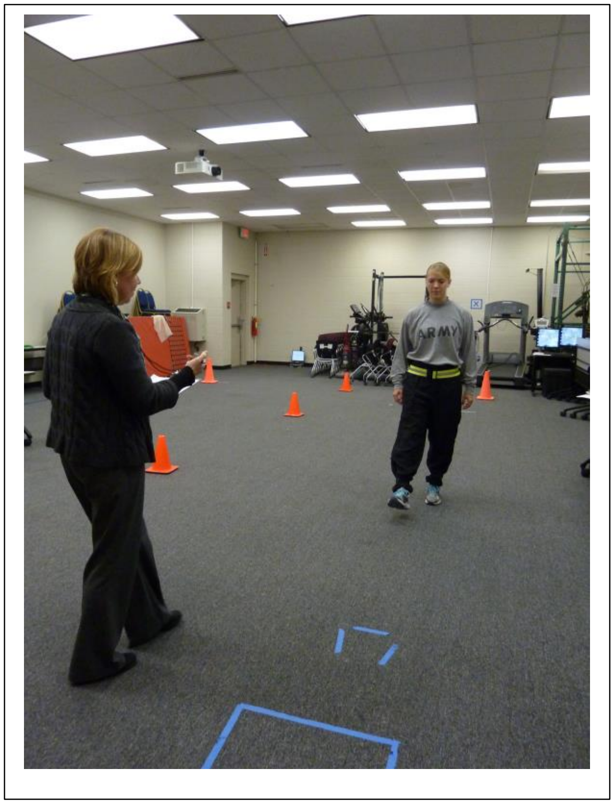
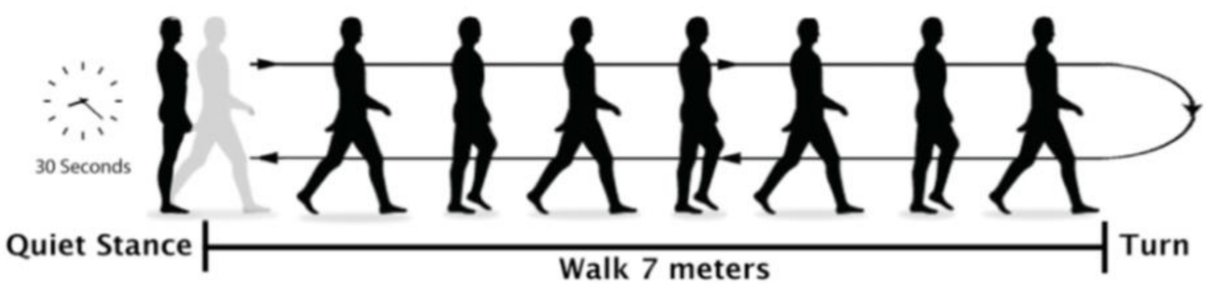


Figure 2. ISAW distances



ISAW – Grid Coordinates
Examiner Instructions and Script

Before testing roll a die to randomly pick one of the six grid coordinate combinations. Circle the number condition on the scoring sheet. This number will be standardized across all remaining test conditions.

INTRODUCTION

This dual-task is called the Instrumented Stand and Walk (ISAW) – Grid Memorization Task. It will assess your standing posture, walking and memory within the context of a military patrolling scenario. Accelerometers measure your speed and position changes during the test.

Put the Opal accelerometers on the participant's ankles and around his or her waist.

INSTRUCTIONS

This test has one practice trial and several assessment trials. The task requires standing still and walking, a memory task, and then several trials of doing both together.

I will orient you to each condition before it begins.
Do you have any questions?

- Standardize foot placement on the blue tape marks which are marked on the floor around the Opal standardization board at the start line.

<u>Practice Stand and walk:</u>

The walking task has two parts, standing followed by walking. Stand with your feet on these blue tape marks. Your eyes should be open and focusing on the "X" on the wall, your arms at your sides. When I say "begin" you'll stand quietly for 30 seconds.

- Point to the X marked on the wall at the end of the room, this should be put just above eye level at the far end to the testing room; tape marks on the floor should be set up ahead of time using the trapezoid like block from the Opal box).
- Demonstrate the walking and turn (see Opal video) by walking the 8-10 steps before the turn, demonstrate a correct pivot turn and then walk back toward start 8-10 steps.

Then I'll say "walk". When you hear this, walk at a brisk, comfortable pace to the tape, cross the tape, turn around and return to the box here. (Have a taped outline of a box about 18" square about 3 feet before the start line—which is past the start line on the return trip.) **Stand motionless in the box for a few seconds while the computer finishes processing the trial. I'll say "RELAX", and then you can step out of the box.**
Do you have any questions?

- Perform the PRACTICE ISAW single task condition. Use your stopwatch to time a 30 second stand and then give command "WALK" and have them stop in the tape outlined box which is behind the start line. Total time is about 45 seconds depending on their walking speed. If the subject does not perform the turn correctly (e.g., a pivot turn as demonstrated), repeat the turn instructions and verify their understanding.

1. Single Task: Motor (Balance and walk [ISAW]):

Now we are going to repeat the walking task a few times with the computer recording your movement. Do you have any questions before we begin?

- Perform the ISAW single task condition. The ISAW program is started when you say "BEGIN" and it is stopped when the subject stops in the taped square box after the accelerometer tracing has essentially flat-lined. After the "3…2…1" countdown on the computer screen, say **"RELAX"** and the subject returns to the start position.
- Perform 3 recorded trials in all. After the first trial say "**We will do that same thing 2 more times"**. After the second trial say "**We will do that one more time".**
- If the subject needs a reminder of the standardized start position say **"Arms at your sides, feet on the lines, focus your gaze on the "X", READY?"**….

2. Single Task: Cognitive only (Grid Coordinates Recall and Backbrief):

Next we are going to do a memory task. In this scenario, you are a squad leader in a reconnaissance unit. Your Commander has instructed you to perform a recon operation in the vicinity of grid coordinates that will be provided. I will read 2 letters and 6 numbers to you ONLY one time

During this task there are several rules:

1) **Do what is necessary to remember the coordinates, but you may not repeat them out loud or write them down.**
2) **Listen carefully, as you need to remember them in the order that they were given.**

After 45 seconds I will say "now". At that time tell me the letters and numbers that you remember.

Do you have any questions?
Are you ready? Let's begin…

- Refer to score sheet for the script and list of grid coordinates. Use selected coordinates based on die roll.
- Read 1 digit per second. Drop vocal inflection on final digit to communicate list completion.
- Start timing on the stopwatch approximately ½ second after you say the final grid digit and at 45 seconds say **"NOW".**

During memory recall 45 seconds later, the examiner will write down the letters and numbers vocalized by the participant on the scoring sheet in the order they are provided. A maximum of 8/8 points may be achieved for this condition. If the participant ~~does~~ remembers less than half of the letters/numbers correctly, do a repeat trial to ensure they understand the instructions.

3. Dual-Task Motor Cognitive
3a. Dual Task (Walking and Grid Recall and Backbrief)

Now we'll combine the stand and walk test with the GRID recall task. FORGET the last GRID coordinates I asked you to remember. I would like you to REALLY FOCUS ON remembering the grid coordinates during these trials. I will give you a new set of grid coordinates, then I will say "Begin" for the standing portion. After 30 seconds I will say "walk". You will walk the course as before. When you get back to the box, state the letters and numbers that you remember. Wait until I say "Relax" before stepping out of the box. Do you have any questions?

- **Arms at your sides**
- **Focus your gaze**
- **Feet on the markers**
- **Remember the grid coordinates in the correct order AND be prepared to walk the course when I say "Walk" as you have done in the other stand-walk conditions.**
- **Stop in the box and when I give the command "Now", repeat the coordinates that you remember. Wait until I say "RELAX", before stepping out of the box.**
- See the score sheet for script and choice of grid coordinates.

Mission Brief: **Change in mission, new grid coordinates are_____________**
Start timing on the stopwatch when you say "walk". Record the time on the scoresheet for each trial.

3b. Dual Task (Walking and Grid Brief back)
We will do that same thing 2 more times. Please FORGET the last set of GRID coordinates I asked you to remember.
Refer to score sheet for script and choice of grid coordinates.

3c. Dual Task (Walking and Grid Brief back)
This is the last trial. Again, please FORGET the last set of GRID coordinates I asked you to remember.
Refer to score sheet for script and choice of grid coordinates
Remember… (say this if they need a reminder of the start position)

- **Arms at your sides**
- **Focus your gaze**
- **Feet on the markers**

Study ID:	Rater:	Date:	Order #:

Did SM complete the task? ___Yes ____No (examiner stopped) ____No (subject stopped)

ISAW Grid Test-Task Scoring Form

1. SINGLE TASK MOTOR
a. Time to complete 7 meter walk (single task condition): __________ (sec:XX).
b. Time to complete 7 meter walk (single task condition): __________ (sec:XX).
c. Time to complete 7 meter walk (single task condition): __________ (sec:XX).

1. Median time (Middle value of a. or b. or c. here) to complete 7 m walk_______(sec:XX)

(Circle Selected Grid Assignment 1-6 for all cognitive conditions)
2. SINGLE TASK COGNITIVE "*The Recon Operation is in the vicinity of_____"*

Assigned Grid Coordinate *Reported Grid Coordinate (write exactly as spoken)*

- *1) Uniform Charlie 6-1-9-4-7-3* ___________________________
- *2) Bravo Gulf 3-9-2-4-8-7*
- *3) Zulu Mike 5-9-1-7-4-2*
- *4) Echo Quebec 6-5-9-3-7-2*
- *5) Delta Tango 4-9-7-3-9-2*
- *6) Sierra Oscar 4-1-7-9-3-8*

Number of grid coordinates accurately recalled in correct order (single task cognitive condition):
2. _________ (Max Score 8)

3. DUAL TASK MOTOR-COGNITIVE
(Circle Randomly Selected Grid Assignment 1-6 for all cognitive conditions)

TRIAL 3A "*Change in mission, new grid coordinates are_________"*
Assigned Grid Coordinate *Reported Grid Coordinate (write exactly as spoken)*

- *1) Romeo X-Ray 3-8-2-9-5-1* _________________________
- *2) Whiskey Alpha 3-7-6-2-1-9*
- *3) Foxtrot Kilo 5-8-1-9-2-6*
- *4) Yankee Papa 2-7-5-8-6-2*
- *5) November India 3-5-4-8-5-1*
- *6) Oscar Hotel 7-1-3-9-4-2*

3a1. Time to complete 7 meter walk (dual task condition): ________ (sec:XX).

3a2. Number of grid coordinates accurately recalled in correct order (dual task condition):
_________ (Max Score 8)

Study ID:

TRIAL <u>3B</u>"*Change in mission, new grid coordinates are_________*"

Assigned Grid Coordinate *Reported Grid Coordinate (write exactly as spoken)*

- *1) Charlie Tango 5-3-8-9-1-4.* ______________________________
- *2) Lima Victor 2-4-7-5-9-1*
- *3) Delta Juliet 3-6-1-9-5-2*
- *4) Alpha November 2-5-3-9-4-1*
- *5) Yankee Quebec 8-1-4-9-6-3*
- *6) Papa Bravo 4-1-3-7-5-2*

<u>3b1</u>. Time to complete 7 meter walk (dual task condition): ________ (sec:XX).

<u>3b2</u>. Number of grid coordinates accurately recalled in correct order (dual task condition): _________ (Max Score 8)

TRIAL <u>3C</u>"*Change in mission, new grid coordinates are_________*"

Assigned Grid Coordinate *Reported Grid Coordinate (write exactly as spoken)*

- *1) Mike Sierra 4-1-7-9-2-5.* ________________________________
- *2) Hotel Echo 1-5-3-0-4-6*
- *3) Juliet Uniform 2-5-1-9-3-7*
- *4) Kilo Victor 8-3-5-9-2-4*
- *5) Gulf Whisky 9-2-5-8-3-7*
- *6) Lima India 2-6-9-3-5-1*

<u>3c1</u>. Time to complete 7 meter walk (dual task condition): ________ (sec:XX).

<u>3c2</u>. Number of grid coordinates accurately recalled in correct order (dual task condition): _________ (Max Score 8)

Grid coordinate scoring:

1) Digits correct if:

- first or last digit is correct if stated correctly in first or last place
- any digits adjacent to first or last digit is correct
- a correct sequence of three or more anywhere in span

2) Letters correct –must be in the correct position (said first or second) and order to be counted as correct.

3) If subject says grid coordinates incorrectly and then rapidly corrects him/herself, the corrected version is written down and scored.

ISAW-Grid
SCORING INSTRUCTIONS

Examiner scoring supplies/materials:

- Stopwatch
- Clipboard
- Pencil
- Subject score sheets and administration instructions
- Opal Movement Monitor, laptop and sensors with ankle and waist straps
- Army Phonetic Alphabet knowledge; for example that "D" is Delta, "L" is Lima so when the subject says "Delta" you write down "D".

At the start of the task the rater has the subject set up with the sensors in place (ankles and waist) and has the OPAL (ISAW) computer and system turned on.
Before starting the task, the rater fills out the following:
Subject's study ID
Your Rater ID
Today's date
Test order (testing 1st, 2nd …6th of the test tasks)

Section 1) For **the SINGLE TASK MOTOR**, the rater times how long it takes the subject to walk from the "WALK" verbal signal until his or her front foot crosses the start line, then fills in the blank 1a, 1b, or 1c on the score sheet, depending on trial. The examiner records the time to the nearest second using a stopwatch (1.a, 1.b, 1.c).

The MEDIAN TIME is the median or middle value of the 3 (1a, 1b, or 1c) and is filled in after the 3rd single task walking trial (BLANK 1).

Section 2) The rater circles which one of the "Assigned Grid Coordinate" choices for **SINGLE TASK COGNITIVE** was presented to the subject at the beginning of the trial (random choice by use of a dice to determine grid coordinate 1-6 for each trial). At the end of the elapsed time, the examiner says "NOW" and the rater writes exactly what the subject says on the blank line for Single Task Cognitive (for example, "BE 3 9 4 2 8 7").

In Blank 2, the examiner writes the # of grid coordinates recalled in the correct order.

NOTE: The examiner should count the number of alpha-numeric digits reported and scored per the scoring instructions on the score sheet (scoring rules included below also).

Grid coordinate scoring:

1) Digits correct if:

- first or last digit is correct if stated correctly in first or last place
- any digits adjacent to first or last digit is correct
- a correct sequence of three or more anywhere in span

2) Letters correct –must be in the correct position (said first or second) and order to be counted as correct.

3) If subject says grid coordinates incorrectly and then rapidly corrects him/herself, the corrected version is written down and scored.

Section 3 A, B, C) The rater circles which one of the “Assigned Grid Coordinate” choices for **DUAL TASK MOTOR-COGNITIVE Trial 3A** was presented to the subject at the beginning of the trial. At the end of the elapsed time during which the subject is standing and walking the course, the examiner says “NOW” and writes down exactly what the subject says on the blank line for Dual Task Trial 3A (for example “BE 3 9 4 2 8 7”). This is repeated for Dual Task 3B and 3C.

For 3a1, 3b1, 3c1 – Record the amount of time to complete the 7 meter stand and walk to the nearest second (use hand held stopwatch).

For 3a2, 3b2, 3c2 – Write down the # of grid coordinates recalled in the correct order using the Grid Coordinate scoring rules described above.

<u>After subject has completed task</u>

- Name each data file on the OPAL system laptop using the participant’s unique study ID number, task (single task/ dual task) condition, and trial (1,2, or 3) (e.g., 046#4_ST2 or 046#4_ DT3)
- Validate and save the Opal recordings at the completion of each test condition
- If not already complete, record the number of correctly identified grid coordinates in the appropriate fields (cognitive demand) on the scoring sheets.
- Ensure all motor performance scores (times in seconds) are correctly and legibly recorded on the scoring sheets.
- Note that Dual-Task Costs for motor and cognitive task performance will be calculated automatically within the data base spread sheet.

EXAMPLES FOR COUNTING GRID COORDINATE Letters and Numbers:

Subject B was able to report 7 of the 8 letters/digits from the chosen grid coordinate. If for example the subject is given:

“A (alpha)-Z (zulu)-4-8-1-6-2-9” The response is “A-Z-8-4-1-6-2”

[first two are correct (A,Z), second two transposed (both incorrect), next three correct (1,6,2), one digit omitted (9)].

The total number of correct numbers/digits is 5 of 8.

Subject C was able to report 8 letters/digits from the chosen grid coordinate. If for example the subject is given:

“*<u>J</u>uliet <u>U</u>niform 2-5-1-9-3-7*” The response is “U-I-*2-5-1-9-3-7*” (i.e., “Uniform-India_2-5-1-9-3-7”)

[U is transposed (incorrect); I is incorrect, the remainder of the digits are correct].

The total number of correct numbers/digits is 6 of 8.

LOAD MAGAZINE-RADIO CHATTER

Load Magazine-Radio Chatter Listening
Task Description and Set Up

Description: SM completes a relatively automatic manual task choosing from a bin of mixed size dummy rounds (5.56 and 7.62 caliber) and loading 5.56 caliber training rounds into magazines as fast as possible both in a single and a dual task condition. The dual-task condition requires monitoring radio communication and verbally announcing when radio chatter is relevant to scenario instructions.

Purpose: The purpose of this task is to assess the cost of a cognitive task overlay on the speed of a relatively automated upper extremity manual task. This task is intended to challenge attention allocation (divided attention), sustained attention, executive function, manual dexterity/speed, and auditory processing.

mTBI-related task challenges: Primary ● Secondary ○

Cognitive				Sensorimotor				Physical		
Executive function	Memory	Attention	Reaction time	Eye gaze tracking	Scanning	Vestibular	Balance	Bend - lift	Exertion	Manual UE Speed
○		●								●

Source: Based on the work of Cicerone (1996) assessing dual task measures in persons with mTBI. Cicerone, K. D. (1996). Attention deficits and dual task demands after mild traumatic brain injury. *Brain Injury, 10*(2), 79-89.

Materials and Supplies

- 1-gallon open bin or tub for holding snap cap 5.56 caliber (M16) and 7.62 caliber (foil) dummy rounds
- 2nd empty bin for emptying magazine(s) to allow for counting the number of rounds loaded
- 100 snap cap dummy rounds (M16)
- 50 snap cap dummy rounds (M20) as foils
- 5 magazines for M16 caliber weapon
- Computer or audio-player such as an I-pod or MP3 player
- Speakers to play radio chatter audio files at sufficient volume.
- 3 versions of prerecorded ambient mock radio chatter.
- Radio chatter Audio files
- Cue sheets-set of 3 laminated sheets for reminding subjects of "key words" they are responding to during each trial (Practice, single task, dual task)

Test Task Set Up
<u>Space estimate:</u> 6x6 foot area with rectangular table and 2 chairs

Table is set up so that 4 M16 magazines are directly in front of subject with the bin of mixed rounds either to right or left side depending on subject preference. Speakers and audio player are close enough to play the sound directly in front of the subject. (See Figure 1.)

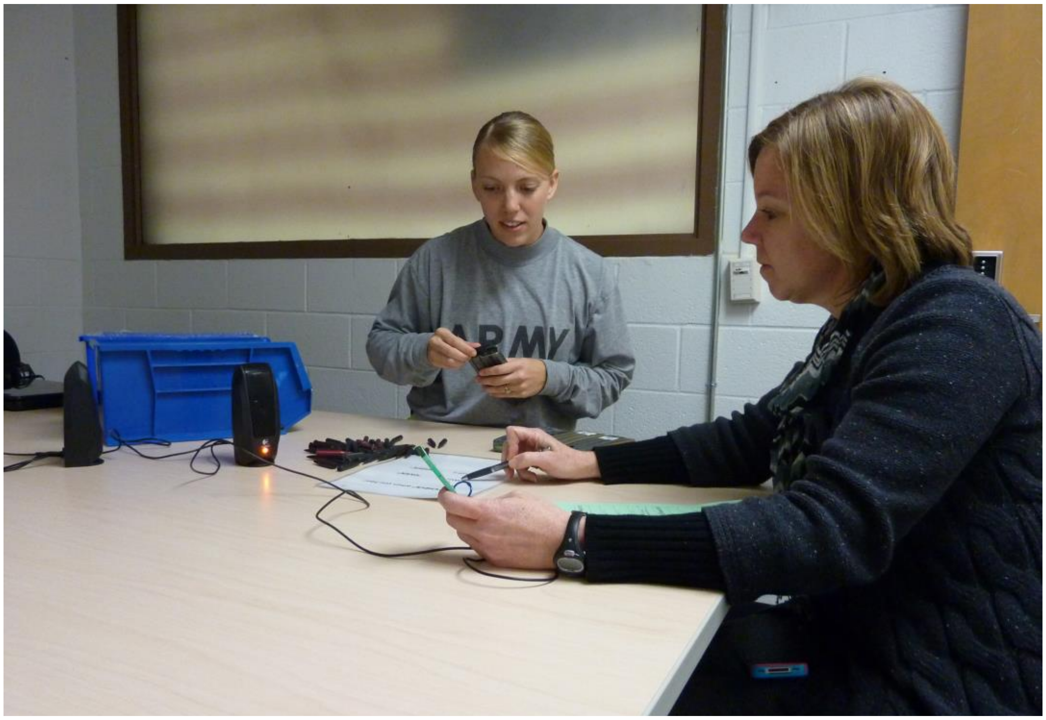


Figure 1: Load-Magazine-radio chatter set up. NOTE: M16 dummy rounds are kept in the bin during the trials, they are displayed here to show what they look like.

Load Magazine-Radio Chatter Listening
Examiner Instructions and Script

INTRODUCTION

- **For this task you will load M-16 dummy rounds into magazines and will listen to recorded radio chatter for specific *key* words.**
- **First you will practice both tasks by themselves. Then you will perform a recorded trial for each task separately, and then do both tasks simultaneously.**

Allow SM to practice loading rounds for 10-50 seconds or so as you are setting up, if you are already set up, you can skip this practice and just move straight in to the two 60 second trials.

Make sure that the volume is turned up relatively loudly so that the white noise is audible and slightly distracting.

INSTRUCTIONS

1. Magazine Loading Practice:

- **I want you to load M16 rounds from this bin into these magazines as *FAST* as you can for 60 seconds. I'll time you and then we will count them. If one of the magazines jams or gets stiff, just set it down and pick up a different one. If you drop a round on the floor don't try to get it, just pick up another round from the bin and keep loading. Start at magazine "1" and go through "4". The magazines hold 30 rounds.**
- **Any questions?**
- **Ready?…GO.**
- Time for 60 seconds with the stopwatch and call out **"STOP".**
- Empty filled magazines into the padded blue bin and count them, recording the total rounds loaded on score sheet.
- Return dummy rounds to the full bin and REPEAT.

- **Now for a 2nd 60 second practice trial, remember load as *FAST* as you can.**
- **Ready? ….GO**
- Record the number of rounds loaded in the 2nd practice trial on the score sheet.

NOTE: If, over time the magazines start malfunctioning, move to using #4 first and go to #1. The point is that it needs to be with the same magazines in single and dual task trials. For example, brand new magazines are much stiffer and harder to fill than the used ones.

2. Single Task Magazine Loading:

- **Again, I want you to load M16 rounds as *FAST* as you can.**
- **This time I'll use a recording that has radio static and a BEEP TONE sound. Start loading at the first BEEP and Stop when it BEEPS again. You will load for a little more than 2 minutes this time. Remember, if the magazine jams or gets stiff, set it down and pick up a different one. If you drop a round, keep going. We will get it later.**
- **Do you have any questions?** Answer all questions.

- **Ready?** Start the recording.

After the 2nd BEEP and subject stops loading, empty filled magazines into the padded blue bin and count them, recording the total rounds loaded on score sheet. Return dummy rounds to the full bin.

3.Radio Chatter Responses Practice:

Hand the TRAINING Scenario Sheet to the subject and review Key Words while pointing them out.

- **Now I am going to play a recording of radio chatter about the logistics of an FTX for several platoons. This is for practice.**
- **You are a radio operator monitoring the company communications network for an upcoming "Whiskey" Company FTX. Ignore the BEEP tones in the recording.**
- **Your task will be to report Specific Key Words in the chatter regarding the FTX.**

    - **When WOLF 7 says "OVER" whenever he is speaking, Say *"CHECK" LOUDLY***
    - **When WOLF 2 says "ROGER" whenever he is speaking, Say "CHECK"*LOUDLY***
    - **"Other people will say these words; ONLY respond to WOLF 7 and WOLF 2**

- **Do you have any questions?** (Answer all questions.)
- **What words are you responding to?** Make sure subject is correct. ASK THIS QUESTION BOTH with the Training Scenario in view and again with the sheet out of sight.
- **Ready?**

After the recording is completed, review the score sheet with the subject and tell them where their errors were made.

If the subject is 100% correct or makes a maximum of 1 mistake on the first practice trial and he/she does not want to run through the practice trial a 2nd time, then only play the TRAINING Scenario once.

If a 2nd practice is needed, replay the recording and mark the training score sheet in the second column. Again review the score sheet with the subject and tell them where their errors were made.

EXAMINER GUIDANCE/REMINDER:

- If the SM speaks softly during first trial, instruct him/her to speak louder and/or move closer.
- If the SM makes 0 or 1 mistake, he/she does not need a 2nd practice.
- If the SM makes 2 or more mistakes, he/she must complete a 2nd practice.

4. Radio Chatter Responses (Test 1: Single Task Condition) (Test_Script_1):
Hand the TEST1 Scenario Sheet to the subject and review Key Words while pointing them out.

- **Now I am going to play a new recording of radio chatter about a different FTX. Please ignore the BEEPS in this recording.**
- **You are now monitoring communications for a "Tango" Company FTX. Your task is the same as in the practice but the key words are different.**

    - **When TIGER 4 says "OVER", Say "CHECK" LOUDLY**
    - **When TIGER 7 says "BREAK", Say "CHECK" LOUDLY**

- **Do you have any questions?** Answer all questions.
- **What words are you responding to?** Make sure subject is correct, with scenario sheet in view and again with it out of view. The point is to make sure the last thing the subject is thinking about is the KEY WORDs and not about other off task topics. This must remain consistent throughout all trials.
- **Ready?**

Start the tape, and mark the score sheet.

5. Dual-Task: Magazine Loading and Radio Chatter (Test_Script_2):
Hand the TEST2 Scenario Sheet to the subject and review Key Words while pointing them out

- **Now we are going to combine loading M16 magazines and reporting on KEY words.**
- **Load rounds as fast as you can. If a magazine jams just set it down and start a new one. If you drop a round, don't chase it, just keep loading. Start loading with the first BEEP TONE. Keep loading after the radio chatter stops until the 2nd BEEP sounds.**
- **You are now monitoring communications for a "Sierra" Company FTX.**
    - **When STRIKER 2 says "OVER", say *"CHECK"LOUDLY***
    - **When STRIKER 7 says "BREAK", say "CHECK" LOUDLY.**

- **Do you have any questions?** Answer all questions.
- **What words are you responding to?** Make sure subject is correct, once with scenario sheet in front of them and once with it out of sight.
- **Ready?**

Start the tape and mark the score sheet.

Study ID:	Rater:	Date:	Order #:

Did SM complete the task? ____Yes ____ No (examiner stopped) ___No (subject stopped)

Military Radio Chatter Test-Task Scoring Form (Training Script)

Rounds loaded Practice 1 (60 s)	
Rounds loaded Practice 2 (60 s)	
Rounds Loaded Single Task (130 s)	**1.**
Rounds Loaded Dual Task (130 s)	**2.**

Correct Responses: **"Check"** when **Wolf 7 says "OVER"** or **Wolf 2 says "ROGER".**

Graded Script	**Over/Roger Points**	
	Time 1	Time 2
Wolf 2: Wolf 7 this is Wolf 2, **over**.		
Wolf 1: Wolf 7 this is Wolf 1, **over**.		
Wolf 7: This is Wolf 7. Battalion has authorized Whiskey Company to commence with FTX in 3 weeks, **OVER**.		
Wolf 2: This is Wolf 2.**ROGER, over**.		
Wolf 1: This is Wolf 1. Copy on the FTX. **Break**.		
Be advised, we are down 1 squad and 3 vehicles at this time, **over.		
Wolf 7: This is Wolf 7. Wolf 1, Coordinate with the NCOIC from second platoon to cross level the troops and vehicles you'll need for the op **OVER**.		
Wolf 1: This is Wolf 1. **Roger** that. **Break**.		
Our other training challenge is that the additional M-16 range we requested for the FTX is already occupied by C Battery that week, **over.		
Wolf 2: This is Wolf 2. **ROGER**,		
Weapons qual is a challenge for us too. If we don't identify another range, two of our squads will be RED on their training status for the Commander's QTB, **over.		
Wolf 7: This is Wolf 7. Schedule the second range the week after the FTX. **Break**.		
I will clear it with Battalion S-3, **OVER.		
Wolf 1: This is Wolf 1. **Roger** that, **over**.		
Wolf 2: This is Wolf 2. Copy last transmission. We'll take the lead on the second range, **over**.		
Wolf 7: This is Wolf 7. **Roger** that.		
Wolf 2, have LT Smith come see me for the range book. **Break.		
Also, have operations contact range control to re-confirm availability of our primary range during the FTX, **OVER.		
Wolf 1: This is Wolf 1. WILCO, **over**.		
Wolf 2: This is Wolf 2. **ROGER, over**.		
Wolf 7: Wolf 7, **OVER** and out.		
Totals: 5 –"over" 3 – "Roger" Possible Distractors: (13 of both Over and Roger or Break)	**Correct ___/8** **Distract ___/13**	**Correct ___/8** **Distract ___/13**

**continuation of speaker from prior line

RATER INFORMATION:
-Clear area is correct check mark; shaded area is error check mark.
-Indicate in box if Subject says "CHECK" for any phrase, before the next keyword.

Study ID:	Rater:	Date:	Order #:

Military Radio Chatter Grading Sheet (**Test Script 1-Single)**

Correct Responses: **"Check"** when **Tiger 4 says "OVER"** or **Tiger 7 says "BREAK".**

Graded Script	Over/Break Points
Tiger 3: Tiger 7 this is Tiger 3, **over**.	
Tiger 7: Tiger 3 this is Tiger 7, go ahead, **over**.	
Tiger 4: Tiger 7 this is Tiger 4. **OVER**.	
Tiger 7: This is Tiger 7. Next week's training exercise will be conducted in training area XZ. **BREAK**.	
Key leaders need to give me a SITREP on their status by 1600 today, **over.	
Tiger 4: This is Tiger 4. **Roger, OVER**.	
Tiger 3: This is Tiger 3. Copy last transmission. **Break**.	
Are we still covering Class I for all phases of the exercise, **over?	
Tiger 7: This is Tiger 7. Negative. The initial piece is yours but resupply will be on Tiger 4 at Day 3, **over**.	
Tiger 3: This is Tiger 3. **Roger, over**.	
Tiger 4: This is Tiger 4. Copy last transmission. **Break**.	
Tiger 7, can you verify that our assets are also tasked to provide the command group transport to and from the FTX, **OVER.	
Tiger 7: This Tiger 7. Affirmative, **over**.	
Tiger 3: This is Tiger 3. Tiger 4, be advised the DFAC has 10 cases of water and MRE's ready for pick up, **over**.	
Tiger 4: This is Tiger 4. **Roger** that, **OVER**.	
Tiger 7: This is Tiger 7. Tiger 3 also be prepared to transport the Class V to the training area if we receive final approval that the qualification range is a "go", **over**.	
Tiger 3: This is Tiger 3. **Roger** that, **over**.	
Tiger 4: This is Tiger 4. Battalion tasked out our supply vehicles through the end of next week. **Break**.	
We will need two additional vehicles to cover the resupply mission while keeping a vehicle open to transport the command group **OVER.	
Tiger 7: This is Tiger 7. Tiger 4, coordinate with the Tiger 3 to cross level 2 vehicles for the mission. **BREAK**.	
We need that done by COB today, **over.	
Tiger 4: This is Tiger 4. Roger Top, we will tap SGT Jones on that at the planning meeting **OVER**.	
Tiger 7: This is Tiger 7. Tiger 3, what is your status on drivers at this time? **BREAK**.	
Can you assist Tiger 4 with additional personnel for his taskers, **over?	
Tiger 3: Tiger 7, this is Tiger 3, We'll cover it Top, **over**.	
Tiger 7: Tiger 7, **over** and out.	
TOTALS	**3. Correct ____/ 9** **4. Distractors _____/17**

**continuation of speaker from prior line

RATER INFORMATION:
-Clear area is correct check mark; shaded area is error check mark.
-Indicate in box if Subject says "CHECK" for any phrase, before the next keyword.

Study ID:	Rater:	Date:	Order #:

__Military Radio Chatter Grading Sheet__ **(Test Script 2-Dual)**

Correct Responses: **"Check"** when **Striker 2says "__OVER__"** or **Striker 7 says "__BREAK__".**

Graded Script	Over/Break Points
Striker 7: Striker 2 this is Striker 7, **over**.	
Striker 2: Striker 7 this is Striker 2. Go ahead, **__OVER__**.	
Striker 7: This is Striker 7. Day 1 Ops at the FTX will include establishing all tactical checkpoints and setting up the bivouac site. **__BREAK__**.	
Striker 2 NCO's will teach immediate action drills: reaction to ambush; react to indirect & direct fire, **over.	
Striker 2: This is Striker 2. **Roger, __OVER__**.	
Striker 7: This is Striker 7. On days 2 & 3 Striker 2 NCO's will teach their elements small unit patrolling, individual & squad movement techniques, and first aid training. **__BREAK__**.	
They will also cover communications and UXO training, **over.	
Striker 2: This is Striker 2. **Roger, __OVER__**.	
Striker 1: This is Striker 1. We are responsible for teaching Land Nav on day 3. **Break**.	
Can we move that block of instruction today 4, **over?	
Striker 7: This Striker 7. Negative, cover it on day 3but coordinate the start time with Striker 2, **over**.	
Striker 1: This is Striker 1.**Roger**, **over**.	
Striker 2: This is Striker 2.**Roger**, **__OVER__**.	
Striker 7: This is Striker 7. Striker 1on days 4 & 5 your NCO's will teach NBC decon, SALTE reports, and MEDEVAC lanes, **over**.	
Striker 1: This is Striker 1.**Roger**, **over**.	
Striker 2: This is Striker 2. Striker 1, we have the training plans and materials from last year's FTX if you need them. **Break**.	
SGT Jones will be the POC if you want to sign for the training materials, **__OVER__.	
Striker 1: This is Striker 1.WILCO. **Break**.	
Have SGT Jones set it to the side and we'll sign for it later today, **over**.	
Striker 2: This is Striker 2, Roger I'll let him know, **__OVER__**.	
Striker 7: This is Striker 7. FTX ends on day 6.**__BREAK__**.	
Striker 1, your element is tasked to transport personnel and training assets back to garrison and will police and close the training site, **over.	
Striker 1: This is Striker 1.**Roger** that, **over**.	
TOTALS	**5. Correct______/9** **6. Distractors _____/14**

**continuation of speaker from prior line

RATER INFORMATION:
-Clear area is correct check mark; shaded area is error check mark.
-Indicate in box if Subject says "CHECK" for any phrase, before the next keyword.

11-5-2012, 7-24-13, 9-9-13, 10-14-13, 12-1-13

Load Magazine-Radio Chatter Dual Task
Scoring Instructions

Examiner scoring supplies/materials:

- Clipboard
- Pencil
- Subject score sheets
- Stopwatch
- Radio recording (iPod) and speakers

<u>Before starting the task</u>
Fill out the following:

- Subject's study ID
- Your Rater ID
- Today's date
- Test order (testing 1st, 2nd …6th of the test tasks?)

Count number of rounds for each of 2 timed 60 second practice trials and record on score sheet at the top. **Note** that this is to reduce the practice effect and provides general information to see if there is a major practice effect in the number of rounds loaded (for example, if during the first practice trial the subject loads 10 rounds and the 2nd trial the subject loads 28 rounds, this information will aid data analysis).
NOTE that the ROUNDS LOADED information is all recorded on the TOP of the TRAINING Script.
<u>Rounds Loaded ST</u>
Play the White Noise recording which has tones for start/stop of loading rounds. When finished, empty the magazines into the padded bin. Count the number of dummy rounds loaded in the single task condition and record under 1._________. Return rounds to the start bin.
<u>TRAINING SCRIPT</u>
Play the Training Script recording, score and repeat according to the instructions. Place a check mark on the score sheet for each phrase when the subject says "CHECK". Practice script is played twice unless SM is 100% correct or up to 1 wrong on 1st trial and does not want a 2nd practice trial. If subject makes more than 1 error on first Training Script, then they automatically do a second practice round. Record the number of correct checks (white box) and the number of distractors (shaded box) at the bottom under either Trial 1 or Trial 2 as appropriate. [Note: distractor/shaded represent errors.]

<u>TEST SCRIPT 1</u>
Play Test Script 1 recording. Place a check on the score sheet for each phrase when the subject says "CHECK".
3.________ is the number of correct checks (white rows)
4.________ is the number of distractors (shaded rows)

TEST SCRIPT 2/ Rounds Loaded DT

When playing Test Script 2, the subject is also loading rounds. Play the **Test Script 2-Dual** recording which has tones for start/stop of loading rounds. Place a check on the score sheet for each phrase when the subject says "CHECK". When finished, empty the magazines into the padded bin. Count the number of dummy rounds loaded in the dual task condition and record under 2.__________ on the front page of the scoresheet (at the top of the form). Return rounds to the start bin.

5.________ is the number of correct checks (white rows)

6.________ is the number of distractors (shaded rows)

After subject has completed task

- Write down any comments the subjects made about the strategies they used or other comments.
- Calculation of dual-task costs for motor and for cognitive costs will be done during analysis
- Return any dummy rounds to the start bin

July 26, 2013

REV: 22Sept2014

REV: June 2015

Load Magazine-Radio Chatter Dual Task
Cue Sheets

Practice

Say **“CHECK”** when you hear:

Wolf 7 **“OVER”**

Wolf 2 **“ROGER”**

T1

Say **“CHECK”** when you hear:

Tiger 4 **“OVER”**

Tiger 7 **“BREAK”**

T2

Say **“CHECK”** when you hear:

Striker 2 **“OVER”**

Striker 7 **“BREAK”**

APPENDIX 4: MEETING ABSTRACTS

American Physical Therapy Association Combined Sections Meeting Federal Section 2016 Anaheim, CA-Symposia Proposal-ACCEPTED February 2016

1) Title: Validation of the Assessment of Military Multitasking Performance for Mild TBI (Weightman, Scherer, McCulloch)

2) Course/session description

Concussed Service Members (SM) often present with sensorimotor and cognitive deficits that disrupt optimal performance of Warrior tasks. Post concussive sequelae can be subtle but sufficient to impede timely return-to-duty (RTD). Current best practices for post concussive screening rely heavily on symptom self-report and single domain impairment metrics not validated against the functional demands of the Warfighter. Dual-task and multitask methods are sensitive to subtle cognitive and sensorimotor deficits following concussion, although, these methods have not previously been used to guide military RTD decision-making. Validation of an end-user informed, performance based assessment battery will enhance, evidence-based RTD decision-making. Led by Investigators at Courage Kenny Research Center, a team of civilian and military rehabilitation scientists have developed the Assessment of Military Multitask Performance (AMMP) to meet this need. This battery of six dual-task and multitask tests can be administered and scored reliably. Components of the battery distinguish healthy control Active Duty participants (n=50) from SM with persistent post-concussive deficits (n=47). We will summarize the AMMP refinement process, the challenges of establishing reliable task metrics, and correlational findings that validate AMMP components.

3) Course/session learning objectives

<u>Learning objectives (at least 3):</u>

1. Discuss challenges and successes associated with dual-task and multitask measurement approaches in the Assessment of Military Multitasking Performance.

2. Highlighting where appropriate, the relative contributions of both instrumented and clinical metrics in each of the AMMP tasks that are able to discriminate Active Duty healthy control participants from Soldiers with persistent symptoms following concussion.

3. Summarize correlational findings between participant symptoms, performance on standard neurocognitive metrics, and clinical gaze stability measures with AMMP performance to demonstrate relative construct validity in AMMP tasks.

4. Explore the feasibility of administering AMMP test clusters to patient subjects with specific impairment profiles as a possible next-step in RTD screening or performance testing.

4) REFERENCES:

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5) Timed outline of content (including breaks) 120 minutes total

I. Session overview /Introduction to the problem: Valid and reliable metrics for rehabilitation providers to contribute to RTD decision-making for Service members with mTBI and persistent symptom complaints (20 minutes)

A. Subtle deficits missed by standard assessment tools
B. Typical dual-task metrics; application to militarized test metrics
C. Typical multitask metrics: application to militarized test metrics.

II. AMMP validation findings

- Reliability findings and challenges (15 minutes)
- Ability to discriminate healthy versus Service Members with persistent mTBI symptoms (25 minutes)
- Correlation to standard neurocognitive and dynamic visual acuity tests (20 minutes)
- Next steps in validation process—development of a new metric (10 minutes)
- Conclusions, lessons learned, overview of current approaches return-to-duty decision-making; an evolving process (15 minutes)
- Q & A/Discussion (10-15 minutes)

IVSTEP Conference, American Physical Therapy Association
(McCulloch, Favorov, Weightman), IVSTEP-POSTER, Columbus, OH, July 2016

Non-linear Analyses of Agility Task Performance After Military Mild Traumatic Brain Injury: An Approach to Identify Subtle Motor Control Impairments

Introduction: Recent advances in medical science have highlighted the need for methods to quantify the effects of mild traumatic brain injury (mTBI). The ability to determine when an individual has recovered from injury is a particular challenge. Typical approaches use neurological examination, neuropsychological tests, standing balance tests or self-report of post-concussive symptoms. If impairments are subtle, these methods may not detect impairments that could have significant implications for military duty. Quantitative evaluation of performance on motor tests with accelerometry can be both practical and objective, with the potential to be highly sensitive to even subtle neural abnormalities associated with mTBI. This approach has been used with some success in a stand and walk test post-concussion, but performance on higher level mobility tasks (run, obstacle avoidance, etc) have a stronger relevance for military training and combat related activities.

Purpose: We investigated whether the Illinois Agility Test (IAT) might be sensitive to subtle mTBI impairments. The IAT requires a transition from prone to standing, running short distances while navigating multiple obstacles, changing direction, and speed accelerations/decelerations, placing high demands on the sensorimotor system.

Subjects: Recruited from active duty Army service members aged 18-42 stationed at Ft Bragg, North Carolina. Our preliminary sample consisted of 19 subjects diagnosed with mTBI who were undergoing comprehensive outpatient rehabilitation at Womack Army Medical Center, Department of Brain Injury Medicine. All mTBI subjects were at least 30 days post injury, with persistent symptoms preventing return to duty (RTD). 25 healthy control subjects were recruited following a TBI briefing required of all soldiers who transfer to Ft Bragg.

Methods: Two tri-axial accelerometers (1 on an adjustable headband, 1 on a belt at lumbar area) were worn during the test, allowing for continuous wireless transmission of time series data by each of the 6 sensors during the IAT. Following a 'walk-through' of the IAT and a practice trial to ensure the task was understood, each subject ran a test trial at full speed. The power spectrum of each subject's time series for this trial was computed for each accelerometer using Fast Fourier transform. Power spectra of all subjects were averaged to identify the dominant frequencies. The top 35 frequencies were used as the input to a linear Support Vector Machine (SVM). The SVM was trained to distinguish between the control and mTBI subjects. Cross-validated using the standard leave-one-out approach, the SVM was found to correctly classify 23 out of 25 control subjects (92% accuracy) and 10 out of 19 mTBI subjects (52.5% accuracy) based on anterior-posterior torso accelerometer readings. The other 5 sensors were less accurate.

Conclusions and clinical relevance: In a group of subjects with chronic mTBI, performance on the IAT using non-linear methods provided a high level of accuracy for identifying healthy control subjects. The mTBI group included some individuals who were nearing readiness for RTD as a result of rehabilitation, which may explain lower accuracy in identifying those with mTBI. Our group plans to optimize this method on a larger military sample that must perform at a high level of physical function under conditions of significant risk. The ability to identify subtle movement abnormalities during tactical training activities stands to aid therapists in predicting readiness for RTD in active duty military populations.

2015 American Congress of Rehabilitation Medicine Dallas, Tx
Poster Abstract (October 2015)

Title: Inertial sensors detect subtle mobility differences in soldiers with persistent concussion symptoms: preliminary findings for the instrumented stand and walk in single and dual-task conditions

Objective: To describe findings from an instrumented 30 second stand, 7 meter walk with 180 degree turn for the ability to distinguish healthy control (HC), "duty ready" Soldiers from Soldiers undergoing rehabilitation for persistent post-concussive deficits (mTBI). Testing was completed in single task and dual-task conditions with an 8 digit alphanumeric grid memorization task as the cognitive challenge.
Design: Convenience sample case-control measurement study.
Setting: Active Duty (AD) US Army installation
Participants: AD Soldiers ages 18 – 42 y.o. (n= 61 HC; n= 37 mTBI).
Interventions: Not applicable.

Main Outcome Measures: The Instrumented Stand and Walk (ISAW) test (Mobility Lab, APDM INC), uses small, wireless Opal™ movement monitors with 3D angular rate sensor, 3D accelerometer and gyroscope. Monitors were affixed to the lumbar area and ankles to quantify sway, gait, and rotational kinematics. A commercial algorithm analyzed all movements. Three trials of the ISAW were completed in single task and dual-task conditions. Median values from three-replication sets were compared between groups for sway, turning, and gait using a two-sided t-test; $p < 0.05$.
Results: Measures of sway during quiet stance and gait at self-selected walking pace failed to discriminate groups ($p > 0.05$).. Measures of turning revealed between group differences in both single and dual-task conditions. Soldiers with mTBI demonstrated longer turn durations ($p < 0.001$); increased steps to complete a turn ($p < 0.001$), and decreased peak rotational velocities ($p = 0.003$) during turns. The number of recalled grid coordinates also distinguished groups ($p < .008$).
Conclusions: These findings support the utility of the ISAW in both single and dual-task conditions to detect subtle sensorimotor deficits in Soldiers with persistent post-concussive deficits during a 180 degree turn.

Keywords: concussion, inertial sensors, military

2015 American Congress of Rehabilitation Medicine Dallas, Tx
Symposium Proposal (October 2015)

<u>Title:</u> Assessment of Military Multitasking Performance *Dual-task* Components: Informing Return-to-Duty After Concussion

<u>Focus:</u>

Research Methods (assessment)
Traumatic Brain Injury and Military

<u>Faculty (w positions and affiliations):</u>

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University of North Carolina at Chapel Hill

Chapel Hill, NC

Abstract (250 words or less):

Concussion/ mild traumatic brain injury (mTBI) often results in subtle physical and psychological deficits in Service members (SM) that interfere with peak performance of warrior tasks. Symptoms associated with mTBI can be difficult to objectively assess and commonly complicate return-to-duty (RTD) efforts (Scherer et al., 2013). Dual-task methods have demonstrated sensitivity to subtle cognitive and sensorimotor deficits following mild brain injury (Catena et al., 2007; Abernathy 1988; McCulloch 2007), although, this method has not been used to inform military RTD decision-making. Development of an end-user informed functional assessment is an important step in advancing improved, evidence-driven RTD decision making. Led by investigators at the Courage Kenny Research Center, a team of interdisciplinary civilian and military rehabilitation researchers developed a performance-based assessment battery including 3 dual-task components to help inform duty-readiness decisions after concussion/mTBI, called the Assessment of Military Multitask Performance (AMMP) (Radomski et al., 2013, Scherer et al., 2013, Smith et al., 2014). Through an iterative development process, the dual-task components in the AMMP battery have demonstrated acceptable interrater reliability. Components of the battery distinguish Active Duty healthy control participants (n=44) from SM with persistent post-concussive symptoms (n=43). We will summarize the AMMP refinement process and the challenges of establishing reliable task metrics. Validation findings to date will also be shared. Implications of these research findings on test development for civilian practice will be outlined.

Learning objectives (at least 3):

Discuss the challenges and successes with regard to the use of dual-task metrics in the Assessment of Military Multitasking Performance (AMMP).

Summarize findings for task metrics that are able to discriminate healthy control from Soldiers with a history of mTBI receiving services in a military TBI rehabilitation department.

Summarize correlational findings between standard neurocognitive and dynamic visual acuity tests and AMMP dual-task metrics to inform construct validity of the AMMP.

Describe “lessons learned” for application to performance-based test development in civilian populations.

Course outline (topic title, presenter, time allotment, brief outline of each section) 90 minutes:

- Session overview /Introduction to the problem: Valid and reliable metrics for rehabilitation providers to contribute to RTD decision-making for soldiers with mTBI residuals (Weightman, 15 minutes)
    - Subtle deficits missed by standard assessment tools
    - Typical dual-task metrics; application to militarized test metrics
- AMMP validation findings (Weightman and McCulloch, 35 minutes)
- Discriminate validity
- Correlation to standard tests
- Reliability findings and challenges
- Next steps in the dual-task validation process—development of a new metric (McCulloch, 10 minutes)

- Conclusions, learnings and implications for civilian practice (McCulloch, 5 minutes)
- Q & A/Discussion (All, 10 minutes)

Diagnoses
Concussion/mild Traumatic Brain Injury

2015 American Congress of Rehabilitation Medicine Dallas, Tx
Symposium Proposal (October 2015)

Title: Assessment of Military Multitasking Performance *Multitask* Components: Informing Return-to-Duty After Concussion

Focus:
Research Methods (assessment)
Traumatic Brain Injury and Military

Faculty (w positions and affiliations):

Margaret M. (Maggie) Weightman PT, Ph.D.
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University of North Carolina at Chapel Hill
Chapel Hill, NC

Abstract (250 words or less):

Concussion/ mild traumatic brain injury (mTBI) often results in subtle physical and psychological deficits in Service members (SM) that interfere with peak performance of warrior tasks. Symptoms associated with mTBI can be difficult to objectively assess and commonly complicate return-to-duty (RTD) efforts (Scherer et al., 2013). Multitask methods have demonstrated sensitivity to subtle cognitive and sensorimotor deficits following mild brain injury (Alderman et al., 2003), although, this method has not

been previously used to inform military RTD decision-making. Development of an end-user informed functional assessment is an important step in advancing improved, evidence-driven RTD decision making. Led by investigators at the Courage Kenny Research Center, a team of interdisciplinary civilian and military rehabilitation researchers developed a performance-based assessment battery that includes 3 multitask scenarios to help inform duty-readiness decisions after concussion/mTBI, called the Assessment of Military Multitask Performance (AMMP) (Radomski et al., 2013, Scherer et al., 2013, Smith et al., 2014). Through an iterative development process, the 3 multitask components in the AMMP battery have demonstrated acceptable interrater reliability. Components of the battery distinguish Active Duty healthy control participants (n=54) from SM with persistent post-concussive symptoms (n=54). We will summarize the AMMP refinement process and the challenges of establishing reliable task metrics. Validation findings of the multitask components will be shared. Implications of these research findings on test development for civilian practice will be outlined.

Learning objectives (at least 3):
Discuss the challenges and successes with regard to multitask metrics in the Assessment of Military Multitasking Performance (AMMP).

Summarize findings for task metrics that are able to discriminate healthy control from Soldiers with a history of mTBI receiving services in a military TBI rehabilitation department.

Summarize correlational findings between standard neurocognitive and dynamic visual acuity tests and AMMP multitask metrics to inform construct validity of the AMMP.

Describe “lessons learned” for application to performance-based test development in civilian populations.

Course outline (topic title, presenter, time allotment, brief outline of each section) 90 minutes:

- Session overview /Introduction to the problem: Valid and reliable metrics for rehabilitation providers to contribute to RTD decision-making for soldiers with mTBI residuals (Weightman, 15 minutes)
    - Subtle deficits missed by standard assessment tools
    - Typical multitask metrics: application to militarized test metrics
- AMMP validation findings (Radomski and Scherer, 35 minutes)
- Discriminate validity
- Correlation to standard tests
- Reliability findings and challenges
- Next steps in validation process—development of a new metric (Radomski, 10 minutes)
- Conclusions, learnings and implications for civilian practice (Radomski, 5 minutes)
- Q & A/Discussion (All, 10 minutes)

Diagnoses
Concussion/mild Traumatic Brain Injury

American Physical Therapy Association Combined Sections Meeting Abstract-Platform Presentation 4-7February 2015, Indianapolis, IN

Authors: M Scherer[1], M Finkelstein[2], K McCulloch[3], L Smith[4], M Weightman[2]
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4 US Army Research Institute of Environmental Medicine, Natick, MA

Title: Inertial sensors detect subtle mobility differences in soldiers with persistent concussion symptoms: preliminary findings for the instrumented stand and walk

Purpose/Hypothesis: Imbalance following concussion often results from abnormal sensory integration between visual, somatosensory and vestibular inputs. Subtle postural control and mobility deficits may impact performance, safety, and readiness to return to duty (RTD) or play following concussion/mild traumatic brain injury (mTBI) and go undetected by standard clinical balance and gait tests. The purpose of this report is to describe findings from an instrumented 30 second stand and 7 meter walk with a 180 degree turn for the ability to distinguish healthy control (HC), "duty ready" Soldiers from Soldiers undergoing rehabilitation for persistent deficits following mTBI.
Subjects: A convenience sample of 34 healthy (23 male, age 26.9 ± 5.1 years) Soldiers and 30 active duty (all male; age 28.7 ± 6.7 years) Soldiers receiving treatment for persistent post-concussive symptoms at a military TBI care center.
Materials/Methods: The Instrumented Stand and Walk (ISAW) test (Mobility Lab, APDM INC, Portland OR) uses small, wireless Opal™ movement monitors which contain 3D angular rate sensor, 3D accelerometer and gyroscope. Monitors were affixed to the lumbar area and lateral ankles to quantify sway, gait, and rotational kinematics. A commercial algorithm was used to analyze all movements to include the initiation and completion of turns. Three trials of the ISAW were completed. Median values from three-replication sets were compared between groups for the sway and gait parameters using a two-sided t-test; p-values <0.05 are reported.
Results: Measures of sway during quiet stance and gait at a self-selected, "comfortable" walking pace were not significantly different between groups. Instrumented measures of turning revealed significant between group differences. Soldiers with post-concussive deficits demonstrated longer turn durations (HC: 1.58 ± 0.29 seconds; mTBI: 1.90 ± 0.37 seconds, p<.001); increased step numbers to complete a turn (HC: 3.51 ± 0.56; mTBI: 4.07 ± 0.87 steps, p<.004), and decreased peak rotational velocities during turns (HC: 225.73 ± 45.49°/s; mTBI: 192.10 ± 35.33°/s, p<.003).
Conclusions: These findings support the utility of the ISAW to detect subtle sensorimotor deficits in Soldiers with persistent post-concussive deficits during a 180 degree turn which involved rapid peak rotational movements. Analysis of sway and gait kinematics did not reveal significant between groups differences.
Clinical Relevance: Based on this preliminary analysis, instrumented assessment with inertial sensors shows promise as a means to detect subtle post-concussive differences where standard clinical measures of mobility and balance may be insufficient in highly trained military personnel. This type of instrumented assessment in combination with other functional metrics may more fully characterize readiness to RTD or play.
Keywords: concussion, inertial sensors, turning

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3rd International Congress Soldier Physical Performance, 20 August 2014, Boston MA

Title: A novel dual-task and multitask assessment battery guiding return-to-duty in concussed Service Members. Platform Abstract

Laurel Smith[1], Mary Vining Radomski[2], Marsha Finkelstein[2], Karen McCulloch[3], Leslie Freeman Davidson[4], Henry McMillan[5], Matthew Scherer[6], Margaret Weightman[2]

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2 Courage Kenny Research Center, Allina Health, Minneapolis, MN
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4 Riverbend Therapeutics, LLC, Great Falls, VA
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PURPOSE: The Assessment of Military Multitasking Performance (AMMP) is a battery of military-related functional dual-tasks and multitasks that target known sensorimotor, cognitive, and exertional vulnerabilities after concussion/mild traumatic brain injury (mTBI). Once validated, the AMMP is intended for use in combination with other metrics to inform duty-readiness decisions in service members following concussion. A dual task paradigm requires a Soldier to perform a physical and a cognitive task simultaneously in order to compare dual-task with single task performance. A multitask format requires

completion of complex physical and cognitive activities that approximate real-world military tasks. Several test tasks challenge agility or activity tolerance. Initial validation for the AMMP involves establishing interrater reliability (IRR); and then convergent/discriminant validity by using correlations to neurocognitive and sensorimotor tests and establishing known groups validity by comparing scores on AMMP tasks between healthy control (HC) and concussed Soldiers undergoing rehabilitation in a brain injury clinic. **METHODS:** Using a convenience sample case-control methodology involving test construction and evaluation, a data-driven iterative process has been used to evaluate the six AMMP test tasks for interrater reliability (IRR) by 3 person rater teams comprised of physical and occupational therapists. Scoring discrepancies identified by intraclass correlation coefficients resulted in further clarifications of scoring rules and scorer training requirements. Ongoing data collection efforts continue at Fort Bragg for both HC and concussed Soldiers with a goal of 80 subjects per group. **RESULTS:** In addition to preliminary HC reliability testing, 34 subjects have been tested to date. Reliability findings frequently differed in HC versus concussed groups. ICCs for task completion time were 0.96-0.99 in HC and 0.77 to 0.99 in subjects with concussion. Cognitive components for each of the 3 dual-tasks, such as responding to key words in recorded radio chatter or recalling grid coordinates, demonstrated ICCs between 0.64 and 0.99. Subjects with concussion typically demonstrated greater number and range of errors than were seen in HC. **CONCLUSIONS:** Preliminary testing informed modifications in test structure, instruction, and scoring to enhance IRR. Development of measures that meet military stakeholder requirements for face validity and functional relevance contribute to the challenges of development of a valid AMMP battery. The consistency of scores across raters and the ability to discriminate known groups are fundamental to using the findings of the AMMP to make substantive recommendations regarding readiness to return to duty following concussion/mTBI.
Funding for this work provided by MRMC W81XWH-12-2-0070.

International Brain Injury Association Meeting Abstract, 20 March 2014 San Francisco, CA – Poster Abstract

Title: Preliminary inter-rater reliability for a novel dual-task and multitask assessment battery guiding return-to-duty in concussed Service Members.

Margaret Weightman[1], Karen McCulloch[2], Leslie Freeman Davidson[3], Matthew Scherer[4], Laurel Smith[5], Marsha Finkelstein[1], Mary Vining Radomski[1]

1 Courage Kenny Research Center, Allina Health, Minneapolis, MN

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3 Riverbend Therapeutics, LLC, Great Falls, VA

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5 United States Army Research Institute of Environmental Medicine, Natick, MA

OBJECTIVES: The Assessment of Military Multitasking Performance (AMMP) is a battery of military-related functional dual-tasks and multitasks that target known sensorimotor, cognitive, and exertional vulnerabilities after concussion/mild traumatic brain injury (mTBI). Once validated, the AMMP is intended for use in combination with other metrics to inform duty-readiness decisions in active duty service members following concussion. The assessment of inter-rater reliability (IRR) provided data regarding IRR of individual AMMP tasks, and informed training requirements needed for reliable scoring of the battery. Preliminary IRR findings highlight the challenges and successes in development of performance based assessments designed to identify subtle deficits in highly trained personnel.

METHODS: Six AMMP test tasks were individually evaluated for IRR by 3 person rater teams comprised of physical and occupational therapists who were the task developers, with at least one rater

who was initially unfamiliar with the task. Initial IRR evaluation for 4 tasks was completed on 20 healthy Soldiers (HC), and for 2 tasks on 12 HC. Scoring discrepancies identified by the statistical analysis using Krippendorf Alpha resulted in further clarifications of scoring rules and scorer training requirements. Tasks were again tested by 3 raters on 11 to 13 Soldiers undergoing rehabilitation following concussion/mTBI. **RESULTS:** Reliability findings frequently differed in HC versus concussed groups. For example, ICCs for task completion time were 0.96-0.99 in HC and 0.77 to 0.99 in subjects with concussion. Cognitive components for each of the 3 dual-tasks, such as responding to key words in recorded radio chatter or recalling grid coordinates, demonstrated ICCs between 0.64 and 0.99. Multitask metrics demonstrated variable ICCs. For example, task completion and number of transits during a 'Charge of Quarters' multitask demonstrated excellent IRR (ICCs of 0.90 to 0.98). IRR calculations were highly sensitive to the range of possible values with metrics that involve restricted ranges such as number of errors, cues, or rule breaks, demonstrating variable and often lower ICCs (ICC range 0.13-0.85). Subjects with concussion typically demonstrated greater number and range of errors than were not seen in testing the healthy control Soldiers. **CONCLUSIONS:** Preliminary IRR testing informed modifications in test instruction, structure, and scoring to enhance IRR. Development of measures that meet military stakeholder requirements for face validity and functional relevance contribute to the complexity of development of a reliable AMMP battery. The consistency of scores across raters is fundamental to the ability to use the findings of the AMMP to make substantive recommendations regarding readiness to return to duty following concussion/mTBI.

Funding for this work provided by MRMC W81XWH-12-2-0070. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Army or the Department of Defense.

AMSUS 2013 ABSTRACT:

Returning Service Members to Duty Following Mild Traumatic Brain Injury: Exploring the Use of Dual- and Multitask Assessment Methods

Matthew R Scherer, PT, PhD, NCS, U.S. Army Research Institute of Environmental Medicine, Natick MA; Karen L. McCulloch PT, PhD, NCS, University of North Carolina, Chapel Hill, NC, ORISE Fellow Office of the Surgeon General

Within the last decade, over 220,000 Service Members (SM) have sustained Traumatic Brain Injury (TBI), many with complex co-morbidities, in support of military operations in Iraq and Afghanistan. Mild TBI may result in subtle cognitive and sensorimotor deficits that adversely affect Warfighter performance, creating significant challenges for SM, Commanders and medical providers. In the current conflicts, physical therapists have played an important role in evaluating SM readiness to return-to-duty (RTD). Incorporating research and best practices from the sports concussion community, military providers are increasingly adopting a sports medicine model to manage "tactical athletes" in operational environments. Because pre-morbid (baseline) performance is not typically available for deployed SM as it may be for athletes, clinicians determine duty readiness based upon the absence of post-concussive symptoms and return to "normal" performance on clinical assessments not yet validated among Warfighters. While similar practices described within the sports concussion literature guide "return to play" determinations, resolution of symptoms or improvement of isolated impairments may be inadequate to predict readiness in a military operational environment. Existing clinical metrics informing RTD decision-making are limited as they fail to emphasize functional, Warrior Task demands and lack versatility to assess the effects of co-morbid deficits. Emerging research efforts aim to address this

discrepancy by developing challenging, realistic, and "standards-based" criteria to verify operational competence. Dual- and multitask methods have been described previously for the evaluation of sensorimotor and cognitive function following TBI. These show promise for approximating the complex operational demands of warfighting and guiding RTD decision making.

Key Words: Traumatic Brain Injury, Outcomes Assessment, Sensorimotor Performance

3 Objectives for the 6 November 2013 talk:

Upon conclusion of this 45 minute presentation, the learner will be able to successfully:

1) Identify common clinical symptoms and signs (neurocognitive or sensorimotor) associated with concussion/ mTBI in an operational setting.
2) Identify three or more limitations associated with current "standard of care" return to activity (i.e., "play" or "duty") standards.
3) Recognize advantageous characteristics of dual- or multitask testing techniques for the determination of duty readiness in concussed SM.

MAY 2015 Annual Research Symposium Abstract

Select one: ☐ **Podium** ☐**Poster**

Presenter: Amy Cecchini, PT, MS

Title: Preliminary Inter-rater Reliability of the Assessment of Military Multitask Performance: An Assessment Battery for Concussed Service Members

Institution/Department: Womack Army Medical Center/Brain Injury Medicine

Co-Author(s): CAPT Henry McMillan, PT, DPT, MBA, **Institution/Department**: Womack Army Medical Center/Brain Injury Medicine

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Objective/Introduction: The Assessment of Military Multitasking Performance (AMMP) is a battery of 6 military-related tasks that target known vulnerabilities after concussion/mild traumatic brain injury (mTBI). The goal of this project was to examine inter-rater reliability (IRR) of the AMMP tasks.
Methods/Strategies/Case: AMMP tasks were rated by 3 persons (physical and occupational therapists, at least one rater who was not involved in development of the tasks) in 20 uninjured service members (SM) for 4 tasks and 12 SM for 2 tasks. Scoring discrepancies resulted in further clarifications of scoring rules and scorer training requirements. Tasks were again tested by 3 raters on 11-13 SMs undergoing rehabilitation following concussion.

Results: IRR differed in uninjured versus concussed groups. ICCs for task completion time were 0.96-0.99 in uninjured SMs and 0.77-0.99 in SMs with concussion. Cognitive components for 3 dual-task items demonstrated ICCs between 0.64 and 0.99. Multitask ratings had variable ICCs. Time related ICCs were high (ICC .90-.99), but other elements were sensitive to restricted range of scores (e.g. number of errors made or cues provided) resulting in lower ICCs (range 0.13-0.85). SM post-concussion exhibited more errors, and errors that were not seen in uninjured SMs.

Conclusion: IRR testing resulted in improvements in test instruction, structure, and scoring to enhance IRR. Measures that require rating of errors, need for cues during complex military oriented tasks can be rated reliably, but IRR testing of SM with concussion is essential. IRR is acceptable to allow AMMP findings to be considered for return to duty readiness decisions.

MAY 2015 Annual Research Symposium Abstract

Select one: ☐ Podium ☐Poster

Presenter: CAPT Henry McMillan, PT, DPT, MBA
Title: Assessment of Military Multitask Performance: Preliminary Validity of a Test Battery for Concussed Service Members
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Objective/Introduction: The Assessment of Military Multitasking Performance (AMMP) is a battery of 6 military-related tasks that target known vulnerabilities after concussion/mild traumatic brain injury (mTBI). Beginning in 2013, a team based at WAMC began data collection to validate this test battery in individuals with persistent symptoms after mTBI and a comparison group of active duty service members.
Methods/Strategies/Case: A single testing session of 2 1/2-3 hours was conducted to complete intake, neurocognitive testing, dynamic visual acuity testing and the 6 tasks from the AMMP that involve militarized dual- and multi-task scenarios: patrol, charge of quarters duty, load magazine/radio chatter, agility/word list memory, walking/grid coordinate memory, run-roll-aim. Time and performance of each task was recorded based on procedures developed by an interdisciplinary team.

Results: Over the course of 18 months of testing, we enrolled and tested 50 individuals with mTBI and 51 active duty healthy subjects. Demographics of each group and the differences in ability to complete each AMMP task will be shared as preliminary indicators of task ability to discriminate between the injured and non-injured groups.

Conclusion: A successful collaboration with WAMC investigators and University/private hospital investigators resulted in data collection on more than 100 participants to aid in validation of the AMMP test battery to aid return to duty decision making after military mTBI. Additional analyses will be completed by August 2015 to inform future use or need for additional study of the AMMP battery or its components.

APPENDIX 3: PUBLISHED OR SUBMITTED PAPERS

Manuscripts (published)

Scherer M, Weightman M, Radomski M, Davidson L, McCulloch K. "Returning Service Members to Duty Following Mild Traumatic Brain Injury: Exploring the Use of Dual-Task and Multitask Assessment Methods", *Phys Ther.* 2013; 93:1255-1267.

Smith, LB, Radomski, MV, Davidson LF, Finkelstein, M, Weightman, MM, Scherer, MR, McCulloch, K (2014). Development and preliminary reliability of a multitasking assessment following concussion. *American Journal of Occupational Therapy, 68*, 439-443.

Manuscripts (submitted)

Weightman MM, McCulloch KL, Radomski MV, Finkelstein M, Cecchini A, Davidson L, Heaton KJ, Smith L, Scherer M. Further development of the Assessment of Military Multitasking Performance: Iterative Reliability Testing. Submitted to the *Journal of Rehabilitation Research & Development* (20 October 2015).

Physical Therapy
Journal of the American Physical Therapy Association and de Fysiotherapeut
Royal Dutch Society for Physical Therapy

PTJ Online First

Returning Service Members to Duty Following Mild Traumatic Brain Injury: Exploring the Use of Dual-Task and Multitask Assessment Methods

Matthew R. Scherer, Margaret M. Weightman, Mary V. Radomski, Leslie F. Davidson and Karen L. McCulloch

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Returning Service Members to Duty Following Mild Traumatic Brain Injury: Exploring the Use of Dual-Task and Multitask Assessment Methods

Matthew R. Scherer, Margaret M. Weightman, Mary V. Radomski, Leslie F. Davidson, Karen L. McCulloch

Within the last decade, more than 220,000 service members have sustained traumatic brain injury (TBI) in support of military operations in Iraq and Afghanistan. Mild TBI may result in subtle cognitive and sensorimotor deficits that adversely affect warfighter performance, creating significant challenges for service members, commanders, and clinicians. In recent conflicts, physical therapists and occupational therapists have played an important role in evaluating service member readiness to return to duty (RTD), incorporating research and best practices from the sports concussion literature. Because premorbid (baseline) performance metrics are not typically available for deployed service members as for athletes, clinicians commonly determine duty readiness based upon the absence of postconcussive symptoms and return to "normal" performance on clinical assessments not yet validated in the military population. Although practices described in the sports concussion literature guide "return-to-play" determinations, resolution of symptoms or improvement of isolated impairments may be inadequate to predict readiness in a military operational environment. Existing clinical metrics informing RTD decision making are limited because they fail to emphasize functional, warrior task demands and they lack versatility to assess the effects of comorbid deficits. Recently, a number of complex task-oriented RTD approaches have emerged from Department of Defense laboratory and clinical settings to address this gap. Immersive virtual reality environments, field-based scenario-driven assessment programs, and militarized dual-task and multitask-based approaches have all been proposed for the evaluation of sensorimotor and cognitive function following TBI. There remains a need for clinically feasible assessment methods that can be used to verify functional performance and operational competence in a variety of practice settings. Complex and ecologically valid assessment techniques incorporating dual-task and multitask methods may prove useful in validating return-to-activity requirements in civilian and military populations.

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[Scherer MR, Weightman MM, Radomski MV, et al. Returning service members to duty following mild traumatic brain injury: exploring the use of dual-task and multitask assessment methods. *Phys Ther.* 2013;93:xxx–xxx.]

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Submitted: March 29, 2012

Over the last decade, in excess of 220,000 military service members have sustained traumatic brain injury (TBI) (Box 1), resulting in significant morbidity and a commensurate degradation of military operational readiness.[1,2] Current criteria to assess readiness to return to duty (RTD) in an operational environment following mild TBI (mTBI) are based primarily on clinical best practices and evidence from the sports concussion literature.[3–7] Although widely used, it is not clear that existing return-to-play (RTP) guidelines developed for the management of sports-related blunt head trauma are sufficient to detect subtle and potentially duty-limiting effects of deployment-related mTBI.[8] The purposes of this article are to provide perspective on the current state of mTBI assessment in the military practice environment and to introduce alternatives given emerging requirements for more rigorous, feasible, and ecologically valid methods to guide RTD decision making. We propose a rationale for shifting the RTD readiness assessment model from an impairment-based approach to a more functionally oriented and standards-based paradigm. Finally, we highlight relevant findings from the dual-task and multitask literature that support this proposed approach to RTD assessment.

Box 1. Traumatic Brain Injury (Definition)

The Department of Defense (DoD) *defines traumatic brain injury* as head injury (via blunt trauma or barotrauma, or both) resulting in even momentary alteration of consciousness, loss of consciousness, or posttraumatic amnesia. Mild traumatic brain injury is further characterized as meeting one or more of the following criteria: loss of consciousness for 0 to 30 minutes, alteration of consciousness or mental state for a moment or up to 24 hours, and posttraumatic amnesia for up to 1 day.

RTD Following TBI in the Deployed Environment: What Is the Scope of the Problem?

According to Department of Defense (DoD) estimates, approximately 165,000 (75%) of the 220,000 TBIs sustained by US service members over the last decade have been classified as mild.[1,9] Although these numbers are significant, recent epidemiological studies suggest the prevalence of head injury in returning service members may be even greater, with an estimated 11.2% to 22.8% of returning personnel screening positive for mTBI during their deployment.[10–14] Blast or explosion as a mechanism of injury is known to account for as much as 78% to 80% of in-theater–related TBI.[9,10] Although evidence suggests recovery from blunt head trauma occurs days to weeks after injury, recovery from blast-related mTBI is less understood.[5] Relative to blunt head trauma, injuries from blast exposure generally result in a more complicated clinical presentation characterized by greater frequency of headache, facial injury, visual and hearing impairment, elevated levels of vestibular morbidity, and more severe posttraumatic stress syndrome symptoms.[15–18] Given the morbidity and persistent sequelae associated with mTBI sustained in-theater, there is legitimate concern among military medical providers and commanders that such complexity may result in a more challenging RTD process, with direct implications for operational readiness of the fighting force. Furthermore, with approximately 80% of military TBIs occurring in noncombat environments, management of TBI-related sequelae and their potential impact on readiness represents a persistent and challenging military health issue for the foreseeable future.[1]

RTD Decision Making: A Page From the "RTP" Book?

Challenges to RTD Decision Making in the Military Practice Environment

In recent years, the "tactical athlete" analogy has increasingly been used to describe the highly functioning personnel within the ranks of the military, law enforcement, and firefighting professions. The description of the modern warrior-athlete fits within a broader "sports medicine on the battlefield" concept that emphasizes early, far-forward management of injured military service members with the intention to return them quickly to the battlefield. This model has been readily adopted for the management of musculoskeletal injury, although its utility for managing RTD determinations among service members with concussion has yet to be validated.

In the deployed environment, DoD policy dictates that physical therapists and occupational therapists administer functional RTD assessments of concussed service members.[3] Military physical therapists and occupational therapists are well suited to perform these assessments, given their existing doctrinal mission within the force. Occupational therapists are typically key providers in concussion care centers in the deployed setting and are highly familiar with combat stress issues. Physical therapists are assigned directly to Brigade Combat Teams and have the clinical training to perform neurologic assessment and rehabilitation. Physical therapists provide a broad spectrum of services to their units ranging from health promotion and performance optimization to direct-access patient care.[19,20]

Current in-theater policy guidelines require mandatory neurological and functional evaluations for personnel exposed to a specified number of blast-related or blunt trauma–related events.[3] Additionally, official guidance establishes progressively longer mandatory rest periods for concussed service members following each successive incident.[3] Physical therapists and occupational therapists facilitate recovery and decrease risk of cumulative injury by focusing on early rest and graded return to activity.[21,22]

The sports concussion literature has provided a valuable starting point from which to evaluate RTD assessment procedures following mTBI in both deployed and continental United States (CONUS)-based clinical practice environments. However, after more than 5 years of military TBI research, legitimate questions remain regarding the sensitivity of symptom- and impairment-based testing paradigms for informing return-to-activity decisions in concussed service members.[23] Within the military context, current RTD decisions are made by focusing on symptom resolution, neurocognitive testing, and clinical balance assessments as primary indicators of duty readiness.

Symptomology

Following a concussive event, a service member may experience a variable range of sensorimotor, cognitive, and physical sequelae related to primary or secondary injuries affecting body structure or function. These symptoms may include headaches, dizziness, imbalance, tinnitus, hearing loss, impaired cognitive processing, dysexecutive syndrome, musculoskeletal pain, or comorbid stress symptoms.[24,25] Military medical treatment facilities, especially those in a deployed setting, are currently challenged to objectively assess the spectrum of vulnerabilities associated with mTBI. Department of Defense evidence-based clinical practice guidelines neither support nor discount reliance on patient self-report of symptoms for the management of mTBI.[26]

Until recently, with the widespread adoption of the Zurich guidelines for concussion management, symptom resolution (in the absence of more objective findings) may have driven premature RTD decisions.[21] Such decision making can be particularly challenging in deployed environments, where sensitive and objective measures to justify "sidelining" the service member often are unavailable. The risk of premature RTD is further elevated by the tendency of personnel to downplay or "underreport" symptoms to hasten their return to their unit.[27] If not checked with more stringent assessment measures, the pervasive willingness within military culture to push through discomfort and "accomplish the mission" following concussion could lead to an elevated risk of post concussive syndrome, increased likelihood of subsequent exposure, or greater risk to self and members of the unit resulting from the injured service member's diminished situational awareness.[27]

Recent in-theater efforts to increase the sensitivity of symptom self-report under more challenging and realistic conditions have included the introduction of a 2-minute RTD exertion test. Similar to the concept of exertion testing in the sports concussion community, service members with mTBI who are symptom-free at rest or under light exertion conditions are pushed to perform under more strenuous (typically 65%–85% of age-predicted maximum heart rate) conditions to probe for postconcussive symptoms.[28,29] Functional RTD tasks range in difficulty from donning and doffing of body armor and helmet to road marching (with a load) or sprinting short distances. Variations of exertional testing also have included the use of push-ups, treadmill running, or step aerobics.[8] Although therapists are directed to perform functional testing, there is no clear standard for testing across practice settings or branches of service.

Although not a "gold standard" diagnostic metric, there is an implicit responsibility for peers and leaders to observe and confirm a service member's readiness to resume duty when he or she returns to the unit.[3] Subtle behavioral abnormalities suggesting persistent mTBI-related impairments often are first identified not by the service member or even by the provider, but by fellow warriors (in a deployed setting) or family members while at home.[13] Persistent postconcussive sequelae may vary widely and include difficulty sleeping, irritability, trouble with peer or family relationships, difficulty navigating uneven or urban terrain under dimly lit conditions, or a diminished capacity to concurrently accomplish multiple activities (ie, multitask) relative to one's premorbid capabilities.[30] Because unit leadership may be among the first to identify behavioral health systems, unit leadership can play an important role in initiating appropriate management and support actions if such symptoms, behaviors, or deficient performance areas are identified.

Clinical Impairment Testing

Neurocognitive assessment batteries used by military providers and researchers for mTBI screening, management, and monitoring include, but are not limited to, the Automated Neuropsychological Assessment Metrics (ANAM) and the Immediate Post Concussion Assessment and Cognitive Testing (ImPACT).[31,32] Neurocognitive testing has been recommended for the assessment of suspected concussion in both civilian and military practice settings. However, it is difficult to interpret findings, as there are no normative data for service members in a deployed setting. Furthermore, these tests lack face validity for service members and commanders anxious to keep "boots on the ground" in an operational setting.[27,33,34]

Balance testing also is commonly incorporated into postconcussive evaluations, either independently or in conjunction with a broader multimodal assessment. Although research indicates that a person's cognitive performance as measured by automated neurocognitive testing typically returns to normal within 1 week of a concussive incident, deficits in balance as measured by the Balance Error Scoring System (BESS) or force platform systems reveal impairments that outlast discernible cognitive symptoms.[4,35–37] Recent findings confirm significant recovery time disparities among the most commonly considered RTP indicators, including symptom self-report, balance assessment, and neurocognitive testing, among concussed athletes.[38] Lack of congruency across symptom, balance, and neurocognitive domains casts reasonable doubt on the validity of single-domain assessment measures for the identification of duty limiting impairments in people with subtle (but significant) deficits. Complex warfighting tasks represent a confluence of multiple domains demanding simultaneous functioning from all. If a provider bases RTD decisions solely upon the absence of isolated impairments in a single domain (without a relevant multimodal functional assessment), the risk of premature RTD increases. To date, assessments of cognition and balance have not been found to be predictive of postconcussive symptom development or readiness to return to activity.[39] Neither of these relationships has been systematically investigated in a military population.

Limitations of Current Clinical Tests for Military Populations

Existing clinical tests being used to assess injured service members are hampered by psychometric and practical issues. Clinical measures used by deployed physical therapists and occupational therapists lack sensitivity to high-level functional deficits revealing ceiling effects when used to assess a highly conditioned warrior population.[40] These tests lack face validity among injured service members and their leaders because it is unclear how substandard performance on an isolated body structure–based or function-based task (eg, tandem standing) relates to performance in one's role as a combatant. The use of existing clinical measures is further complicated by the lack of normative values in the typical age and activity range of the service member. Although there are many measures that have been demonstrated valid and reliable to predict falls or other adverse outcomes in aging or clinical populations with more severe neurologic pathology, such evidence is lacking in service members who sustain mTBI. Service members in military operations commonly experience significant physical and mental fatigue, elevated stress levels, inadequate or disrupted sleep, and variability in hydration and nutrition.[41–44] As most research on natural recovery following sports concussion is based on care provided under optimal clinical conditions, it is unclear how exposure to psychologically and physiologically stressful conditions before, during, or even after clearance to RTD might affect outcomes.

A Standards-Based Approach to RTD Decision Making

From Structure and Function to Activities and Participation

The previous section highlighted a number of symptoms and impairments believed to degrade duty readiness. However, in addition to symptoms of physical discomfort, sensory instability, or disorientation, acutely concussed personnel may experience activity- or participation-level performance deficits in previously highly practiced and well-trained military occupational competencies.[27,45,46] Postconcussive activity-level deficits in service members, for example, may include impaired marksmanship (stemming from gaze instability, visual, or central processing deficits), degraded situational awareness (related to diminished visual, auditory, or central cognitive processing capabilities), or difficulty engaging in radio communications (due to central auditory or cognitive processing impairments). Such deficits likely reflect diffuse involvement across multiple domains (eg, sensorimotor, cognitive, musculoskeletal) and, although subtle in some cases, can clearly have duty-limiting or even career-limiting implications if improperly managed. Deficits associated with concussion also may result in participation restrictions (Box 2). Duty limiting barriers to participation may range from distraction or prolonged reaction times during patrolling by an infantryman, or degraded telecommunication performance by a radio operator, to unsafe or poorly executed vehicle handling during convoy operations by a truck driver. Impaired service member job performance has significant implications for safety and operational effectiveness for the individual, unit, and mission.

Box 2. *International Classification of Functioning, Disability and Health* (CF) Model of Functioning and Disability (Definitions)

Body functions are physiological functions of body systems (including psychological functions).
Body structures are anatomical parts of the body such as organs, limbs, and their components.
Impairments are problems in body function or structure such as a significant deviation or loss.
Activity: qualified as an individual capacity (ie, the ability to execute a task or an action) or performance (the ability of the individual to perform an activity in his or her current environment).
Participation: Involvement in a life situation.
Participation restrictions are problems an individual may experience in involvement in life situations.

The *International Classification of Functioning, Disability and Health* (ICF) model provides a framework to illustrate the complex interplay of factors, including the health condition of concussion, affected body structure or body function systems, task performance deficits, and personal or environmental factors that collectively contribute to limitations in duty readiness or operational competence (Figure).[46]

Theoretical and Practical Basis for a "Standards-Based" RTD Model

The process of defining a service member's duty readiness is complex. Competence as a warfighter demands not only technical prowess in military skills, it also necessitates resilience, self-efficacy, the capacity for complex thought, and other personal factors highlighted in the Figure, which are both abstract and difficult to measure using conventional clinical or impairment-based means. Within the field of development economics, Sen[47] has described individual capabilities as vectors (in the mathematical sense), which may be summed together to obtain an abstract representation of one's total level of functioning. From a theoretical perspective, we might draw on this approach and conceive of readiness as the vector-sum of relevant military competencies and other nonparametric characteristics (such as the capacity for complex thinking, resilience, or even self-efficacy) deemed critical for mission success. This approach acknowledges and normalizes the heterogeneous nature of inputs into the readiness equation and accounts for individual differences in outcomes based on an individual's premorbid capability set and coping strategies. Conceptually, this approach mirrors the complex contributions to functioning in the framework posed by the ICF model.

Existing military performance standards require demonstrated competence in warfighting capabilities (ICF: activity/participation level), based on well-established tasks, conditions, and standards.[48] Currently, clinical decisions guiding RTD following concussion are objectively informed primarily at the level of body structure and function.[27] One might argue that given the variability inherent in human functioning and performance, any attempt to quantify a participation level construct such as duty readiness should be informed by activity- or participation-level performance metrics. It is likely that any advance in readiness assessment methods not recognized as ecologically valid by the warfighter community will fall short in key domains of realism, generalizability, and complexity necessary to determine safe and appropriate return of injured service members to duty.

Foundational competencies or standards of soldiering are described in terms of warrior tasks and battle drills.[48] Formally defined, *warrior tasks* are a collection of individual soldier skills deemed critical to soldier survival, including activity-level competencies such as proficiency with weapons handling, communications skills, or negotiating obstacles. Duty readiness in the operational environment also requires proficiency with integrated, multiperson, unit-level activities known as *battle drills*. These participation-level competencies are complex "tasks performed as a part of a unit in order to react and survive in common combat situations" and include a range of activities from dismounted patrolling to casualty evacuation.[48] According to existing military operational competence standards, individual and collective service member proficiency in these types of complex military tasks are essential for an organization to be deemed mission ready.

In order to objectively measure service member performance in a way that is ecologically valid, an assessment must simulate the vocational demands of military tasks, demonstrate complexity adequate to account for fluid conditions in an operational environment, and challenge known mTBI-related vulnerabilities. Although the idea of assessing service member performance on unmodified warrior tasks to guide RTD decisions might be attractive from the standpoint of simplicity, such an approach can be problematic from a clinical perspective. Without a consistent methodological approach, clinicians may find interpretation of performance challenging. For example, if the tested service member is experienced, he or she may be able to rely on rote motor memory even in the presence of residual deficits if the tested task is not assessed with elements of complexity or unpredictability associated with a real-world scenario.

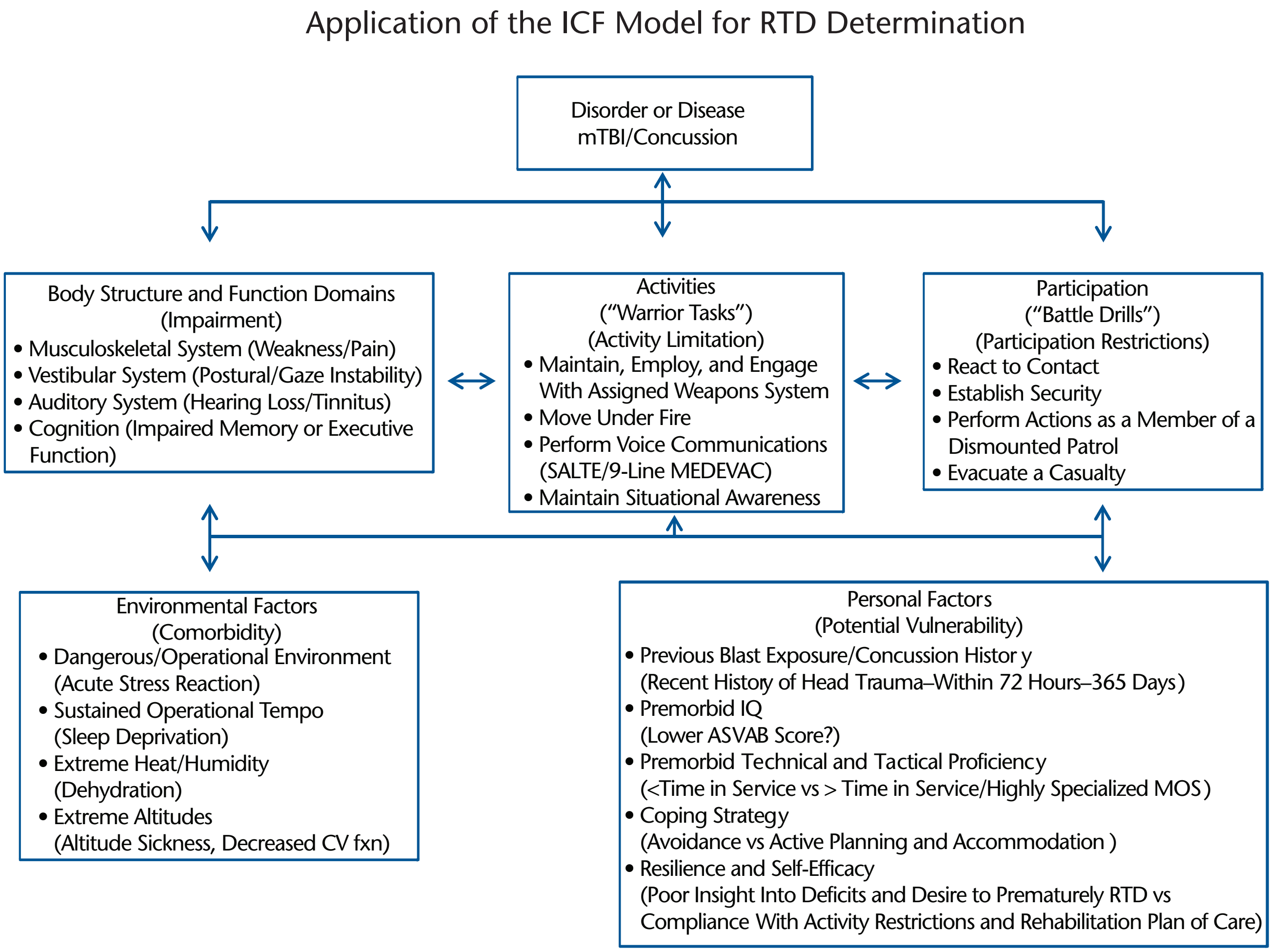

Figure.
International Classification of Functioning, Disability and Health (ICF) model for service member capabilities and vulnerabilities. This model highlights service member capabilities and limitations at every level of consideration. Body structure and function deficits include known vulnerabilities affecting functioning at the systems level and behavior. Activity and participation blocks summarize relevant warfighting task skills of varying complexity among duty-ready service members who are healthy. Finally, environmental and personal factors influencing service member resilience propose theorized limits on service member performance. RTD=return to duty, mTBI=mild traumatic brain injury, SALTE=Size Activity Location Time Equipment Intelligence Report, 9-Line MEDEVAC=Standardized Military Medical Evacuation Request, ASVAB=Armed Services Vocational Aptitude Battery, MOS=Military Occupational Specialty, CV fxn=cardiovascular function.

Complex Task Assessment Following mTBI in the Military Treatment Environment

Although not yet widely available throughout the DoD, preliminary efforts in select military treatment facilities and laboratories to assess mTBI-related deficits have focused on developing realistic duty scenarios to challenge service members across the range of functioning (ie, body function to activity level demands). These approaches include highly sophisticated, immersive virtual reality (VR)–based assessments; observational, scenario-based programs; and more clinically oriented testing that draws on components of each.[40,49,50]

Immersive VR systems such as the Computer Assisted Rehabilitation Environment (CAREN) provide highly sensitive, instrumented means of assessing physical, sensorimotor, and cognitive performance during ambulation and other functional movements in a laboratory-based environment.[49,51] Use of instrumented VR systems are advantageous because they allow an examiner to assess multiple performance domains simultaneously or to probe specific deficits by manipulating relevant sensory stimuli. As a clinical tool, the CAREN has been used extensively within larger DoD medical centers to assess and treat duty-limiting postconcussive deficits in service members using highly realistic operational scenarios and complex task conditions.[49,51] Although this type of RTD approach has great versatility and numerous applications for assessing and managing service members with concussion, obvious barriers to widespread use include cost; the requirement for specialized technical support to program, run, and maintain the system; and the relative immaturity of evidence to support generalizability of "readiness" in a virtual environment to "fitness for duty" in an operational environment.

In contradistinction to the laboratory-based VR approach, recent efforts by rehabilitation providers at military installations such as Fort Campbell, Kentucky, and Fort Bragg, North Carolina, have made significant progress in developing RTD testing modules that integrate traditional military training techniques with observational methods from a multidisciplinary team.[50] These scenario-based RTD programs assess a broad range of competencies ranging from individual warrior tasks such as marksmanship, vehicle rollover extrication, and land navigation to more challenging, small group–oriented battle drills such as VR convoy operations or simulated combat lifesaver operations. Specially designed assessment modules challenge service member performance under highly realistic and progressively more difficult operational scenarios designed to approximate the real-world stresses of combat. As with VR, this approach has both strengths and limitations. Although anecdotal evidence suggests good face validity and favorable RTD generalizability, scenario-based training lacks the precise measurement and repeatability of instrumented laboratory-based assessment techniques. Also, like VR, implementation of this approach requires significant resources, including costly technology, substantial logistical support, a large dedicated clinical staff, and numerous staff member hours to coordinate and execute. Thus far, assessment modules have not yet been standardized across sites, and test psychometrics have not yet been established.

Another RTD assessment approach seeking to bridge the sensitivity of laboratory measures with the ecological validity of scenario-based techniques uses militarized functional clinical test tasks. Although many DoD providers have sought to objectively quantify performance on specific warrior tasks (such as time to don a protective mask or time to complete a road march below a specified symptom severity level), such efforts have been neither standardized nor validated and likely lack the complexity to discriminate duty readiness. To address such limitations, recent efforts by a team of military and civilian rehabilitation scientists have led to the development of a novel battery of militarized dual tasks and multitasks designed to challenge known mTBI-related vulnerabilities. This battery, known as the Assessment of Military Multitasking Performance (AMMP), represents a preliminary attempt to incorporate complex clinical testing methods into RTD assessment and illustrates a potential application of the standards-based assessment paradigm in a clinical environment.[40] The AMMP integrates dual-task and multitask paradigms previously described in the literature with functional military requirements to create individual test tasks able to probe the broad range of duty-limiting symptoms and deficits associated with mTBI (Table).[52–61] Although the AMMP's ability to discriminate duty readiness in service members with mTBI has not yet been validated and the reliability of the individual test tasks has yet to be reported, similar procedures have been successfully applied in the assessment of athletes with concussion and mTBI.[35,36,62–64] Clinical measures may have an added benefit of superior feasibility in remote or CONUS-based military treatment facilities relative to more resource intensive approaches described previously.

Given the importance of defeating ceiling effects associated with impairment-based clinical measures, the adoption of a more complex RTD assessment approach such as one using dual-task and multitask methods is appealing for evaluating service members with mTBI. Multitask assessment methods are used with success by clinicians with patients recovering from moderate TBI and mild stroke to tax multiple cognitive demands. Multitask scenarios provide semistructured challenges of problem-solving and organization skills required in daily routines and work activities but have not been examined in mTBI.[57–60] Dual-task activities tested in laboratory contexts following mTBI show impairments when a combination of skills must be performed simultaneously (eg, cognitive task while walking), even when symptoms have apparently "resolved."[63,65] These same abilities, when tested separately, appear comparable to those of controls who are healthy, suggesting it may be important to test in dual-task conditions to uncover subtle mTBI impairments. Dual-task and multitask approaches provide ways to probe activity- and participation-level performance in service members with mTBI, although military-specific tasks have not been described in the literature. In the following sections, characteristics and evidence supporting each approach are highlighted to provide an overview of their potential prognostic utility and clinical feasibility in assessing service members with mTBI.

Table.
Assessment of Military Multitasking Performance (AMMP)[a]

AMMP Task	mTBI-Related Vulnerabilities/ Task Demands	Task Description	Assessment Metric	Task Rationale	Published Sources and Stakeholder Inputs Contributing to Task Design
Illinois Agility Test (dual task)	Memory, attention, dynamic stability, and agility	Single task (motor): running distance of 9.1 m (30 ft) with rapid direction changes and navigation of serpentine obstacles. Single task (cognitive): 7-word list memory task. Dual-task condition: agility task and the memory task are done at the same time.	Accuracy of memory recall and time to complete the agility task are measured in single and dual-task conditions. Dual-task costs for cognitive and motor components.	Tests of walking with dual-task performance are unlikely to identify discernible dual-task costs. Service member demand for speed and agility during quick maneuvers while attending to other information supports this high-level balance, running, and working memory task.	Getchell (1979)[53] McCulloch et al (2009)[55] Hyndman et al (2006)[61]
Step initiation–Stroop test (dual task)	Executive function, reaction time, and balance	Single-task condition: service member initiates forward and backward steps in response to a vibratory stimulus to the stepping leg. Dual-task condition: stepping trials performed in conjunction with a modified visual Stroop test.	Step initiation time, foot lift time, and step time in single-task and dual-task conditions.	Testing paradigm allows for sensitive measurement of reaction time, susceptible to mTBI. Vocational importance of quick responsiveness to sensory stimuli supports this task.	Melzer et al (2007)[56]
Radio chatter–magazine load (dual task)	Executive function, attention, and manual dexterity	Single task (motor): service member loads simulated M-16 rounds into an ammunition magazine. Single task (cognitive): service member identifies discrete audio cues on a simulated radio transmission. Dual-task condition: loading magazine while listening to simulated radio broadcast.	Number of cognitive errors (omission, commission) and number of rounds loaded in single-task and dual-task conditions.	A dual-task scenario using a manual task and a cognitive task demonstrated mTBI deficits. The requirement to hear and identify relevant information on a tactical network while performing bimanual dexterity tasks is functionally significant.	Cicerone (1996)[52]
ISAW-grid (dual task)	Memory, attention, gaze stability, balance, and dynamic stability	Single task (motor): instrumented postural sway and gait assessment. Single task (cognitive): 8-digit alphanumeric grid coordinate memory task. Dual-task condition: instrumented sway and gait measures while performing memory task.	Accuracy of memory recall, postural sway area, gait path variability, and time for completion in single-task and dual-task conditions.	Preliminary testing of individuals postconcussion using this paradigm has been reported. The importance of maintaining postural and dynamic stability in activities of daily living is fundamental to all other functional tasks, behaviors anecdotally susceptible to effects of blast exposure. This task utilizes accelerometry, sensitivity that may be necessary to identify movement aberration resulting from mTBI.	Mancini et al (2012)[54]

(Continued)

Table.
Continued

AMMP Task	mTBI-Related Vulnerabilities/ Task Demands	Task Description	Assessment Metric	Task Rationale	Published Sources and Stakeholder Inputs Contributing to Task Design
SALUTE (multitask)	Executive function, attention, memory, visual scanning, gaze stability, and exertion	Service member is challenged to gather information from video surveillance recordings and radio communication recordings (SALUTE) while performing a continuous modified step test at >65% of age-predicted maximum THR.	Accuracy/errors of SALUTE report; ability to maintain appropriate exertional load.	The ability to integrate and retain in one's working memory visual and auditory stimuli that are operationally significant under exertion represents a high level of functional readiness in a clinical environment in a task that is clearly relevant to a service member.	Warrior Resiliency and Recovery Center, Fort Campbell, Kentucky Developed to address key vulnerabilities not addressed with existing methods
Run, roll, aim (multitask)	Attention, smooth pursuit tracking, dynamic stability, exertion, vertical gaze stability, and monocular vision	Service member completes a high-level mobility task with multiple visually cued maneuvers while carrying a simulated weapon. Rapid start, obstacle (trip wire) avoidance, 3- to 5-second rush, dive to a prone position, combat rolling. Visual target selection through weapon scope, rapid lateral dodging and back pedaling.	Total time for complex task completion with penalties for errors; accuracy of visual target identification; head-mounted inertial sensor measures of acceleration and angular velocity for movement components.	The ability to execute individual movement techniques may provoke vestibular symptoms, known to be an issue following mTBI. Intermittent visual search via weapon scope and fast position changes challenges sensory stability and motor performance at a high level of functional performance in a task that is clearly relevant to a service member.	Warrior Resiliency and Recovery Center, Fort Campbell, Kentucky Developed to address key vulnerabilities not addressed with existing methods
CQ duty (multitask)	Executive function, memory, and visual scanning	Service member organizes and performs an array of interleaving tasks associated with a hypothetical assignment to staff duty, including communicating information via radio at the beginning, middle, and end of the task; assembling a footstool for an injured service member; filing a duty log; and obtaining additional information from wall charts. Following directions for additional subtasks, and radio when the exercise is completed. A prospective memory task also is incorporated into the CQ duty scenario.	Number of subtasks completed accurately. Number and types of errors and rule breaks. Number of transits between the 4 workstations to complete the task. Overall performance time required to complete the task.	This task requires planning a series of subtasks that dovetail with each other to accomplish the goal in the most efficient way, requiring executive function. Working memory requirements are integrated throughout the task.	Alderman et al (2003)[77] Burgess (2000)[59] Burgess et al (2006)[60]

[a] mTBI=mild traumatic brain injury; ISAW=instrumented stand and walk; SALUTE=Size, Activity, Location, Unit, Time, Equipment report; THR=target heart rate; CQ=charge of quarters.

Dual-Task Performance

Dual-task assessment methods require an individual to perform a primary task while simultaneously performing a secondary task, with combined performance compared with one's baseline performance in each single-task condition.[66] In this context, a motor task with a secondary cognitive task is a reasonable combination. Reduction in performance of a task when executed in conjunction with a secondary task is termed the *dual-task cost* (eg, cost in time or in number of errors) of performing 2 tasks simultaneously. The interpretation of dual-task paradigms follows the view that human processing resources are limited and capacity must be shared to accomplish both tasks, often resulting in dual-task performance costs.[67]

Many studies have revealed accentuated deficits in dual-task abilities following concussion and mTBI during postural control tasks acutely, with impairments sometimes persisting several months postinjury.[35,36,62] These dual-task costs are significantly greater than those observed in age-matched controls and are influenced by environmental and visuospatial complexity.[62,65,68–70]

The ability to do 2 tasks at once is theorized to require executive control. Attention must be allocated appropriately to perform both tasks successfully. Laboratory studies using cognitive dual tasks reveal slower reaction and response times and increased cognitive task error following sports concussions.[70–72] Additionally, difficulty with dual tasks or an inability to perform such tasks is associated with safety problems and may not be evident if motor or cognitive tasks are assessed singly and not in combination.[62,65] Individuals with concussion and mTBI and those with more severe acquired brain injury show consistent difficulty with dual-task performance of cognitive and motor tasks in laboratory dual-task paradigms and clinical tests during walking.[67,70,73] After concussion, dual-task costs have been documented in walking speed, variability, and stability. The ability to orient, allocate attention to, and switch focus between visual stimuli is impaired, which is correlated with problems with obstacle avoidance while walking.[62–64,70,74,75] Higher-level balance deficits, vestibular injury, or musculoskeletal injury may contribute to these performance problems. These dual-task gait deficits have been observed to persist over longer time frames than cognitive deficits after concussion and could influence mobility on uneven terrain.[35,76]

Dual tasks that have been used clinically include memory tasks executed during walking and running conditions. One example of a dual task formulated to challenge a military service member population could involve administering the Illinois Agility Test (which requires rapid direction changes and obstacle avoidance, consistent with service member physical training activities) while performing a secondary cognitive task to challenge dynamic stability, agility, and cognitive function simultaneously.[40] Most studies of dual-task performance postconcussion also have used sensitive instrumentation to capture what are sometimes small changes in postural control. Dual-task scenarios tailored to service members could be designed in a similar way by using compact technologies (eg, inertial sensory measures) to improve measure sensitivity in forward-deployed or remote environments where safe and timely RTD decisions are most critical.

Multitask Observational Performance

Competence in everyday life requires the ability to multitask, using multiple cognitive and motor abilities to plan, organize, and carry out complex tasks (Box 3). Standardized testing of multitask performance is used in occupational therapy and neuropsychology to approximate the demands of a real-world environment (ie, role engagement) and is valued for its ecological validity.[57,60] Planning, organizing, and problem solving, governed by executive function, are required during a multitask assessment. The evaluator observes performance for *errors in action* while a patient is given free rein to perform prescribed multistep everyday tasks that involve an array of multiple objects, task demands, and rules.[57]

Box 3. *Burgess' Definition of Multitasking* describes 5 features that are commonly included in performance-based multitask assessments.

Many tasks: Numerous separate and varied tasks are completed.
Interleaving: Tasks are dovetailed (ie, alternated or coordinated in accordance with a plan).
Only one task performed at a time: Tasks are performed one at a time due to either cognitive or physical constraints, further reinforcing interleaving.
Interruptions and unexpected outcomes: Tasks are dynamic and may have unanticipated interruptions or situations where things do not go as originally planned.
Delayed intentions: Tasks require a person to remember to do a second thing, unrelated to the successful completion of the overall multitasks (referred to as a "prospective memory" requirement).

Performance-based multitask assessments have been developed that focus on frontal lobe dysfunction that occurs with stroke and TBI.[57,77] These assessments reveal common problems with multitasking across the spectrum of patients with neurologic involvement from subtle deficits after mild stroke to more significant cognitive deficits following moderate to severe TBI.[65,67,70,78–80] Without exception, the multitask scenarios described in the literature lack face validity for the military population; they require instrumental activities of daily living such as simple cooking tasks or telephone use (Naturalistic Action Test [NAT], Executive Function Performance Test), wrapping a present (NAT), or running errands in a mall or hospital setting (Multiple Errands Test). Although these assessments evaluate high-level executive functioning deficits and require prioritization of tasks, switching sets, and prospective memory, such metrics are not reflective of military vocational demands.

Effective multitasking is essential during combat operations. A report by Fischer and Mautone[81] on multitasking requirements in military environments suggests that environments vary along 3 main dimensions: type of multitask required (decision making, information monitoring, and task-flow management), intensity of multitask, and consequences of failure. Multiple sensory, motor, and cognitive systems contribute to successful multitasking skills, systems that may be compromised following mTBI.

Service members may perform well on impairment-based assessments that evaluate single-component processes in nondistracting and nonstressful environments. Performance deficits become evident when tasks are presented with less structure and increasing difficulty, requiring real-time decision making and the effective allocation of cognitive, physical, and sensorimotor resources across multiple simultaneous demands. Anecdotally, service members who are successful in performing isolated cognitive, physical, and sensorimotor tasks (eg, BESS, ANAM, ImPACT) often report a sense of feeling "off" when similar challenges combine within the multidimensional demands that are critical to most service members' duties or to complex family life situations when in garrison.

Theorized military multitask scenarios should focus on the multisystem vulnerabilities associated with concussion and mTBI. Examples of multitask formulations that may prove useful in discriminating RTD readiness have recently been described.[40] One such measure challenges a service member to observe, process, and retain relevant information from a customized, computer-generated mission scenario while continuously stepping on an exercise step at a moderate pace. This task combines physical exertion with a demand for vigilance or "situational awareness" during a simulated dismounted patrol in a way that approaches the real-world demands on a member of a reconnaissance patrol in deployed environment. Although highly realistic computer graphics and meticulously scripted scenario content allow an examiner to target known mTBI-related vulnerabilities, this assessment differs from more sophisticated VR approaches in its simplicity and clinical feasibility. The task can be projected to any treatment environment that will support a computer monitor and an exercise step (with or without inertial sensor data collection). Another task approximates the physical agility required for military individual movement techniques while intermittently challenging visual sensory stability and attention to detail (verbal identification of targets) during target sighting through a simulated weapon scope. Demands of this test task are consistent with rapidly changing physical, sensory, and cognitive demands in a combat environment.

Conclusion

Determination about service members' readiness to RTD following mTBI is still informed primarily by a patient's self-report of symptoms and by clinical tests that assess performance within distinct body structure or function domains. Widespread adoption of a theoretical framework that measures service member fitness for duty at the activity or participation level would be highly desirable to improve prognostication of real-world warfighting performance. General acceptance of a paradigm that conceives of an individual's *readiness*, not as the absence of impairments but as a vector-sum of military competencies, represents an important ideological shift from what a member *cannot* do, to what he or she *can* do. Although this type of standards-based construct may be difficult to quantify using conventional impairment-based testing, complex assessment methods should help to bridge this assessment gap.

Measures of postconcussive functional performance emerging to address RTD assessment challenges within the DoD include immersive virtual environments; field or scenario-based programs; and clinical tests incorporating dual-task and multitask methods. Although each of these approaches has relative strengths and limitations, all are challenged by a general lack of clarity on how to externally validate duty readiness following mTBI. Absence of a "gold standard" benchmark of duty readiness within the DoD persists as much due to the complexity of factors that affect human performance following neurotrauma as to uncertainty surrounding how to measure such a multifaceted construct. Measurement may be further confounded by the expense required to install, administer, and sustain technologically sophisticated or intensive assessment programs, dramatically limiting use of certain methods outside of hub military treatment facilities. Such barriers constrain the widespread feasibility of these approaches and make DoD-wide standardization of RTD metrics difficult. Development of militarized dual-task and multitask methods represent a potential solution to these practice and dissemination barriers given the relative feasibility of clinical assessment techniques, demonstrated utility of dual-task and multitask assessment in civilian patients with TBI, and their strong face validity for commanders, service members, and clinicians.[65,67,70,73–75,79,80]

Dual-task and multitask testing methods may be more time consuming to administer than impairment-based assessments and not necessarily feasible for all environments of care.[82] Nonetheless, their potential sensitivity to duty-limiting performance gaps could be quite valuable in remote clinical practice settings where timely and appropriate RTD determinations often are essential.

Future research efforts should continue to explore and develop standards-based criteria to guide RTD and RTP decision making, not only in the wake of mTBI but also to address the broad spectrum of potential duty- or play-limiting deficits. Standards-based metrics do not replace traditional clinical decision making by clinicians who manage patients and their injuries. Such methods provide military clinicians with additional data points for evaluating abilities more clearly related to functional occupational demands. This approach ultimately benefits the service member, the unit, and the military as a whole by verifying that a returning service member is not only symptom-free but truly "duty ready."

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Returning Service Members to Duty Following Mild Traumatic Brain Injury: Exploring the Use of Dual-Task and Multitask Assessment Methods

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Brief Report

Development and Preliminary Reliability of a Multitasking Assessment for Executive Functioning After Concussion

Laurel B. Smith, Mary Vining Radomski, Leslie Freeman Davidson, Marsha Finkelstein, Margaret M. Weightman, Karen L. McCulloch, Matthew R. Scherer

MeSH TERMS

- brain concussion
- executive function
- military personnel
- reproducibility of results
- task performance and analysis

OBJECTIVES. Executive functioning deficits may result from concussion. The Charge of Quarters (CQ) Duty Task is a multitask assessment designed to assess executive functioning in servicemembers after concussion. In this article, we discuss the rationale and process used in the development of the CQ Duty Task and present pilot data from the preliminary evaluation of interrater reliability (IRR).

METHOD. Three evaluators observed as 12 healthy participants performed the CQ Duty Task and measured performance using various metrics. Intraclass correlation coefficient (ICC) quantified IRR.

RESULTS. The ICC for task completion was .94. ICCs for other assessment metrics were variable.

CONCLUSION. Preliminary IRR data for the CQ Duty Task are encouraging, but further investigation is needed to improve IRR in some domains. Lessons learned in the development of the CQ Duty Task could benefit future test development efforts with populations other than the military.

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Concussion has received unprecedented attention in the military because of the increased incidence in the past decade (Helmick, Baugh, Lattimore, & Goldman, 2012) and has been called the "signature injury" of the conflicts in Iraq and Afghanistan (McCrea et al., 2009, p. 1369). Concussion may result in symptoms including headache, dizziness, nausea, sensitivity to noise and light, slowed thinking and reaction time, memory problems, difficulty concentrating, executive dysfunction, and visual and balance changes (Carroll et al., 2004). Although subtle and sometimes difficult to detect, these multisensory symptoms can negatively affect job performance and safety in servicemembers.

Army occupational therapists play key roles in evaluating servicemembers and making recommendations regarding their ability to return to duty after concussion. Currently, occupational therapy practitioners rely on self-reported symptoms and vestibular and neuropsychological assessments to determine duty readiness. However, subjective symptom report does not always coincide with clinical recovery (Vagnozzi et al., 2008), and neuropsychological assessment batteries do not always predict real-world functioning, especially after a combat experience (Brenner et al., 2010). Accurate assessment is further limited by measures with ceiling effects or minimal sensitivity to concussion-related deficits.

Multitask assessments may be more sensitive to subtle performance deficits because they replicate the simultaneous cognitive and sensorimotor demands of unstructured, complex real-world activities (Frisch, Förstl, Legler, Schöpe, & Goebel, 2012). Despite the potential benefit of this assessment approach and alignment with priorities for occupational therapy evaluation, few options exist that have satisfactory reliability, validity, and clinical utility (Dawson et al., 2009). The

Multiple Errands Test (MET; Shallice & Burgess, 1991) is an example of a multitask assessment of executive functioning based on five demands of multitasking: (1) performing multiple but discrete tasks that vary in priority, complexity, and length; (2) managing interleaving and dovetailing tasks; (3) performing tasks without feedback; (4) dealing with interruptions, reprioritization, and rule changes; and (5) self-initiating task changes within the activity (Burgess, 2000). The many versions of the MET involve completing at least 10 unrelated tasks while complying with a series of rules in either a shopping mall or hospital lobby setting (Alderman, Burgess, Knight, & Henman, 2003; Cuberos-Urbano et al., 2013; Dawson et al., 2009; Morrison et al., 2013). Although the MET appears to assess "the central aspects of executive functioning in everyday life" (Frisch et al., 2012, p. 257), it has yet to be widely adopted in clinical practice because of site-specific validation requirements, time-intensive administration, and a lack of standardized scoring manuals specific to each site (Radomski & Morrison, 2014).

A team of military and civilian occupational and physical therapists are currently developing a performance-based assessment battery called the Assessment of Military Multitasking Performance (AMMP; Radomski et al., 2013). The AMMP includes six dual- and multitask assessments designed to assess concussion-related deficits. If proven reliable and valid, the AMMP will be used by military occupational and physical therapists to determine duty readiness for servicemembers after concussion.

The Charge of Quarters (CQ) Duty Task (CQDT) was developed as one of the assessments included in the AMMP battery that uses the structure of the MET to assess executive functioning. CQ duty is an additional duty in the military during which servicemembers are responsible for 24-hr supervision and security of a facility; servicemembers on CQ duty are frequently tasked with various assignments that are unstructured and unrelated in nature. This scenario provides a realistic backdrop for the multitask assessment given the reality of task demands and face validity among servicemembers. This article describes the rationale and development process of the CQDT and presents pilot data from the preliminary evaluation of interrater reliability (IRR).

Description of the Charge of Quarters Duty Task

In the CQDT, as in the MET, participants receive in-depth instructions and a written list of assignments and performance rules. They are required to visit four different hypothetical work areas (marked with duct tape): (1) the CQ desk, (2) the bulletin board, (3) the supply closet, and (4) the assembly area, each containing the information and resources necessary to complete their assignments. They are encouraged to keep transits between work areas to a minimum (seven or fewer) and are told to revisit an area only if necessary to complete the task. Task assignments include reporting a CQ duty shift change, assembling a footstool from PVC pipe, reporting the number of vacant rooms in the barracks (living quarters for servicemembers) using a barracks layout, conducting an inventory of PVC supplies, obtaining the address of the manufacturer of the footstool materials, locating the telephone number of another servicemember using a personnel roster, and locating the room of a specified servicemember using a map of a barracks layout.

During the exercise, participants must adhere to four rules: (1) Assemble the footrest only in the assembly area, (2) bring only the number of PVC parts needed for the footrest to the assembly area, (3) do not move or remove any of the materials from the walls in any of the work areas, and (4) do not speak to the examiners during the assessment. Throughout the task, participants must also deal with interruptions and reprioritization of tasks. Scoring metrics borrowed from the MET include accuracy of task performance (Cuberos-Urbano et al., 2013; Dawson et al., 2009; Morrison et al., 2013), total rule breaks (Cuberos-Urbano et al., 2013; Dawson et al., 2009; Morrison et al., 2013), frequency of rule breaks (Dawson et al., 2009), transits between work areas (Morrison et al., 2013), and total performance time.

Method

Instrument Development

The CQDT was developed as part of the AMMP battery. The initial version of the AMMP included five multitask assessments and three dual-task assessments (Radomski et al., 2013). After initial pilot testing of the AMMP battery, data analysis indicated variable IRR (intraclass correlation coefficients [ICCs] of .45, .37, and .79 for task performance) for the three multitask assessments of executive functioning. Scoring was complicated by errors resulting from simultaneous observation and scoring requirements and by a lack of clearly defined scoring criteria outlining acceptable tolerances for partially accurate task performance. For example, when participants were told to obtain an address, rater disagreements occurred if part of the address was incorrect (e.g., transposed digits, spelling errors); some examiners gave full credit for task completion and others gave no credit. In addition to multiple scoring challenges, test developers indicated substantial test burden from three relatively similar multitask assessments and limited face validity of the tasks as reported by participants. In an effort to improve IRR, face validity, and clinical feasibility, the CQDT was developed to replace the three previous iterations of multitask assessments.

The first step in the development of the CQDT was to reexamine the literature pertaining to current multitask assessments. The team also shared the initial concept, materials, and instructions of the CQDT with a panel of experienced servicemembers who provided recommendations to improve face validity of the task with the target population. On the basis of the definition of multitasking (Burgess, 2000) and feedback from subject matter experts, the team created a list of parameters to be tested.

Once the initial task was developed, test developers practiced administering the task on servicemembers and civilians to observe variations in performance and variations in the interpretation of performance by multiple evaluators. After practice administrations, test developers clarified task instructions and revised the approach to scoring by creating operational definitions that clarified situations in which no credit, partial credit, or full credit should be given. These operational definitions were included on the score sheet. For example, a participant who reported the incorrect number of barracks rooms would receive partial credit for task performance in that domain as determined by the operational definition for that task. This scoring approach reduced scoring complexity and allowed raters to assign a score quickly upon observation of task completion.

The score sheet was also improved to reduce scoring errors resulting from simultaneous observation and scoring requirements. Many aspects of the CQDT required scoring in real time (i.e., radio communications with various personnel on the correct radio frequency) to determine whether participants completed tasks independently and accurately or required cueing. Raters who were distracted or who failed to score performance on these tasks immediately made scoring errors. To address this issue, task assignments were listed chronologically on the score sheet, and tasks requiring immediate scoring were emphasized with bold font. This design helped cue the evaluators to ensure observation of performance at appropriate times. Last, the score sheet included correct responses for objective performance components (e.g., correct number of vacant barracks rooms to be reported, manufacturer's address), allowing the rater to quickly identify performance accuracy and assign the appropriate score. These additions were implemented to maximize scoring efficiency.

After all modifications were made to the CQDT, test developers piloted the revised multitask assessment in a healthy population to assess IRR. Given the anticipated variability in task performance between healthy servicemembers and those with concussion, evaluation of IRR in healthy servicemembers allowed for subsequent scoring and procedural refinements to be made before evaluating IRR in servicemembers with concussion.

Intrarater Reliability Testing

Preliminary IRR was assessed between 3 (2 trained and 1 novice) raters when measuring individual participant performance on the CQDT. The two trained raters were involved in test development, and the novice rater was a physical therapist with no prior experience with the CQDT. This design helped determine whether inexperienced providers could easily and accurately score the assessment. Before evaluating participants, the novice rater received a brief orientation (<30 min) to the score sheet, performance metrics, and operational definitions of task performance, rules, and rule breaks. IRR was established for all raters.

Participants

Participants were recruited by convenience sampling from the U.S. Army Research Institute of Environmental Medicine in Natick, Massachusetts. All healthy active-duty servicemembers (active duty, guard, or reserve component) ages 18–42 yr were eligible to participate. Participants were excluded if they reported a history of traumatic brain injury (TBI) or concussion in the previous year, any documented active-duty restrictions (currently on a military profile), any physical or behavioral health condition preventing sustained activity for up to 30 min, history of psychiatric disorder, and uncorrected hearing deficits. All participants gave written informed consent before participation, and the institutional review board at the U.S. Army Research Institute of Environmental Medicine approved the study.

Data Collection

The following components were measured via observation:

- *Task completion* was defined as the extent to which participants independently and accurately completed each assignment. Each assignment was scored 0 (*not complete*), 1 (*partially complete or required cueing to complete*), or 2 (*completed to defined standard independently without cueing*). The test included 17 assignments (some assignments required more than one task), with up to 2 points possible for each, for a total of 34 possible points for task completion.
- *Total rule breaks* for the four rules were operationally defined on the score sheet. Each rule that was broken was recorded.
- *Frequency of rule breaks* was recorded for each rule; it was possible to break the same rule multiple times. No limit was placed on the frequency of rule breaks.
- *Performance time* was defined as the total time to complete the task.
- *Transits* were defined as movements between work areas. Leaving one work area and entering another was considered one transit.

Data Analysis

The ICC was used to quantify preliminary IRR. The Krippendorff (Hayes & Krippendorff, 2007) α macro was run under SPSS Version 18.0 (IBM Corporation, Armonk, NY) to generate the ICCs. Twelve cases provided 95% confidence to measure our objective for an ICC of .90 against a minimum ICC of .70 (Bonett, 2002). For metrics that achieved an ICC of .90, the mean, standard deviation, and range are reported on the basis of the median of the three scores for each participant.

Results

A total of 12 servicemembers (7 men and 5 women) participated in this study. The mean time to perform the CQDT was 19.6 min; 7 of 12 participants completed the task in <20 min and 11 of 12 in <23 min. The maximum test duration was 31.9 min. The average number of transits was 10.5. Table 1 provides the IRR results. Rule breaks and frequency of rule breaks were not reliable, with ICCs of .66 and .64, respectively. Task completion, transits, and total time were highly reliable, with ICCs of .94, .98, and .98, respectively.

Discussion

Occupational therapists are charged with developing and implementing measurement strategies that characterize the extent to which impairments impede daily life performance (Baum, Perlmutter, & Dunn, 2005). Doing so is difficult when impairments such as executive dysfunction are potentially difficult to detect, as in servicemembers with concussion. Performance-based assessments that involve multitasking have demonstrated the potential to discriminate between

Table 1. Preliminary Interrater Reliability Results for the Charge of Quarters Duty Task (*N* = 12)

Item	Reliability (ICC)	95% CI	Mean (*SD*)	Range
Task completion	.94	[.86, .99]	27.6 (5.6)	13–33
Rule breaks	.66[a]	[.39, .88]		
Frequency of rule breaks	.64[b]	[.32, .90]		
Transits	.98	[.96, .99]	10.5 (4.0)	5–18
Total time (min)	.98	[.96, .99]	19.6 (4.8)	13.2–31.9

Note. CI = confidence interval; ICC = intraclass correlation coefficient; *SD* = standard deviation. The mean, standard deviation, and range are reported only for metrics that achieved an ICC of .90.
[a]Four of 12 triplets did not agree. [b]Six of 12 triplets did not agree.

healthy control participants and people with executive dysfunction (Alderman et al., 2003; Baum et al., 2008; Morrison et al., 2013; Wolf, Morrison, & Matheson, 2008) and may be an alternative to traditional measures of cognitive domains, which often fail to detect existing deficiencies in complex task performance (Tranel, Hathaway-Nepple, & Anderson, 2007). Although such tests do not appear to be subject to the ceiling effects of more structured measures of performance (Hall et al., 1996; Scott et al., 2011), they are typically complex to administer and score (Morrison et al., 2013). More multitasking tests that are specific to various clinical populations and life situations are needed. IRR specific to servicemembers with concussion and discriminant validity remain untested for the CQDT, but the preliminary evaluation of IRR in healthy participants suggests progress in the development of a multitask assessment of executive functioning for servicemembers with concussion.

The current evaluation of preliminary IRR highlights easily scored metrics for multitasking assessment and those requiring further refinement by the research team. IRR for task completion improved from previous versions of multitasking assessments because the score sheet was redesigned to include operational definitions and list performance tasks chronologically. These elements helped clarify scoring criteria and reduce rater disagreements regarding task performance.

Unfortunately, behavioral aspects of rule breaks and frequency of rule breaks were not as well specified, accounting for continued but solvable problems with IRR. Rater disagreements in how to score vocalizations directed at the examiners (e.g., asking the examiner questions) and the number of PVC parts brought to the assembly area largely explained the unacceptable ICCs for rule breaks and frequency of rule breaks. Operational definitions were not clear enough to account for the unpredictable nature of human performance in these areas. Additionally, the restricted range resulting from only four rules may have had a negative impact on the ICC values. With a restricted range, one missed observation in rule breaks can affect the ICC value to a greater degree than with a greater number of rules. In preparation for future data collection, operational definitions have been revised and piloted to improve IRR for rule breaks.

Limitations and Future Directions

The CQDT is in relative infancy in terms of test development. Thus far, clinical feasibility and IRR for the CQDT have been evaluated in only a small number of healthy participants. Results of future data collection will determine IRR and clinical feasibility of the CQDT in a clinical population and, most important, will ascertain whether it discriminates between healthy control participants and servicemembers with concussion. If so, further research will need to be conducted to determine whether the CQDT predicts successful return to duty. Finally, the team is exploring the development of a civilian version of the CQDT that could be used as a standalone assessment of executive dysfunction.

Implications for Occupational Therapy Practice and Research

The results of this study have the following implications for occupational therapy practice and research:

- Performance-based assessments of multitasking may enable occupational therapy practitioners to identify executive function deficits after concussion.
- Because of the complexity of scoring a multitask assessment, operational definitions for scoring are best developed on the basis of observed variations in task performance and differences in interpretation of that performance by multiple evaluators.
- The lessons learned in the development of the CQDT may benefit occupational therapy practitioners interested in developing performance-based assessments of executive dysfunction tailored to populations and practice settings other than the military.

Conclusion

There remains a need for reliable, valid, and clinically feasible assessments that can be used to identify executive dysfunction. Performance-based assessments that incorporate multitask methods and accurately simulate job demands may prove useful for occupational therapy practitioners in determining return-to-activity timelines in various populations. ▲

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Title: Further Development of the Assessment of Military Multitasking Performance: Iterative Reliability Testing

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Abstract:
The Assessment of Military Multitasking Performance (AMMP) is a battery of functional dual-tasks and multitasks based on military activities that target known sensorimotor, cognitive, and exertional vulnerabilities after concussion/mild traumatic brain injury (mTBI). The AMMP was developed to help address known limitations in post concussive return to duty (RTD) assessment and decision making. Once validated, the AMMP is intended for use in combination with other metrics to inform duty-readiness decisions in Active Duty Service Members following concussion. This study used an iterative process of repeated interrater reliability testing and feasibility feedback to drive modifications to the 9 tasks of the original AMMP which resulted in a final version of 6 tasks with metrics that demonstrated clinically acceptable ICCs of > 0.90 for most task metrics. Study findings support continued validation of this assessment tool to provide rehabilitation clinicians further RTD assessment methods robust to ceiling effects with strong face validity to injured Warriors and their leaders.

Key Words: concussion, dual-task, mild traumatic brain injury, military personnel, multitask, OIF/OEF, outcome measures, performance based assessment, interrater reliability, return to duty.

Abbreviations: AMMP = Assessment of Military Multitasking Performance, BI = brain injury, COG = cognitive priority, CQ = charge of quarters, DTC = dual task cost, DVBIC = Defense and

Veterans Brain Injury Center, HC = healthy control, HRV = human research volunteers, IAT = Illinois Agility Test, ICC = intraclass correlation coefficient, IED = improvised explosive device, IRR = interrater reliability, ISAW = Instrumented Stand and Walk, MOB = mobility priority, mTBI = mild traumatic brain injury, NA = not applicable, NI = no instruction, OT = occupational therapist, PT = physical therapist, RPE = rate of perceived exertion, RRA = Run Roll Aim, RTD = return to duty, Rx = reaction, SALUTE = size, activity, location, unit or uniform, time, and equipment, SM = Service member(s), USAARL = United States Army Aeromedical Research Laboratory, USARIEM = United States Army Research Institute of Environmental Medicine, VAS = visual analog scale, WAMC = Womack Army Medical Center.

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STATEMENT of RESPONSIBILITY

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MMW contributed to study concept and design, acquisition of data, analysis and interpretation of data, drafting and critical revision of manuscript for important intellectual content, obtaining funding as PI/PD of the grant; administrative, technical and material support and overall study oversight and supervision.
McCulloch KL,
KM assisted with study concept and design, acquisition of data, analysis and interpretation of data, critical revision of manuscript, and administrative support at Fort Bragg.
Radomski MV,
My author contributions include study concept and design; acquisition of data; interpretation of data; contributing intellectual content to the manuscript. MVR
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Marsha Finkelstein contributed to the study design's analytical methods, analysis and interpretation of data, drafting and revising the manuscript, design of data capture processes and the database. MF
Cecchini AS,
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I contributed to study design and concept, IRB approval/ supervision (for USARIEM), test development and refinement (CQ Duty Task), and data acquisition for all test tasks (USARIEM, FT Bragg). I provided final approval for version publication. LS

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I, Matthew R Scherer, contributed to study design and concept, IRB approval/ supervision and research administration requirements at one of the primary test sites (Site PI at USARIEM), data collection (USARIEM), analysis and interpretation of data, critical revision and re-writes to the manuscript. I provided final approval for version publication.

INTRODUCTION

Combat-related exposures, routine operational and training activities as well as common sports and leisure activities all put military service members (SM) at increased risk for sustaining a traumatic brain injury (TBI) in both theater and garrison environments. In excess of 320,000 Service Members (SM) sustained at least one TBI from 2000 through the end of 2014 with more than 82% of these injuries classified as mild (http://dvbic.dcoe.mil/dod-worldwide-numbers-tbi, accessed 1May2015). Military personnel who have been concussed may experience persistent cognitive, postural and dynamic stability deficits in addition to disabling headaches, sleep dysfunction, auditory, vestibular, and visual impairments. The occurrence of such symptoms and deficits can limit safe and effective job performance in the inherently demanding military profession [1}. While most personnel recover within days or weeks after concussion, for some individuals [2], symptoms can persist impairing duty performance and disrupting a SM's ability to safely return to duty.

Rehabilitation clinicians currently use a variety of metrics to evaluate acute concussion including subjective symptom reports combined with neuropsychological testing and standardized postural stability assessments such as the Balance Error Scoring System [3]. These approaches, based on a sports medicine model, typically involve comparison of post-injury results to a pre-injury baseline test of the same measures. Pre-injury baseline tests are typically not available for many in the military, so alternatives are needed. Presently, there are limited options for military-based functional assessments to evaluate SM following concussive injury [4]. In deployed settings, Department of Defense policy mandates the use of functional assessment measures for Soldiers after three or more concussive events to guide return to duty (RTD) decision-making in that environment [1]. Given the inherent risks associated with premature return to combat [4], this approach acknowledges the importance of assessing complex task performance under realistic conditions. It is noteworthy however, that specific guidance on the type, difficulty and duration of such assessments has not been established, defined or standardized by the DoD or other potential stakeholders in the professional athletics community [1,4]. To address these gap areas in functional performance testing for military personnel, our military-civilian rehabilitation research team developed a post concussive functional assessment battery to provide RTD guidance following mild traumatic brain injury [4]. The Assessment of Military Multitasking Performance (AMMP) is a battery of functional dual-tasks and multitasks that simulate the combined sensorimotor, cognitive, and exertional demands of common Soldier tasks. The initial AMMP development which was informed by military stakeholder inquiry, expert consultation & literature review, has been described elsewhere [5]. In brief, the AMMP test battery initially consisted of nine dual-task and multitask assessments which were developed by members of the research team with one investigator serving as the principal developer of each task. Task were designed to challenge distinct mTBI related vulnerabilities with some redundancy in terms of the domains or vulnerabilities tested.

The AMMP purports to measure a complex and heterogeneous concept: “readiness for duty”. Unlike similar functional performance measures however, “readiness to RTD” is not a construct that resides in an isolated performance domain such as physical capability [3,6-11] or executive function [12,13]. Common Soldier tasks require decision-making, intact cognitive and sensory function, often in dynamic and stressful environments requiring elite physical abilities. As such, valid measurement of integrated functional performance can be a challenging process relative to standard clinical assessment of isolated performance in physical, sensory or cognitive domains. The AMMP team focused on development of a performance based assessment that targeted known mTBI vulnerabilities. The AMMP had to meet ecological validity standards of military personnel, including commanders, who value the real-world use of the assessment [5]. In addition, practical considerations including the administration time, test space requirements, and cost and durability of test materials were all factors that required consideration in the development of the AMMP [5,10]. Given the consequences of using AMMP metrics to contribute to duty readiness decisions, a vital first step in the AMMP validation process was to determine if the AMMP tasks could be scored reliably.

The purpose of this article is to describe the iterative task refinement process for the Assessment of Military Multitasking Performance including feasibility considerations and the use of repeated inter-rater reliability testing to improve task metrics, administration and scoring instructions.

METHODS

This measurement development study involved three sequential phases which used inter-rater reliability findings, informal and qualitative feedback from raters and subjects, as well as logistical evaluation by the test developers of practical properties to drive task revision. Specifically, the team integrated lessons learned during testing in an iterative manner over successive phases of testing to improve face validity of the tasks and the quality of subject performance data. Investigators also worked to decrease test burden on participants by decreasing test administration time. Other considerations during task development and refinement included consideration of the cost and durability of equipment, and testing space requirements. Revisions included refinement of task administration and scoring instructions, operational definitions and scoring metrics for the AMMP tasks. All subjects provided informed consent as specified by the relevant institutional review board prior to testing at each phase of AMMP development. Specifically study protocols were approved by the IRB at the United States Army Research Institute of Environmental Medicine (USARIEM) and the Womack Army Medical Center (WAMC) at Fort Bragg.

Phase I: Testing in active duty healthy control Soldiers

The goal of this Phase I was to evaluate the inter-rater reliability (IRR) and feasibility of the AMMP when administered to military healthy control (HC) subjects. There were 2 subcomponents to this phase. During Phase Ia, we evaluated the feasibility and IRR of the original 9 tasks comprising the original version of the AMMP [4,5]. Three of the original [14] 5 multitasks were eliminated and salient components were refined and consolidated into one multitask called the Charge of Quarters (CQ) Duty Task (see Figure). The 3 original multitasks demonstrated poor IRR due to unclear operational definitions of success and failure on task components (Figure), and difficulty observing all components of each task. One of the 4 original dual-tasks, the Step initiation-Stroop task was dropped after this phase of testing in favor of dual task assessments with greater face validity [4,5] and due to concerns about durability of instrumentation. For Phase IIb, feasibility and IRR of 2 test tasks were evaluated, the new multitask, CQ Duty and a revised SALUTE multitask was modified to incorporate improvised explosive device (IED) marker reporting. In a later phase of this study, the SALUTE multitask was modified to incorporate the reaction (Rx) time dimension of the eliminated Step initiation-Stroop task.

Participants.

Healthy subjects between the ages of 18 and 42 were recruited by convenience sampling from both human research volunteers (HRV) and permanent party active duty service members from the U.S. Army Research Institute of Environmental Medicine (USARIEM) in Natick, Massachusetts. Participants were excluded if they reported a history of concussion within the previous year or had any residual symptoms from a prior concussion, Subjects were also excluded for 1) documented duty limiting profile for physical or behavioral health condition preventing continuous activity for up to 30 minutes, 2) history of psychiatric disorder and 3) uncorrected hearing or visual deficits preventing functional hearing or vision. In Phase Ia, the initial 9 AMMP tasks were evaluated on 20 healthy control (HC) volunteers (11 males, 9 females, mean age 25.8 (+/-3.5)) with revisions made that required re-evaluation of IRR on 2 of the tasks. In Phase Ib, these two revised tasks (CQ Duty and SALUTE-Exertion task) were tested on 12 USARIEM subjects who were a subset of the subjects tested in Phase Ia.

Data Collection

In Phase Ia, to standardize the AMMP task administration for initial IRR evaluation, raters reviewed the task administration instructions, the subject instructions, and the task score sheets on his/her own prior to the beginning of testing. The principal developer for each task provided a brief training session followed by a practice scoring session using teams of 3 raters with a mock subject. The raters then discussed scoring discrepancies and came to consensus on operational definitions for scoring as necessary, which were then included in the guidelines for the task. If necessary, a second mock subject was scored with additional discussion to arrive at a clear consensus among raters. Each scorer individually rated 20 active duty service member volunteers on each of 4 or 5 of the tasks. The scorers were both physical (PT) and occupational (OT) therapists (co-authors) with at least one of the raters considered novice or new with limited knowledge or exposure to a particular task. Novice raters had not participated in the development of the task or pilot tested training materials for a given task, thereby providing an unbiased assessment of their experience in rating the task. This iterative approach was used to fine tune the testing materials and scoring sheets for the tasks over the course of testing (Figure). During testing, one rater read the scripted instructions and interacted with the subject and all 3 raters scored the subject from direct observation. Additionally, test developers provided informal feedback throughout the reliability testing sessions to discuss issues with feasibility, face validity and general practicality of tasks and ratings. In Phase Ib, 12 HC volunteers from USARIEM were tested on the revised CQ Duty task and the revised SALUTE-exertion task by a team of 2 OTs and 1 PT.

Phase II: Testing in active duty Soldiers with persistent mTBI related symptoms

The goal of Phase II was to evaluate the IRR and feasibility of the revised AMMP tasks outlined in Table 1 in subjects with mTBI residual symptoms. This phase of testing took place at Fort Bragg, NC with subjects primarily in military occupation specialties related to combat and combat support.

Participants

A total of 12 SM (11 male, median age 31, range 21-42) with mTBI were recruited from the clinical population receiving rehabilitation services at the Womack Army Medical Center (WAMC) TBI Clinic for persistent symptoms from a concussion occurring from 2 weeks to 2 years (median days (range): 306 (71-470)) prior to the AMMP test date. Physical and occupational therapists from the WAMC BI Clinic identified potential participants who met the eligibility criteria and provided an information and study contact form. Participants were excluded as described in Phase I. A second set of 7 SM (6 male) were recruited from this same population for additional reliability testing focused primarily on revisions to the SALUTE-exertion task scoring and instructions to subjects.

Data Collection

Prior to data collection at Fort Bragg, raters were briefed by each AMMP task developer on changes in test administration or scoring that resulted from prior IRR testing on HC subjects. A practice subject was tested by all raters and any discrepancies in scoring were discussed and clarified by the rater team before subject testing. Three raters were present for this data collection phase which took place over 2 separate test weeks. During a single 3 hour session subjects were consented, provided intake information, completed neurocognitive testing and the AMMP. Some subjects were not tested on all AMMP tasks for various reasons including other appointments, duty requirements which took precedence over study participation or poor tolerance to some tasks. The order of AMMP task administration varied to minimize a test order effect. Following modifications to tasks based on findings from these subjects, an additional 7 subjects with mTBI (6 male, 1 female) were tested using a different team of 3 raters. These 7 subjects were evaluated on all AMMP tasks, however, the focus of the IRR was on further revisions to the SALUTE –exertion task. By this point, most scoring or administrative changes for 5 of the 6 test tasks were minor and primarily involved modifications to operational definitions, improvements to scoresheets or clarifications of instructions to subjects. Following this Phase II, significant revisions were made to the SALUTE-exertion task including renaming it the PATROL-exertion task (Figure). Our original intention [5] was to have the rater teams blinded to the subject group for each subject. For practical reasons including recruitment difficulties, subject testing could not be done in larger cohorts that would have allowed raters to be blinded to group.

Phase III: Testing HC active duty SM and SM with persistent mTBI related symptoms

The goal of this Phase III was to evaluate the inter-rater reliability (IRR) and feasibility of the AMMP tasks after the final revisions to all tasks were completed. Both HC and subjects with mTBI were evaluated in this phase.

Participants

Healthy control subjects were recruited by convenience sampling of volunteers from Fort Bragg Special Operations and the 528 Sustainment Brigade, subjects who responded to recruitment postings placed at fitness centers and cafeterias around the base, as well as volunteers from the Defense and Veterans Brain Injury Center (DVBIC) in-processing briefings. These DVBIC briefings occurred on an almost daily basis as part of the standard informational training provided to all soldiers in-processing to Fort Bragg after transfer from other duty stations. Subjects with mTBI were recruited from the clinical population receiving rehabilitation services at the WAMC TBI Clinic using inclusion criteria as described in Phase II above. A total of 26 subjects were involved in this final phase of IRR evaluation, 7 healthy control (5 male, median (range) age 34(20-42)) and 19 subjects with residual mTBI symptoms (all male, median (range) age 24 (19-40)). Median days since most recent concussion was 147 (range 63-632).

Data Collection

Changes that resulted from Phase II IRR testing were reviewed by task developers with the rater team to standardize AMMP task administration. By this point, most scoring or administrative changes for 5 of the 6 test tasks were minor and primarily involved modifications to operational definitions, improvements to scoresheets or clarifications of instructions to subjects. This final phase of data collection for IRR occurred simultaneously with the testing to determine known group validity (which AMMP test tasks could distinguish groups) and for logistical reasons, including proximity to Fort Bragg, involved only 2 raters, both physical therapists. This group of

26 subjects was tested over a several month period usually involving testing one or two subjects in a single day.

Data Analysis for all phases

The Krippendorf Alpha [15] was used to evaluate inter-rater reliability. This general measure can be used regardless of the number of observers, sample size, missing data and type of measurement (nominal, ordinal, interval, or ratio). For both interval and ratio data the analysis is equivalent to the intraclass correlation coefficient (ICC) for two observers and is extended for many observers. For nominal data, analysis for two observers is equivalent to Scott's Pi. Parallel analyses using both the Krippendorf and Kappa (2 observers) have produced identical results. The code was integrated into SPSS V18.0. Bootstrapping using an n=2000 was used to produce 95% confidence intervals. In some cases where the scorers were not constant, the SPSS V18.0 ICC analysis using the two-way random model was used to confirm the Krippendorff result. For items that required a yes/no response, number of triplet (or couplet in Phase III) scoring disagreements was determined. Given that a full range of combinations of responses did not occur, a Kappa-like analysis was not possible. Target ICC was set at >0.90 for dual-tasks and >0.85 for multitasks [16] in order to meet clinical expectations for reliability of assessments.

In addition to the use of IRR findings, clinical feasibility (time to administer, test space requirements, cost and durability of equipment) and both verbal and written feedback from subjects were discussed among the test developers and used to drive task refinement. The first 20 HC subjects tested at USARIEM were administered a team developed "experience survey" which asked for opinions on the clarity of instructions and difficulty of AMMP tasks in addition to requesting general comments on the AMMP test battery. This feedback from test subjects drove edits to clarify test administration instructions and provided impressions of face validity of the individual tasks.

RESULTS:

The revised AMMP tasks and example modifications are described in Table 1. Each of the 6 tasks uses a unique scoring system (Table 1, left column) related to observable domains and task demands [10]. Three of the tasks also used instrumented measures (inertial sensors) that were not evaluated for inter-rater reliability and was not modified during this task refinement process.

Not all subjects completed all tasks. In order to avoid exceeding the maximum IRB approved test time, subjects who were slower to complete tasks were not asked to begin the last scheduled task. Some subjects did not complete testing due to overlapping scheduling conflicts. Four (Run-Roll-Aim) to 6 (Illinois Agility-Packing List) subjects with mTBI self-selected to stop or were stopped by the primary rater before completing all trials due to an exacerbation of dizziness or headache symptoms. One healthy control subject was stopped from completing all trials of the Illinois Agility Test-Packing List task because he reported a mild aggravation to a prior ankle injury.

Phase I-III:

As previously described, findings from Phases I and II informed iterative improvements to the AMMP tasks [5], (Figure). After these initial revisions, the remaining 6 test tasks of the AMMP battery continued through this refinement process. Results of the iterative process and phase-specific IRR will be summarized first for the dual-tasks and then for the multitasks.

Dual-task Revisions

Illinois Agility-Packing List: Rater reliability for run time and words recalled correctly for the Illinois Agility-Packing List (Table 2) task were > 0.89 for all trials in healthy control subjects tested in Phase I. ICC for packing list errors was poor (0.07 to 0.10) in this HC group. Revisions of scoring rules to require that the recalled word matched exactly the given word (e.g. “bandage” repeated as “band aid” defined as an error) and revision of the initial packing list to replace multiword items (e.g. “100 mph tape”) improved the ICCs for word errors when initially tested on subjects with mTBI (0.54 to 0.85 depending on trial) though still below an acceptable range. Further revisions of the packing list ensued, however, the inability of multiple raters to accurately hear responses appeared to contribute to lower reliability. . As well, subjects were instructed to speak with sufficient volume and raters were instructed to stand in close proximity to the subject at the end of the agility run. ICC’s for all revised metrics were above 0.96 when tested on the final 23 subjects. An additional metric of ‘course error’ was added in order to capture the number of times a subject made an error in navigating the agility course correctly. ICCs for this metric for the final 23 subjects were from 0.77 to 1.0 depending on trial, noting that many subjects made no errors running the agility course.

Load the Magazine-Radio Chatter: For this task, all metrics remained unchanged throughout all 3 phases of reliability testing. The ICCs for the Load Magazine-Radio Chatter Dual-task (Table 3) were greater than 0.93 when tested on healthy control subjects in Phase I. When tested on subjects with mTBI, the ICCs for distractor words dropped (0.69 in single task, 0.50 in dual task condition). Feedback from raters indicated that in the testing space at Fort Bragg, ambient sounds interfered and not all subjects spoke loud enough to hear over the recorded radio chatter and ambient noise. In addition, responses were sometimes delayed in time after the target word was spoken. Revised instructions to subjects following the first practice trial (if a voice volume issue was identified) were to “speak loudly so we can all hear you” and to require the raters to be seated directly in front of the subject. Clarification of instructions for when a target response was provided in sufficient time to be counted as correct, reduced rater uncertainty for marking a response correct or incorrect. ICCs for the final reliability testing were all greater than 0.95 for this task.

Instrumented Stand and Walk-Grid coordinates: ISAW-grid task metrics (Table 4) remained unchanged throughout all 3 phases of reliability testing. IRR was generally excellent for time and grid coordinate measures (ICCs > 0.92) in HC subjects in Phase I. Initial testing in subjects with mTBI showed a drop in the ICCs (4 were below 0.90) which when later discussed among raters appeared to be the result of some raters not being able to hear the subject vocalize the grid coordinates at the end of the walk and a greater range of error patterns that had not been observed in HC subjects. Changes were made to administration instructions to require raters to move closer in proximity to the subject at the point they finished their walk and to request that subjects speak louder to facilitate hearing their responses over any ambient sounds. Additional clarification of scoring rules improved the ability to rate these responses reliably. Final testing on 26 subjects resulted in ICCs > 0.92 for all metrics in the ISAW-grid task.

Multitask Revisions

Patrol-Exertion Task: The Patrol-Exertion (Table 5) task underwent multiple revisions in its initial format as a SALUTE report. The SALUTE report is a type of standard Army reconnaissance report which requires specific information related to the size, activity, location, unit or uniform, time and equipment (SALUTE) of the observed enemy. ICCs for various components of the total SALUTE report and the total score ranged from 0.29 to 0.89 in testing 20 HC subjects (Table 5) during Phase Ia and Ib. The addition of the reporting of IED markers seen during scanning reports for Version 2 of the SALUTE tested on 12 HC subjects resulted in ICCs that ranged from 0.14 to 0.90. Testing with 7 subjects with mTBI at Fort Bragg was insufficient to calculate ICC, however, disagreements among raters were evident (Table 5). Discussions with subjects, with military subject matter experts, and AMMP developers led to the determination that while reconnaissance reporting is used within the military, actual reporting of intelligence using this SALUTE format tended to be highly variable in degree of detail, ordering, and overall content reported. Those subjects with combat experience were more likely to verbalize their simulated report to “higher command” outside of the standard SALUTE format prioritizing brevity and key findings over the longer, more detailed doctrinal SALUTE format. Reporting format varied greatly between those subjects with mTBI who had been deployed and those that had not.

Rank, and previous experience serving in key leadership positions in a patrol also appeared to affect how a Soldier reported pertinent information. Following initial IRR testing at Fort Bragg, the reporting format was changed to a general post-patrol question-answer format with clear criteria for correct and incorrect responses. A reaction time component was added and questions on visual clarity and perceived exertion (RPE) during stepping were also added to the metrics for this task. The ICCs for all metrics for the Patrol-Exertion task were above 0.96 for the final 26 subjects tested at Fort Bragg.

Charge of Quarters Duty Task: ICC findings for CQ Duty (Table 6) for task performance (0.94), number of transits between work stations (0.98) and total task completion time (0.98) were excellent when tested on 12 HC volunteers at USARIEM. ICC findings for the number of rule breaks was 0.66 (Table 5) in this HC population. ICCs for all metrics except rule breaks (0.35) were clinically acceptable (0.90) when tested on 12 subjects with mTBI at Fort Bragg. Clarifications to operational definitions of rule breaks and inclusion of example rule breaks on the score sheet were some of the revisions made based on these findings and on rater feedback. The ICCs for all metrics for the CQ Duty task were above .087 for the final 25 subjects tested at Fort Bragg.

Run-Roll-Aim Task: The Run-Roll-Aim task (Table 7) demonstrated ICCs of 0.50 to 0.99 (Table 7) depending on the metric, for HC subjects tested at USARIEM. The ability to hear a subject's verbal identification of visual targets was problematic in the early testing stage, necessitating test instructions to "speak loudly so we can hear you". This task included a potential error of “hesitation” related to the directional Stroop cue. This element was problematic for rating, given with an incongruent Stroop cue where the letter for right (R) or left (L) roll did not match the directional arrow, some delay is typical, so determining whether a motor delay was of inordinate length was difficult. The individual who is operating the remote that advances the slides that presents the computer cues has an innate sense of the delay post-Stroop presentation that observing raters likely do not. Revisions to operational definitions of errors were the primary changes made to this task. Improvement in ICC’s were seen when testing the final 26 subjects at Fort Bragg for time and odd/even numbers (ICC > 0.93) reported. The ICC’s for total errors was 0.64 and for total cues was 0.87 in this group.

DISCUSSION

Rehabilitation assessments that involve multi-system performance often require a multistep process of development and refinement in order to establish IRR [9-11,17,18]. Acceptable levels of IRR were achieved for the AMMP dual-task and multitask metrics with the application of a deliberate refinement process that recognized the importance of measure reliability and feasibility. In this early stage of the AMMP validation process, we have chosen to deal with the complexity of the multifaceted metrics that are used in dual-task and in multitask measures, by evaluating rater reliability for each separate task metric. As the AMMP validation process proceeds, we aim to normalize performance across AMMP tasks, combining individual component metrics to generate a composite score for each task and potentially for the complete AMMP battery. Composite scores should ease interpretation and facilitate decision making as demonstrated with other batteries described in the rehabilitation literature [10,19].

The AMMP is intended for use in combination with other metrics to inform return-to-duty decision-making in SM with mTBI. To make RTD recommendations, the importance of rater reliability in a metric cannot be overstated [16,20]. Kottner et. al., suggests that when important decisions on individuals are being made on the basis of an assessment score, rater reliability values should be 0.90 or 0.95 [20]. Not all metrics for the AMMP tasks met this stringent standard however, following the iterative process in the AMMP battery development, the majority of the ICC's were above 0.90 (Tables 2-7), supporting the continuation of the validation process for the component tasks in this assessment battery. Those metrics that did not meet this standard were typically characterized by restricted value ranges which can significantly reduce ICC values.

The process used for refinement of AMMP test tasks began with healthy control (HC) subjects. Given that the initial 9 tasks took approximately 3 hours to complete, testing on HC subjects allowed our team to recognize tasks that lacked practicality, feasibility and face validity for healthy active duty SM. Testing in a HC group provided investigators with the early opportunity to evaluate the level of difficulty for individual test tasks among SM considered "duty-ready" and deployable by military standards. Reliability metrics for four of the 6 retained tasks (Tables 2-7) were at or above clinically acceptable levels in this HC group. These findings were consistent with the rehabilitation literature wherein rater reliability for functional tasks are often better (higher) for patients who cluster at the high or the low end of the spectrum [21(page 6)].

Phase II testing on subjects with mTBI underscored the importance of optimizing administration and scoring procedures on HC subjects. By the time the AMMP battery was brought to Fort Bragg for testing on subjects with mTBI-related residual symptoms, the mean battery testing time had dropped to 1 hour and 45 minutes, which was reasonably well tolerated by this cohort of participants. With the introduction of subjects with mTBI into the study participant pool, investigators noted a drop in ICCs for several of the AMMP task metrics (Tables 2-7) that had previously been at or close to clinically acceptable levels. Subjects endorsing mTBI-related symptoms committed more frequent and wide ranging errors on AMMP tasks than were not recorded in testing HC Soldiers at USARIEM. These novel errors required research team members to operationally define metrics explicitly, clarifying acceptable and unacceptable responses. The initial groups of subjects with mTBI also represented a broad range of Soldier ranks, occupational specialties and deployment experiences which likely contributed to the variety of participant responses. In addition to the formal test responses, the feedback on the task expectations and realism of the test metrics was made clear to our research team during this process and contributed to practical aspects of task refinement.

Modifications to several AMMP tasks underscored lessons learned and the modifications that were required to achieve clinically acceptable reliability. Development of the IAT-Packing List task highlighted the importance of definitive rules for giving credit for a correct answer. During early reliability testing, some raters gave credit for returned words that were “close but not exact” such as accepting the word “band aid” when the word given was “bandage”. When this “benefit of the doubt” scoring was used by some but not all raters, the IRR suffered. Packing lists were modified to reduce ambiguous or easily misunderstood words. Scoring rules were clarified to require verbatim word responses from the subject, resulting in improved ICCs to clinically acceptable levels. Difficulty with hearing and perceiving items from the packing list occurred more often when test subjects' first language was not English. Having subjects repeat the words as they are provided could reduce the likelihood of misunderstanding based on accent or language differences of the subject or the tester, but this was not done in this study.

Other real-world lessons learned reinforced the practical requirements for reliable scoring of tests that entail recording subject performance, as well as their verbal responses. Performance-based assessments with verbal responses require appropriate rater vantage point to clearly hear the subject's responses. If more than 1 rater was scoring, the physical set-up for test administration must be conducive to allow all raters the ability to hear verbal responses. The issue of being able to hear a verbal response may be less of a concern for clinical use of a measure, given the test administrator is typically in the best position to hear a patient's response and usually is the sole rater of performance.

Development of the Load Magazine-Radio Chatter dual-task and the Patrol-Exertion multitask highlighted the importance of quantifiable metrics that were objective and non-ambiguous requiring no subjective interpretation on the part of the examinee or the rater. For example, in the early development phase of the radio chatter, instructions were to respond to chatter that was "relevant" to a specific character in the chatter. Relevance was not sufficiently defined and was interpreted very broadly by subjects during pilot testing. In the final version of this task, participants were instructed to respond affirmatively to the recognition of pre-established words like "break" from specific character voices in the pre-recorded radio chatter which eliminated ambiguity regarding correct and incorrect responses.

Similarly, early versions of the PATROL-Exertion task required reporting using a standard reconnaissance SALUTE report of the sort used during military operations. During several rounds of reliability testing and repeated modifications to subject instructions and scoring examples, answers for this type of reconnaissance report varied and were clearly based on judgment of the subject using their deployment experience, military occupational specialty and rank. Raters also frequently used "benefit of the doubt" scoring depending on the rater's own experience. Final modifications required post-patrol reporting that had unmistakably defined answers to questions such as "What weapon(s) did you see"? This type of question-response format required focused attention to the Patrol task video without necessitating judgments by the subject or the rater. This change facilitated the clear cut scoring of subject responses by the raters. Sapsford and Jupp discuss issues with observational research including problems with "inconsistency in the way rules are applied by different observers and sometimes by the same observer on different occasions" [22(page 70)]. This inconsistency is often seen when inferences for scoring or coding behavior are required and when there are ambiguities in the scoring system [22]. These examples clarify the importance of using well validated tests with clear cut metrics. As well, they underscore the fallibility of make-up-your-own clinical tests involving dual-task and multitask activities and the importance of a standardized test that has established, acceptable rater reliability.

One side benefit of this repeated process of reliability testing and task material revision is the improved and succinct administration instructions and the script for administering the tasks to subjects. Firsthand participation in at least several testing sessions by all members of the AMMP development team helped to maximize the feedback for revisions[10,11]. Our initial target has been to provide an assessment tool for rehabilitation professionals including physical and occupational therapists. One future goal is to work towards an assessment battery that may be appropriately used by other military medical providers such as nurse practitioners, physician's assistants, and medics. This goal will require further examination of training requirements and additional reliability testing to compare administration of the AMMP by clinicians who commonly interact with SM to a "gold standard" of trained PT and OT raters. The amount of training required to achieve clinically acceptable reliability has yet to be clarified [21(page 10)].

One of this study's strengths was the iterative process used that resulted in clinically acceptable inter-rater reliability for this version of the AMMP. Additionally, the iterative process facilitated the development of succinct instructions to the subjects, as well as efficient scoring forms. Our final inter-rater reliability findings were sufficient to support continued validation of this assessment tool.

This study has a number of limitations. Despite the defined inclusion criteria, no subjects with mTBI residual symptoms were less than 2 months post most recent concussion. Scoring of and responses from subjects with more acute symptoms and from populations at additional installations or deployment environments may result in a requirement for further refinement of operational definitions of task metrics including expansion of acceptable and unacceptable answers. All raters for this study were physical and occupational therapists with a minimum of 6 years of experience and a knowledge of the background and development process of the AMMP battery. This may have contributed to a bias in scoring some or all of the AMMP tasks. Further reliability testing with novice raters who did not participate in the development of this assessment will contribute to clarity on the amount of training required to achieve adequate IRR for a clinical metric. The practical feedback received from the development team and from the subjects resulted in clinically feasible AMMP tasks with some degree of face validity. These tasks, however, may not be feasible in all test environments as some of the tasks require a relatively large space or a very quiet test environment without ambient distractions. This will restrict the use of specific AMMP tasks to environments with adequate facilities. However, the strong face validity and functional relevance likely outweigh the environmental constraints of the testing environments.

CONCLUSIONS: The AMMP was developed to fulfill a defined need for a performance based assessment following military concussion. Military stakeholder requirements for face validity, and functional relevance contribute to the complexity of development of a reliable AMMP battery as a performance-based assessment evaluating multiple domains of function. The consistency of scores across raters is fundamental to the ability to use the findings of the AMMP to make substantive recommendations regarding readiness to RTD following concussion/mTBI. This research demonstrated that following an iterative development process, individual AMMP tasks appear feasible, and have metrics that can be reliably scored by experienced rehabilitation professionals. Evaluation of preliminary known groups and convergent validity using correlation to standard neurocognitive tests is currently underway with members of the AMMP development team. Before the AMMP is used clinically to inform RTD decision-making, further evaluation of intra-rater, novice rater, test-retest reliability, and additional validation studies should be carried out. Future work to further clarify discriminant and convergent validity in subjects along the continuum of recovery from concussion as well as evaluation of the responsiveness of the AMMP should be undertaken.

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Institutional Review: Approved by IRBs at USARIEM, Natick, MA; Womack Army Medical Center, Fort Bragg, NC; Allina Health IRB, Minneapolis, MN; Quorum Review IRB for Allina Health, Seattle, WA. A research investigator answered all questions and all subjects signed an IRB-approved informed consent as specified by the relevant institutional review board prior to testing at each phase of AMMP development.

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FIGURE: AMMP Refinement Phases

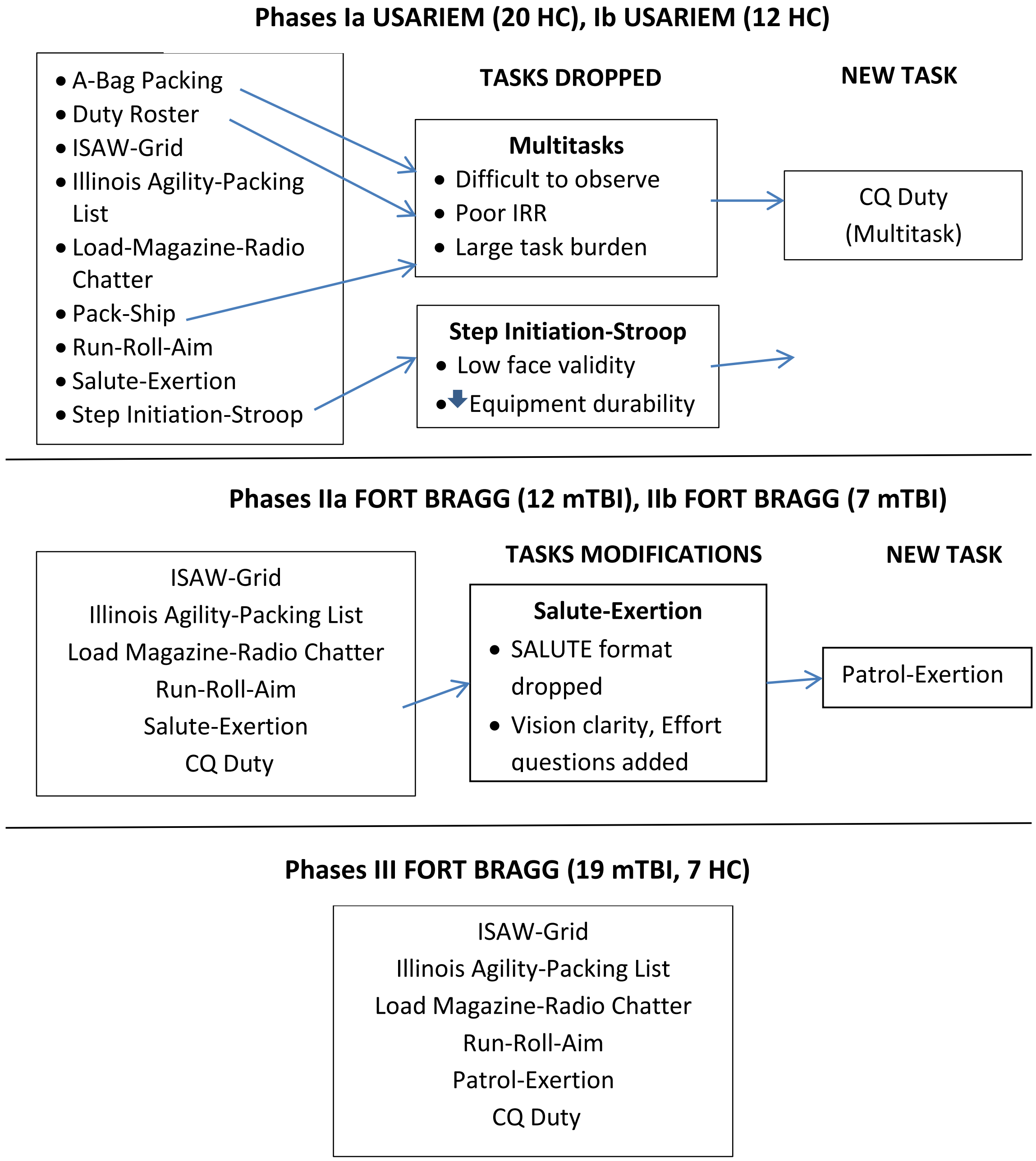

Table 1.
The Assessment of Military Multitasking Performance Tasks, metrics and example modifications

Dual-tasks (Metrics)	Description	Example Modifications
Illinois Agility Test (IAT)-Packing List **-Run time (sec)** **-Words correct** **-Word errors** **-Path errors** **-Dual Task Cost (DTC)**	The IAT requires running a course with rapid direction changes and serpentine navigation of 4 cones. In the dual task condition, the subject is given a 5 to 7 word packing list to remember (number of words scaled to number recalled in single task condition).	1) Instruct raters to stand close to and in front of subject to improve ability to hear call out of recalled "packing list" words. 2) Edit packing list words to remove easily confused (band aid vs bandage) or 3 word items (100 mph tape)
Load Magazine-Radio Chatter **-Rounds loaded DTC** **-Words Correct** **-Word Errors** **-Words DTC**	The subject loads M-16 dummy rounds in a magazine as fast as possible. The dual-task condition requires monitoring radio communication about an upcoming company FTX , responding "check" when key words are spoken by specific characters interacting in the radio chatter.	1) Instruct subject to "speak loudly so I can hear you". 2) Instruct raters to sit directly in front of subjects to improve ability to hear the "check" word response by subject.
Instrumented Stand and Walk-Grid Coordinates (ISAW-Grid): **-Walk time (sec)** **-Grid Coordinates correct** **-DTC time and correct grid coordinates**	The ISAW-Grid task involves using wireless wearable inertial sensors and a clinical software program to measure static postural sway and then dynamic stability during walking and turning, the walk is timed. A grid memorization task provided in the context of a patrol mission provides the cognitive challenge.	1) Instruct subject to "speak loudly so I can hear you". 2) Instruct raters to stand close to and in front of subject to improve ability to hear call out of recalled grid-coordinates.
Multitasks (Metrics)	**Description**	**Example Modifications**
Patrol-Exertion (SALUTE format removed) **-IED Markers Correct** **-Patrol Observations correct** **-Visual Clarity (1-10 VAS)**	The subject gathers information from video surveillance and radio communications while exercising at 65% to 85% of age predicted maximal heart rate by doing continuous step-ups on an exercise step to simulate a dismounted patrol. IED markers and pertinent logistical information must be recalled and reported at specific times while also requiring a reaction time trigger switch press to an	1) SALUTE video revised to include IED marker identification to increase task complexity. 2) Addition of auditory reaction time component. 3) Removal of "SALUTE" reporting format with modification to a "question-answer" general PATROL reporting format. 4) Provide specific examples on score sheets as to correct answers to PATROL questions.

-RPE (Borg 6-20 scale) **-Reaction time (msec)**	intermittently recurring tone sound (11 tones in 12 minutes).	5) Addition of symptom report for visual clarity and level of effort (RPE).
Charge of Quarters (CQ) Duty **-Task Completion** **-Transits** **-Total Task Time (min/sec)** **-Rule Breaks**	Requires the subject to organize and implement a plan in order to complete a number of tasks all while pulling CQ duty. Tasks such as assembling a footstool, inventorying supplies, radioing barracks room availability to the 1st Sergeant all occur under time and efficiency rules.	1) Initial revisions described previously (Smith et al., 2014) 2) Revisions of score sheets to include operational definitions for all task performance metrics and operational definitions of errors. 3) Addition of several task performance items.
Run-Roll-Aim (RRA) **-Task completion time (sec)** **-Correct odd/even numbers** **-Total errors: odd/even number and sequence**	The RRA task requires the subject to respond to a directional Stroop signal and complete several maneuvers such as avoiding a trip wire, a 3-5 second rush, combat rolls, side shuttling and back pedaling while carrying a simulated weapon. The subject uses a short focal point scope on the weapon to identify numbers on a computer screen based on instructions given before the task starts.	1) Instruct subject to "call out the numbers loudly so I can hear you". 2) Instruct raters to stand close to the subject while s/he is calling out numbers to improve ability to hear responses. 3) Improved operational definitions of specific errors (i.e., "hesitation"). 4) Combination of errors into one metric so that all errors were summed.

Table 2.
Illinois Agility-Packing List Interrater Reliability

Scoring item (Metrics)	USARIEM* n=20, Healthy Controls (HC)	Fort Bragg/WAMC* n=12 SM with mTBI	Fort Bragg/WAMC# n= 23 (18 mTBI, 5 HC)
	Reliability, ICC 95% CI (lower, upper)	Reliability, ICC 95% CI (lower, upper)	Reliability, ICC 95% CI (lower, upper)
Single Task Time	0.98 (0.96-0.99)	.82 (0.58-0.98)	0.99 (0.98-0.99)
Single Task Words Correct	0.89 (0.73-0.99)	0.80 (0.69-0.90)	1.0 (1-1)
Single Task Word Errors	NA	0.54 (0.12-0.83)	1.0 (1-1)
Dual Task No Instruction: Time	0.96 (0.94-0.98)	0.96 (0.93-0.98)	0.99 (0.987-0.995)
Dual Task NI: Words Correct	0.93 (0.88-0.97)	0.93 (0.86-0.99)	0.99 (0.97-1)
Dual Task NI: Word Errors	0.07 (0-0.30)	0.93 (0.87-0.97)	0.99 (0.96-1)
Dual Task NI: Course Errors	NA	NA	1.0 (1-1)
Dual Task COG: Time	0.90 (0.85-0.95)	0.98 (0.97-0.99)	0.99 (0.989-.997)
Dual Task COG: Words Correct	1.0 (1.0-1.0)	0.97 (0.92-1)	1.0 (1-1)
Dual Task COG: Word Errors	0.10 (0.0-0.36)	0.74 (0.37-0.99)	0.996 (0.987-1)
Dual Task COG: Course Errors	NA	NA	0.77 (0-1)
Dual Task MOB: Time	0.96 (0.91-0.98)	0.88 (0.80-0.95)	0.98 (0.97-0.99)
Dual Task MOB: Words Correct	1.0 (1-1)	1.0 (1-1)	1.0 (1-1)
Dual Task MOB: Word Errors	0.09 (0-0.35)	0.85 (0.64-1)	0.86 (0.58-1)
Dual Task MOB: Course Errors	NA	NA	1.0 (1-1)

COG: Cognitive priority; "concentrate on remembering the words", NI: no instruction given, MOB: Mobility priority; "concentrate on going as fast as you can" NA: not applicable or not evaluated
*** = 3 raters; # = 2 raters**

Table 3.
Load Magazine-Radio Chatter Interrater Reliability

Scoring item (Metrics)	USARIEM* n=20 Healthy Controls (HC)	Fort Bragg/WAMC* n=12 SM with mTBI	Fort Bragg/WAMC# n= 24 (18 mTBI, 6 HC)
	ICC (95% CI)	ICC (95% CI)	ICC (95% CI)
Rounds loaded single & dual@	Not evaluated	Not evaluated	Not evaluated
Correct Key Word Single	0.99 (0.98-1)	0.94 (0.88-0.99)	0.997 (0.993-1)
Distractor Key Word Single	0.93 (0.83-1)	0.69 (0.38-0.92)	0.995 (0.986-1)
Correct Key Word Dual	0.98 (0.96-1)	0.99 (0.97-1.0)	0.978 (0.949-0.999)
Distractor Key Wo rd Dual	0.97 (0.95-0.99)	0.50 (0.11-0.82)	0.947 (0.869-1)

*** = 3 raters; # = 2 raters; @ = for practical reasons, all dummy rounds were counted one time, not by individual rater**

Table 4.
Instrumented Stand and Walk-Grid Coordinates (ISAW-grid)

Scoring item (Metrics)	USARIEM* n=20, Healthy Controls (HC)	Fort Bragg/WAMC* n=10 SM with mTBI	Fort Bragg/WAMC # n= 26 (19 mTBI, 7 HC)
	ICC (95% CI)	ICC 95% CI	ICC (95% CI)
Walk Time 1 Single	0.99 (0.98-1),	0.77 (0.64-0.86)	0.97 (0.96-0.99)
Walk Time 2 Single	0.97 (0.96-0.98)	0.95 (0.92-0.98)	0.95 (0.90-0.98)
Walk Time 3 Single	0.98 (0.97-0.99)	0.91 (0.85-0.96)	0.98 (0.97-0.99)
Walk Time 1 Dual	0.92 (0.85,0.97)	0.89 (0.78-0.98)	0.92 (0.86-0.97)
Walk Time 2 Dual	0.98 (0.97,0.99)	0.94 (0.89-0.96)	0.95 (0.90-0.98)
Walk Time 3 Dual	0.97 (0.95-0.98)	0.81 (0.72-0.88)	0.98 (0.97-0.99)
Grid Coord Single	0.56 (0.14-0.90)	0.88 (0.78-0.97)	0.97 (0.92-1)
Grid Coord 1 Dual	0.94 (0.90-0.97)	0.94 (0.85-1)	0.98 (0.93-1)
Grid Coord 2 Dual	0.99 (0.97-1)	0.99 (0.99-1)	0.999 (0.998-1)
Grid Coord 3 Dual	0.92 (0.84-0.99)	1.0 (1-1)	0.997 (0.990-1)

* = 3 raters; # = 2 raters

Table 5.
Patrol-Exertion

SALUTE-EXERTION Version 1 (V1)		SALUTE-EXERTION Version 2 (V2)		PATROL-EXERTION	
Scoring item (Metrics)	USARIEM* n=20 (V1)	USARIEM* n=12 (V2)	Fort Bragg/WAMC* n=7 SM with mTBI (V2) Reliability, ICC 95% CI (lower, upper)	Scoring item (Metrics)	Fort Bragg/WAMC# n= 26 (19 mTBI, 7 HC) Reliability ICC 95% CI (lower, upper)
Size	0.85 (0.76-0.93)	0.72 (0.53-0.87)	3 triplets disagreed[1]	X. Sum of IED markers	0.95 (0.91-0.98)
Activity	0.29 (0.0-0.60)	0.77 (0.58-0.94)	5 triplets disagreed[1]	Y. Sum of post-test patrol questions	0.97 (0.94-1)
Location	0.80 (0.64-0.93)	0.78 (0.56-0.95)	1 triplet disagreed[1]	Z. Sum of X and Y	0.97 (0.95-0.99)
Unit	NA[@]	0.14 (0-0.57)	3 triplets disagreed[1]	Vision clarity initial	0.99 (0.97-1)
Time	0.57 (0.22-0.86)	0.73 (0.44-0.96)	1 triplet disagreed[1]	Vision clarity end	0.99 (0.98-1)
Equipment	0.89 (0.79-0.92)	0.81 (0.62-0.95)	3 triplets disagreed[1]	RPE initial	0.98 (0.95-1)
Scan IED Markers	NA	0.90 (0.76-0.98)	0.97 (0.94-0.99)	RPE end	1.0 (1-1)
Total Score	0.80 (0.66-0.91)	0.79 (0.66-0.90)	0.91 (0.84-0.96)		

[@] = In the initial version, the report was described as a SALTE report as the "Uniform or Unit" component of the report was not consistently used, based on advice from one military advisor per local reporting format.
[1] Due to insufficient n to calculate ICC, the number of rater disagreements is reported
RPE = Rate of Perceived Exertion; NA=not applicable or not evaluated
*** = 3 raters; # = 2 raters; V1=Version 1, V2=Version 2**

Table 6.
Charge of Quarters (CQ) Duty

Scoring item (Metrics)	USARIEM * n=12 Healthy Control (HC)	Fort Bragg/WAMC* n=12 SM with mTBI	Fort Bragg/WAMC# n= 25 (19 mTBI, 6 HC)
	ICC (95% CI)	ICC (95% CI)	ICC (95% CI)
Task performance	0.94 (0.86-0.99)	0.90 (0.84-0.95)	0.88 (0.76-0.97)
# of Rule breaks	0.64 (0.32-0.90)	0.46 (0.0-0.79)	0.91 (0.75-1)
# of Visits	0.98 (0.96-0.99)	0.92 (0.80-0.99)	0.98 (0.97-0.99)
Total time	0.98 (0.96-0.99)	0.99 (0.99-1.0)	0.998 (0.994-1)

*** = 3 raters; # = 2 raters**

Table 7.
Run-Roll-Aim (RRA)

USARIEM* n=20 Healthy Controls (HC)		Scoring item (Metrics)	Fort Bragg/WAMC* n=11 SM mTBI@	Fort Bragg/WAMC # n= 26 (19 mTBI, 7 HC)
Scoring item	**ICC (95% CI)**		**Reliability, ICC 95% CI (lower, upper)**	**Reliability, ICC 95% CI (lower, upper)**
Trial 1 incongruent numbers correct	0.996 (0.99-1)	Trial 1-Time(secs)	0.91 (0.80-0.99)	0.999 (0.997-1)
Trial 1 incongruent number errors	2 of 20 triplets disagreed	Trial 1-numbers correct	0.54 (0.08-0.89)	0.96 (0.91-1)
Trial 2 congruent numbers correct	0.86 (0.65-1)	Trial 2-Time (secs)	0.80 (0.57-0.97)	0.999 (0.993-0.999)
Trial 2 congruent number errors	2 of 20 disagreed	Trial 2-numbers correct	0.55 (0.0-0.93)	0.93 (0.70-1)
Trial 3 congruent numbers correct	0.57 (0.15-0.89)	Trial 3-Time(secs)	0.86 (0.67-0.98)	0.995 (0.991-1)
Trial 3 congruent number errors	2 of 20 disagreed	Trial 3-numbers correct	0.72 (0.40-0.95)	0.996 (0-1)
Trial 4 incongruent numbers correct	0.50 (0.23-0.74)	Trial 4-Time(secs)	0.89 (0.75-0.98)	0.999 (0.998-1)
Trial 4 incongruent number errors	1 of 20 disagreed	Trial 4-numbers correct	0.99 (0.97-1.0)	0.98 (0.96-1)
		Total errors (all trials)	ICC's for individual trials calculated, T1: 0.54, T2: 0.13, T3: 0.18, T4: 0.85	0.64 (0.13-0.92)
		Total cues (all trials)	ICC's for individual trials calculated, T1: 0.71, T2: 0.56, T3: 0.37, T4: NA&	0.87 (0.66-1)

Time to complete the RRA was not scored by all raters during initial testing.
Errors for HC were recorded as #triplets disagreed as the range of errors was low, ie., 0-3 total;
Prior to testing mTBI, revisions were made to score sheets and instructions; -Congruent directional Stroop cue= roll direction arrow and R/L letter match, incongruent directional Stroop cue = roll direction arrow and R/L letter do not match:
Correct / Errors = odd or even numbers viewed through scope and called out: & No cues required—all zeros.
***=3 raters; #=2 raters; @ = not all subjects were able to tolerate completion of all trials;**