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Effects of Pilot Workload on EEG Activity Recorded During the Performance of In-Flight Maneuvers in a UH-1 Helicopter

By

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05 08 19. ABSTRACT (Continue on reverse if necessary and identify by block number) In the operational environment, measures that can be collected concurrently with an aviator's performance of primary, in-flight duties may offer a way to monitor pilot status in real time so as to predict performance problems prior to their occurrence. Previous research has shown that electroencephalographic (EEG) changes apparently occur as a function of changes in pilot workload; however, these results have not been replicated in the rotary-wing environment. Also, the earlier studies utilized off-line analyses of tape-recorded EEGs rather than real-time telemetry. The present investigation was designed to: 1) assess the overall quality of EEG recordings collected from helicopter pilots during the actual performance of in-flight maneuvers; 2) determine whether there are workload-induced changes in the EEGs recorded under resting in-flight conditions and "on-the-controls" in-flight conditions; and 3) evaluate whether in-flight EEGs are sufficiently sensitive to detect small changes in the				
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19. Abstract, Continued

Twenty subjects (10 aviators and 10 nonaviators) were tested during the performance of standardized flight profiles in a UH-1 helicopter. There was a resting eyes-open EEG condition at the beginning of each flight, and this was followed by 14 maneuver segments during which EEG data were recorded. During the maneuvers, the pilots maintained full control of the aircraft and attempted to maintain ideal flight parameters. The nonaviators sat quietly with their eyes focused on a fixation point.

Results indicated it was feasible to collect valid EEG data on pilots while they were engaged in actually flying a rotary-wing aircraft. In addition, there were indications that occipital EEG theta activity reliably increased from the condition in which pilots were "resting" to those in which the pilots were on the controls. However, it did not appear that the telemetered EEG was sensitive enough to detect the small shifts in cognitive demands induced by standardized flight maneuvers such as climbs, descents, turns, and straight-and-level flight. A follow-on investigation will 1) attempt to replicate the findings that occipital theta is an indicator of large changes in cognitive workload, and 2) establish whether or not the EEG is more sensitive to differences in workload across flight maneuvers in sleep-deprived as opposed to well-rested aviators.

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Background

Military relevance

The development and validation of objective measures of aviator workload during the performance of actual flight duties is important for both the research and operational communities. In the research environment, objective workload assessments that are not influenced by practice or "hypothesis guessing" on the part of subjects will facilitate studies designed to assess the impact of various stressors on aviator status. In the operational environment, measures that can be collected concurrently with the pilot's performance of his/her primary flight duties may offer a way to monitor pilot status in real time so as to predict performance problems prior to their occurrence. Once real-time, in-flight assessments of aviator status are proven to be possible, the development and refinement of computerized safety networks to predict (and thus avoid) pilot degradation and incapacitation will be within the realm of possibility. Such a tool will contribute greatly to the safety and effectiveness of aviation personnel.

Assessment methodologies

As was presented in detail in Caldwell et al. (in press) the status of personnel can be assessed by: 1) examining various mechanisms of human information processing (AGARD, 1989) and assuming that anything affecting these mechanisms will affect the tasks in which they are required; or 2) evaluating job-related performance such as a pilot's ability to control an aircraft (Dellinger, Taylor, and Richardson, 1986; Simmons et al., 1989; Lees and Ellingstad, 1990; and Caldwell et al., 1991) and assuming that "good" and "bad" performance can be quantified to the extent that a computerized algorithm could decide when a pilot has become unsafe.

Unfortunately, for real-world monitoring of individual status, the first approach requires that testing only be performed before or after the task of interest since the administration of tests invariably interrupt primary task performance (i.e., flying the aircraft), and the second approach requires that every potential performance fluctuation be specified to the extent that an automated system could make a valid decision about an aviator's fitness for duty without any knowledge of individual status (other than his/her ability to perform). Thus, the first strategy would be of little use in situations where a pilot's status degrades during lengthy flights because assessments conducted before and after the flights would not provide timely information. The second strategy (which is very timely) would not be feasible in situations where rapid aircraft control changes are part of successful flight performance because, in the absence of information about individual subject status, it would not be possible for an automated scoring routine to know whether or not these unusual control changes were indicative of an impaired pilot. Thus, in order for such assessment schemes to work as intended, there must be a concurrent assessment of the individual aviator's status. Caldwell et al. (1993) has suggested that this possibly can be accomplished using psychophysiological techniques.

It is necessary to identify a method for assessing the operational status of individual aviators which overcomes the problems that exist with standard performance testing algorithms. Specifically, there is need for an approach which: 1) can be conducted during the accomplishment of the operational task (flight); 2) is feasible from an equipment and personnel perspective; and 3) is objective, reliable, and valid. One type of measure which appears to be a reasonable candidate for an assessment technique which would satisfy all three of these basic concerns is one that directly measures aviator status via assessments of psychophysiological variables.

Of the physiological measures available for use, the electroencephalogram (EEG) appears to be the most direct measure of central nervous system functioning. EEGs have been collected during both simulator and actual flights in the fixed wing environment, and attempts have been made to directly relate EEG activity to performance accuracy on operational tasks. Sem-Jacobsen et al. (1959) reported the feasibility of obtaining 8-channel EEG recordings from both pilots and nonpilots in a T-33 jet during operational flight. Later, Sem-Jacobsen (1961) reported success utilizing in-flight EEG analysis in combination with in-flight motion pictures to aid in the selection of pilots for high-performance aircraft. Other authors (LaFontaine and Medvedeff 1966; Maulsby, 1966; Howitt et al., 1978; and Wilson et al., 1987) have offered further evidence for the utility of using EEG as a measure during flights. Sterman et al. (1987) recorded several channels of EEG from pilots flying fixed wing aircraft and simulators, and the data were analyzed offline following flights. The results suggested that EEG activity distribution may be associated with pilot performance. Specifically, these authors found asymmetries between the centrallyrecorded alpha EEG activity from the left and right hemispheres of pilots engaged in competent performance (the activity in the left hemisphere was greater than the activity in the right). In addition, Sterman et al. (1987) reported bilateral increases in theta activity (4-7 Hz) and decreases in alpha activity (8-11 Hz) recorded from the sensorimotor and visual cortex in response to increasing cockpit workloads (with some associated G-force effects). Wilson et al. (1994) partially confirmed these workload effects in a study which showed that parietal theta activity increased as a function of cognitive demand when pilots were flying several maneuvers in a fixed wing aircraft. Offline analysis of EEG data showed increases in theta across maneuvers that were subjectively judged to require the most mental effort of the maneuvers flown.

Generally, it appears feasible to evaluate the spontaneous cortical activity from fixed wing pilots and to obtain useful information about workload (and possibly pilot status) from these evaluations. Unfortunately, however, the majority of studies to date have been performed in the fixed wing rather than the rotary-wing environment. In addition, most of these studies have relied upon tape-recorded EEG records that are limited to off-line, after-the-fact analyses rather than real time assessments that can be conducted during the flights of interest.

Recently conducted investigations (Caldwell et al., 1994; and Caldwell et al., in press) suggest it is feasible to collect and telemeter 21 channels of spontaneous EEG from helicopter pilots in flight, despite the significant noise and vibration present in rotary-wing aircraft. However, these studies examined only the in-flight EEG recordings made during resting conditions (with a safety pilot "on the controls"). There was no attempt to assess the feasibility of collecting and monitoring EEG activity during the conduct of actual in-flight maneuvers in which the subject was flying the helicopter. Thus, it was not possible to determine whether or not telemetered EEGs could provide an indication of pilot workload.

Objectives

The present investigation is designed to: 1) assess the overall quality of EEG recordings collected from helicopter pilots during the actual performance of in-flight maneuvers; 2) determine whether there are workload-induced changes in the EEGs recorded under resting in-flight conditions and "on-the-controls" in-flight conditions; and 3) evaluate whether in-flight EEGs are sufficiently sensitive to detect small changes in the workload levels associated with different types of flight maneuvers.

Methods

Subjects

Twenty subjects were recruited for this study. Ten were UH-1 qualified aviators, and 10 were nonaviators. The average age of the aviators was 31.0 years (ranging from 25-47), and the average age of the nonaviators was 28.5 years (ranging from 23-36). Three of the 20 subjects were females. During testing, the aviators were seated in the front right seat of the aircraft in close proximity to flight instruments. They were tested under resting conditions and during times at which they were actively involved in certain flight tasks. Nonaviators were seated in the back of the aircraft, away from several potential sources of electronic interference, and they remained passive throughout the entire flight.

Apparatus

Airborne and ground-based Spectrum 32

In-flight electroencephalographic evaluations were conducted with a Cadwell Airborne Spectrum 32 in which the high filter was set at 100 Hz and the low filter was set at 0.53 Hz. The 75-pound unit, which is equipped with microprocessors for data acquisition, data transmission, and process supervision, is shock-mounted in an aluminum cage and mounted to the cabin floor in a UH-1 helicopter (see figure 1). The Airborne unit is equipped with the software necessary to acquire EEG data and transmit these data to a ground-based Spectrum 32 equipped with two specialized circuit boards in addition to the typical hardware configuration. One board conditions the incoming and outgoing radio signals and does the serial-to-parallel conversions for both directions. The other board controls the communications processes, buffers outgoing data until ready for transmission, and buffers incoming data until ready for processing. Incoming data are displayed on the ground-based Spectrum's monitors and stored on an optical storage disk. The ground-based Spectrum 32 is depicted in figure 2.

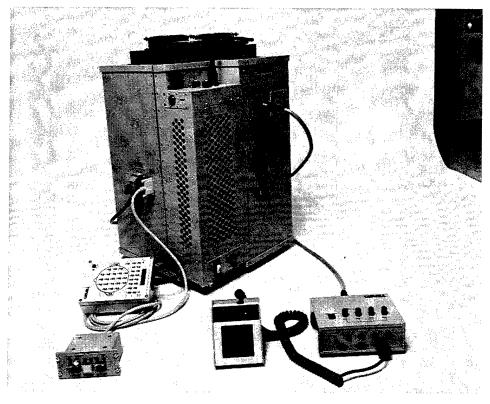


Figure 1. The Airborne Spectrum 32.

The ground-based Spectrum operates similarly to a standard Spectrum 32 although it is equipped with specialized hardware and software to enable radio communications with the Airborne unit. The operator has the same testing features available and can monitor incoming EEG data in near real-time, one "page" at a time, in 8-second blocks. Commands controlling the collection of in-flight data are entered in the usual fashion, and they are transmitted to the Airborne unit via the radio link.

Radio link

The telemetry system uses a two-way microwave radio link to send commands from the ground station up to the aircraft ("uplink") and EEG data signals from the aircraft down to the ground station ("downlink"). Operating at 1740 MHZ, the uplink is composed of a transmitter at the ground station and a matching receiver in the aircraft, and one antenna at each location. The downlink, operating at 1820 MHZ, consists of a transmitter mounted in the aircraft and a matching receiver located at the ground station. It shares the same antennas with the uplink by the use of two diplexers. The ground-based telemetry station is depicted in figure 3.

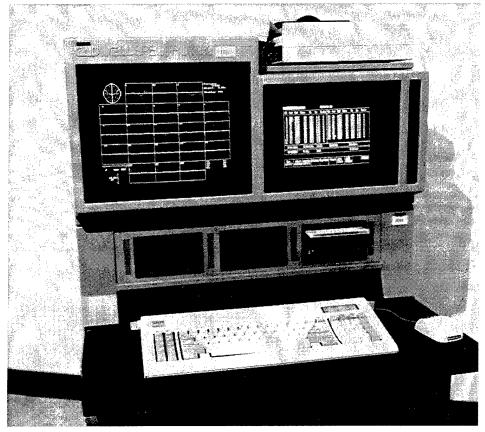


Figure 2. The ground-based Spectrum 32.



Figure 3. The laboratory-based telemetry station with radio transmitter and receiver, antenna tracking controller, oscilloscope, and Cadwell Spectrum 32 equipped with special circuit boards.

The specific components used in the aircraft include a Broadcast Microwave Services (BMS) model TBT-20015SV transmitter mounted in the right aft compartment, and a BMS portable receiver, model TBR-300, located in the left aft compartment. Power for the transmitter and receiver units comes from the aircraft 28-volt DC bus through a 10-amp circuit breaker installed in the overhead control panel. A K&L model 4CZ45-1740/NT1820-N/N diplexer is used to feed the transmitter and receiver cables into a common omnidirectional antenna, a BMS model TBA-2-0, which is mounted to the lower side of the tail boom.

At the ground station, an Anixter Communications Systems model P-1548GN dish antenna is mounted on a Tecom Industries model 203011A Controller and model 203009 rotator system. This azimuth-only system allows the aircraft to be tracked during flight testing. The antenna is connected through a diplexer-as on the aircraft-to the transmitter and receiver. The transmitter and diplexer used at the ground station are identical to those in the aircraft. A Loral Terracom model TCM-601A receiver provides the down-link data signal to the ground-based Spectrum 32.

Recording electrodes

Grass silver cup electrodes, placed on subjects' scalps with collodion, were used to detect EEG signals. These are the standard Grass E5SH electrodes used in typical clinical settings. No modifications to the electrodes or wiring were made (see figure 4).

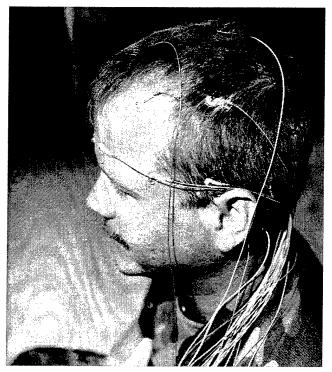


Figure 4. Electrode montage used for the collection of in-flight EEG data.

Procedure

Both pilot and nonpilot subjects were tested during a single, standardized flight in the UH-1 aircraft. Upon arrival at the laboratory, 25 EEG scalp placements were measured, marked, and cleaned with acetone. After each site was thoroughly cleaned, electrodes were attached to the scalp with collodion, and each electrode was filled with electrolyte gel (SignaGel). Impedances were reduced to 5000 ohms or less prior to testing.

In-flight testing for pilots

Pilots were seated in the right front seat of the UH-1 where he/she was connected to the EEG preamplifier. Prior to departing from the helipad, impedances of electrodes and the integrity of the radio link (between ground-based and Airborne Spectrum) were checked, and adjustments were made to maximize the quality of the data.

A USAARL safety pilot conducted each flight in the UH-1, but the test aviator was required to fly the aircraft and complete a profile of upper airwork flight maneuvers lasting approximately 1 hour (see table). The flight profile began at an altitude of 1500 feet mean sea level. The subject flew all of the specified maneuvers under command from the safety pilot. The same sequence of maneuvers was used for every subject.

Table.

Flight profile.

- 1. Standard rate 360 degree right turn
- 2. Straight and level number 1 (2 minutes)
- 3. Standard rate 360 degree left turn
- 4. Straight and level number 2 (2 minutes)
- 5. Climb 1000 feet at 500 feet per minute
- 6. Steep (30 deg. bank) 720 degree left turn
- 7. Straight and level number 3 (2 minutes)
- 8. Steep (30 deg. bank) 720 degree right turn
- 9. Straight and level number 4 (2 minutes)

10. 360 deg. std. rate climbing left turn

- 11. Straight and level number 5 (2 minutes)
- 12. 360 deg. std. rate descending right turn
- 13. Descend 1000 feet at 500 feet per minute
- 14. Straight and level number 6 (2 minutes)
- 15. Instrument landing system (ILS) approach

Shortly after takeoff, but prior to the beginning of the standardized flight profile, aviators completed a resting eyes-open EEG (approximately 5 minutes in length) while the safety pilot flew the helicopter. During this phase of the flight, subjects were told to focus on a fixed point in

order to minimize eye movements while data were collected. In the event that the signal was contaminated with artifact, subjects were instructed via radio link from the ground-based receiving station to correct the problem (i.e., minimize eye movements, relax jaw muscles, etc.). Actual data collection continued until approximately 5 minutes of useable data were stored on optical disk for later spectral analysis. Next, the aviator began the series of maneuvers in the standardized flight profile. Once the subject had begun a specific maneuver, the ongoing EEG recording was marked so the data could later be differentiated into different maneuvers. When a subject completed the maneuver, the EEG recording was marked again to indicate the termination of that maneuver. This process was repeated until all maneuvers were performed, with the exception of the last one (the ILS approach). No data were collected during this last maneuver because of the requirement for subjects to actively communicate with air traffic control and the safety pilot at frequent intervals. Upon completing the ILS approach, the subject relinquished control of the aircraft to the safety pilot who then executed a missed approach at Cairns AAF and returned to the helipad at the Laboratory.

In-flight testing for nonpilots

The flight test for nonaviators (conducted separately from the one for the aviators) was similar to the one outlined above. However, the nonaviators were seated in the rear of the aircraft where they completed the resting EEG. In addition, their EEGs were monitored during the execution of the flight maneuvers presented in the flight profile table. Subjects were instructed to keep their eyes open and focused on a fixation point throughout the completion of all flight maneuvers. The USAARL safety pilot and another rated aviator were at the controls during these flights, but no data were collected from either pilot.

Data analysis

Each subject tested in this investigation had his/her EEG recorded during a resting in-flight segment and during the performance of in-flight maneuvers so that potential differences in EEG activity as a function of workload could be explored. Data from both pilots and nonpilots were recorded to provide a control for factors other than pilot workload accounting for differences between pilots' working and resting EEGs. There were a total of 15 segments of EEG data collected from each subject. The first segment was a resting eyes-open EEG, and the remaining 14 segments were eyes-open working EEGs (at least for the pilots). One EEG segment was collected during each maneuver.

Each subject's EEG record was first examined to extract and analyze a minimum of 4 relatively artifact free 2.5-second epochs in the eyes-open resting condition and a minimum of 2 relatively artifact-free epochs in each of the maneuvers (1-14). The EEG epochs from the pilots that were selected for analysis are presented in the appendix. Fast Fourier Transforms (FFTs) were conducted on all 21 active EEG channels for each epoch within each condition, and the results (all sets of FFTs--one per epoch) were averaged for each. This approach yielded

information about the power distribution of EEG activity at each electrode during each condition/maneuver. Once the FFTs were complete, the results were transferred to computer for statistical analyses, and the data collected under the various conditions/maneuvers in the aircraft were compared.

To facilitate the interpretation of potential workload differences, two sets of analyses were conducted on delta, theta, alpha, and beta activity from several electrode locations. The first set of analyses was designed to examine whether there were any differences in the EEG under resting conditions versus "on-the-controls" conditions. In this set of analyses, the EEG collected during the resting eyes-open condition was compared to the EEGs collected during the five types of maneuvers. The first maneuver type included the standard-rate right/left turns; the second type included the straight and level (SL) segments (SL1-SL5); the third included the standard rate climb/descent; the fourth included the steep (30-degree-of-bank) left/right turns; and the fifth included the standard-rate climbing-left/descending-right turns. The second set of analyses was designed to determine whether there were differences in the EEG among the various maneuvers, potentially as a function of workload (the resting EEG condition was excluded). In this analysis, four of the SL segments first were discarded--SL 1 because it was one of the first flight maneuvers, SL 6 because it was the only SL conducted under pure instrument conditions, and SLs 2 and 4 because they were randomly selected for removal. This left two iterations of every type of maneuver: 1) standard-rate level turns, 2) straight and level flight, 3) standard-rate climb/descent, 4) steep turns, and 5) standard-rate climbing/descending turns.

<u>Results</u>

Resting EEG versus "on-the-controls" EEG

A series of 2-way, mixed-factorial analyses of variance (ANOVA) was used to determine whether or not there were differences between resting EEG and "on-the-controls" EEG. The factors were group (pilot versus nonpilot) and condition (resting, maneuver 1, maneuver 2). There were only two maneuvers included in each analysis with the exception of the straight and level where there were six maneuver iterations. Absolute power data from the delta, theta, alpha, and beta bands were examined separately for electrodes C3, C4, Cz, P3, P4, Pz, O1, O2, and Oz.

Standard-rate 360-degree turns

The analysis of the left and right standard-rate turns indicated there were no interactions in the delta band, but there were group main effects at C4 (F(1,18)=9.35, p=.0068), Cz (F(1,18)=5.31, p=.0334), P3 (F(1,18)=4.20, p=.0553), P4 (F(1,18)=8.54, p=.0091), and Pz (F(1,18)=11.09, p=.0037). In each case, there was more delta recorded from the pilots than the nonpilots. In the theta band, there were group-by-condition interactions at O2 (F(2,36)=4.87, p=.0134) and Oz (F(2,36)=3.58, p=.0383). Both of these were due to increases in theta activity from the condition in which subjects were resting to the ones in which subjects were flying the aircraft (p<.05),

whereas there were no differences in the theta recorded during the flight maneuvers. These effects are depicted in figure 5. There tended to be a similar effect at O1, but it did not attain statistical significance (p=.11). In addition, there was more overall theta recorded from the pilots than the nonpilots at C4 (F(1,18)=4.99, p=.0385), P3 (F(1,18)=5.20, p=.0350), P4 (F(1,18)=5.82, p=.0267), Pz (F(1,18)=7.72, p=.0124), O1 (F(1,18)=4.64, p=.0450), O2 (F(1,18)=8.29, p=.0100), and Oz (F(1,18)=6.58, p=.0195). There were no interactions or main effects in the alpha band. In the beta band, there were group main effects at C3 (F(1,18)=5.76, p=.0275), C4 (F(1,18)=8.85, p=.0081), Cz (F(1,18)=6.17, p=.0231), P3 (F(1,18)=7.25, p=.0149), P4 (F(1,18)=9.27, p=.0070), Pz (F(1,18)=10.03, p=.0053), O1 (F(1,18)=5.32, p=.0332), O2 (F(1,18)=8.18, p=.0104), and Oz (F(1,18)=6.23, p=.0225). Each of these was due to greater amounts of beta activity in the pilots as compared to the nonpilots.

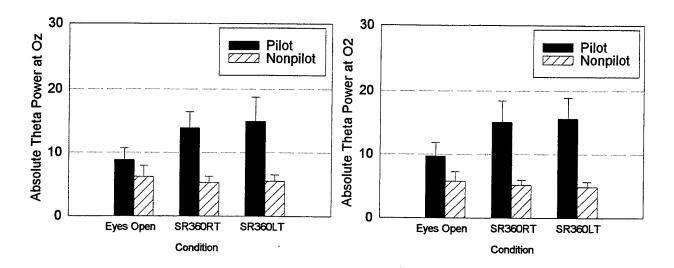


Figure 5. The effects of condition on occipital theta in the pilots versus the nonpilots during the standard-rate turns.

Straight-and-level flight

The 2-way analysis on EEG delta activity during the straight and levels indicated a group-bycondition interaction at P4 (F(6,108)=2.32, p=.0384), and group main effects at C3 (F(1,18)=4.86, p=.0407), C4 (F(1,18)=18.52, p=.0004), Cz (F(1,18)=6.31, p=.0217), P4 (F(1,18)=15.80, p=.0009), Pz (F(1,18)=12.83, p=.0021), and O2 (F(1,18)=4.72, p=.0435). There were no main effects on the condition factor. Analysis of simple effects for the interaction at P4 indicated there were no overall differences among the straight and levels within either the pilot group or the nonpilot group. However, there was a general trend in the nonpilots for delta activity to decrease from the condition in which both groups were resting to the ones in which the pilots were on the controls, whereas in the pilots, delta activity tended to increase (see figure 6). In fact, analysis of simple effects showed that the delta activity of pilots was significantly higher than that of nonpilots at SLs 1, 2, 3, and 6. The overall group main effect was because of higher levels of delta in the pilots than in the nonpilots. The analysis of theta activity revealed no interactions between group and condition, but there was an overall difference in theta across the conditions at Cz (F(6,108)=2.74, p=.0160) and O1 (F(6,108)=2.89, p=.0120). Contrasts for the Cz data indicated that theta activity declined from both the resting condition and SL1 to SL3, and then declined further from SL3 to SL4. Contrasts for O1 showed that theta increased from the resting condition to SL4. Also, theta was greater at SL3 than at either resting, SL4, SL5, or SL6; and theta was greater at SL4 than at SL5 (p<.05). There also were overall differences in theta activity between the pilots and nonpilots at C4 (F(1,18)=4.39, p=.0505), P4 (F(1,18)=6.05, $P_{1,1}$ p=.0242), Pz (F(1,18)=5.16, p=.0356), O1 (F(1,18)=5.31, p=.0334), O2 (F(1,18)=9.50, p=.0064), and Oz (F(1,18)=6.84, p=.0175). All were due to the fact there was more theta recorded from the pilots than the nonpilots. The analysis of alpha activity revealed no 2-way interaction, but there was more overall alpha in the pilots than in the nonpilots at C4 (F(1,18)=5.42, p=.0318) and Cz (F(1,18)=6.16, p=.0231). Also, there was a main effect on the condition factor at O1 (F(6,108)=2.19, p=.0495) which was due to more alpha at SL3 than at the resting condition, SL4, or SL6; and less alpha at SL6 than at SL4 or SL5 (p<.05). In the beta band, there were main effects on the grouping factor at C3 (F(1,18)=14.67, p=.0012), C4 (F(1,18)=17.38, p=.0006), Cz (F(1,18)=19.57, p=.0003), P3 (F(1,18)=18.43, p=.0004), P4(F(1,18)=20.32, p=.0003), Pz (F(1,18)=21.64, p=.0002), O1 (F(1,18)=23.73, p=.0001), O2(F(1,18)=32.19, p<.0001), and Oz (F(1,18)=24.32, p=.0001), all of which were due to the presence of more beta in the pilots than in the nonpilots.

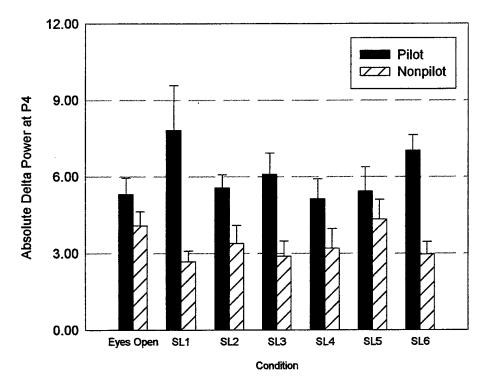


Figure 6. The effects of condition on parietal delta activity in the pilots and nonpilots during the straight and levels.

Straight climbs and descents

The 2-way ANOVA on EEG data recorded during resting conditions and the climb and descent indicated several effects. In the delta band, there were main effects on the condition factor at C3 (F(2,36)=5.43, p=.0087), C4 (F(2,36)=5.30, p=.0096), and Cz (F(2,36)=12.30, p=.0001). In each case, these effects were due to a reduction in delta activity from the condition in which all subjects were resting to the condition in which the pilots were flying the maneuvers (p < .05). There also were main effects on the grouping factor at C3 (F(1,18)=4.62, p=.0454), C4 (F(1,18)=10.58, p=.0044), P4 (F(1,18)=11.31, p=.0035), Pz (F(1,18)=13.17, p=.0019), O2(F(1,18)=12.45, p=.0024), and Oz (F(1,18)=4.67, p=.0444) which were due to greater delta activity in the pilots than in the nonpilots. In the theta band, there was a group-by-condition effect at Oz (F(2,36)=3.16, p=.0545) attributable to differences across the three conditions in the pilots (p<.05), but not in the nonpilots. Contrasts indicated a substantial increase in theta from the resting condition to the condition in which the pilots were on the controls, whereas there was no difference between the theta recorded during the two maneuvers (see figure 7). There were group main effects in the theta recorded from Pz (F(1,18)=6.04, p=.0468), O1 (F(1,18)=6.04, p=.0244), O2 (F(1,18)=9.55, p=.0063), and Oz (F(1,18)=8.69, p=.0086), all of which were due to the presence of more theta activity in the pilots than in the nonpilots. There also were condition main effects on the theta recorded from Cz (F(2,36)=3.34, p=.0466), O1 (F(2,36)=3.72, p=.0340), and Oz (F(2,36)=3.18, p=.0535). At Cz, the effect was due to the fact that theta activity was greater during the rest condition than during the climb, but only marginally greater than during the descent. At O1 and Oz, theta was less during resting than during the maneuvers (p < .05). It is noteworthy that the effect at O1 tended to be similar to the interaction found at Oz, although the differences between pilots and nonpilots were not significant (p=.15). However, for the sake of comparison, the data are presented in figure 8. The analysis of alpha activity during the climb and descent revealed a group-by-condition interaction at Pz (F(2,36)=3.25, p=.0504) which was due to differences among the conditions within the pilots (p < 05), but not within the nonpilots. Analyses of the pilots' data showed that alpha activity tended to increase from the resting condition to the climb (the effect was not significant), and then decreased substantially from the climb to the descent (see figure 9). There was also a condition main effect at Pz (F(2,36)=3.19, p=.0530), as well as one at P3 (F(2,36)=3.24, p=.0507) and Oz (F(2,36)=3.73, p=.0338). Contrasts indicated that at Pz and Oz, alpha activity was greater during the climb than during the descent, and alpha activity tended (p=.07) to be greater during the climb than during rest. At P3, the same basic relationship was observed, but the differences between the climb and the other two conditions only approached significance (p=.07 in both cases). There were main effects on the grouping factor at C3 (F(1,18)=4.44, p=.0494), C4 (F(1,18)=4.77, p=.0424), and Cz (F(1,18)=7.34, p=.0144) which were due to higher levels of alpha activity in the pilots than in the nonpilots. In the beta band, there were no significant interactions, nor was there a significant main effect on the condition factor. However, there was much more beta activity recorded from the pilots than the nonpilots at C3 (F(1,18)=6.51, p=.0200), C4 (F(1,18)=10.04, p=.0053), Cz (F(1,18)=6.66, p=.0189), P3 (F(1,18)=8.32, p=.0099), P4 (F(1,18)=10.16, p=.0051), Pz (F(1,18)=9.95, p=.0055), O1 (F(1,18)=5.28, p=.0337), O2 (F(1,18)=4.90, p=.0400), and Oz (F(1,18)=4.94, p=.0393).

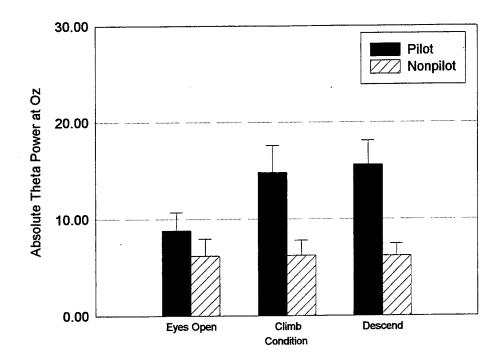


Figure 7. The effects of condition on theta at Oz in the pilots versus the nonpilots during the standard-rate climb and descent.

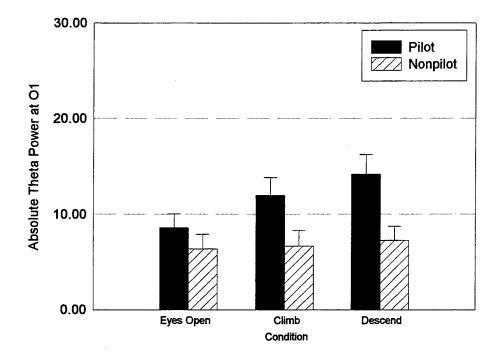


Figure 8. The effects of condition on theta at O1 in the pilots versus the nonpilots during the standard-rate climb and descent.

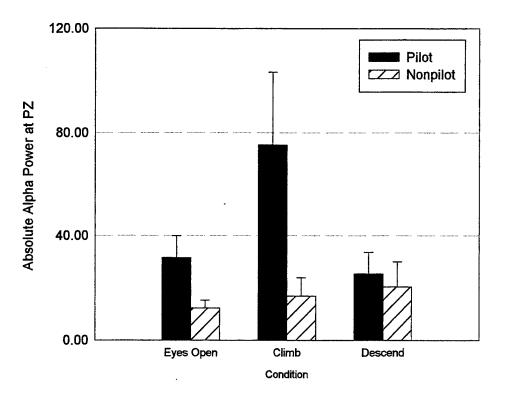


Figure 9. The effects of condition on alpha activity at Pz in the pilots versus the nonpilots during the standard-rate climb and descent.

Steep left and right turns

The analysis of delta activity in the steep turns indicated no significant interactions, but there were main effects on the condition factor at C3 (F(2,36)=10.68, p=.0002), C4 (F(2,36)=6.37, p=.0043), and Cz (F(2,36)=8.21, p=.0012). In every case, there was more overall delta activity during the resting condition than during the maneuvers (p < .05) while there were no differences in EEG activity between the two maneuvers. There also were main effects on the grouping factor at C3 (F(1,18)=6.35, p=.0214), C4 (F(1,18)=15.91, p=.0009), Cz (F(1,18)=8.70, p=.0086), P3 (F(1,18)=4.34, p=.0516), P4 (F(1,18)=16.44, p=.0007), and Pz (F(1,18)=11.78, p=.0030). Within the pilots, there was more delta activity than within the nonpilots at every recording location. Theta activity was affected by the combination of group and condition at O2 (F(2,36)=3.26, p=.0502) and Oz (F(2,36)=5.48, p=.0084) because, at both sites, there were differences within the pilots but not within the nonpilots. Contrasts on the data recorded from pilots showed there was less theta under the resting condition than during either of the maneuvers (right or left turn). These effects are shown in figure 10. There were overall condition main effects at Cz (F(2,36)=3.58, p=.0383) and Oz (F(2,36)=4.52, p=.0177). The effect at Cz was due to tendencies (p<.08) toward reductions in theta from the resting condition to the maneuvers, whereas the effect at Oz was due to increases in theta from the resting condition to the maneuvers (p<.05). There also were overall group effects at P3 (F(1,18)=5.40, p=.0321), P4 (F(1,18)=8.05, p=.0321), P4 (P(1,18)=8.05,
p=.0109), Pz (F(1,18)=8.67, p=.0087), O1 (F(1,18)=6.02, p=.0245), O2 (F(1,18)=9.39, p=.0067), and Oz (F(1,18)=9.99, p=.0054). Generally, more theta activity was recorded from the pilots than the nonpilots. The analysis of alpha activity revealed a condition main effect at O1 (F(2,36)=3.36, p=.0461) which was due to less alpha under the resting condition than during the steep right turn (p<.05), with a similar tendency in the steep left turn (p<.09). Also, there were group main effects at C4 (F(1,18)=4.97, p=.0387), Cz (F(1,18)=5.19, p=.0352), and O1 (F(1,18)=4.58, p=.0463), all of which were due to higher levels of alpha within the pilots than within the nonpilots. In the beta band, there were significant main effects on the grouping factor at C3 (F(1,18)=4.94, p=.0393), C4 (F(1,18)=6.97, p=.0166), Cz (F(1,18)=5.71, p=.0280), P3 (F(1,18)=4.94, p=.0394), P4 (F(1,18)=5.91, p=.0257), Pz (F(1,18)=7.88, p=.0117), O1 (F(1,18)=4.46, p=.0488), O2 (F(1,18)=5.97, p=.0251), and Oz (F(1,18)=5.39, p=.0322) due to greater amounts of beta activity from the pilots than the nonpilots.

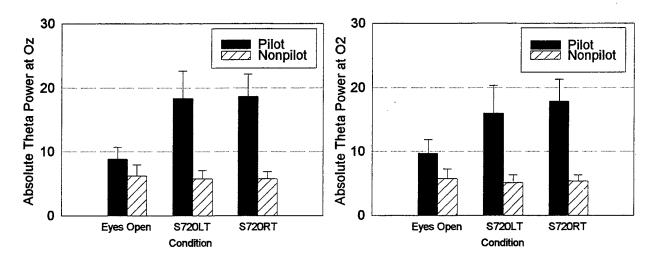


Figure 10. The effects of condition on theta activity at Oz and O2 in the pilots and the nonpilots during the steep turns.

Climbing and descending turns

The analysis of the climbing left turn and the descending right turn indicated a number of effects. In the delta band, there were condition main effects at C3 (F(2,36)=6.86, p=.0030), C4 (F(2,36)=5.85, p=.0063), Cz (F(2,36)=5.57, p=.0078), P3 (F(2,36)=3.60, p=.0377), P4 (F(2,36)=3.97, p=.0276), and Pz (F(2,36)=3.87, p=.0300). In every case, contrasts showed there was more delta activity under the resting condition than during the maneuvers (p<.05; except for the resting-versus-descending turn comparison at P3 and the resting-versus-climbing turn comparison at P2 where p<.07). In addition to these condition main effects, there were group main effects at C3 (F(1,18)=6.30, p=.0219), C4 (F(1,18)=12.82, p=.0021), Cz (F(1,18)=6.85, p=.0174), P3 (F(1,18)=5.06, p=.0372), P4 (F(1,18)=9.99, p=.0054), Pz (F(1,18)=11.97, p=.0028), and O2 (F(1,18)=8.96, p=.0078), all of which were due to more delta within the pilots than within the nonpilots. In the theta band, there were group-by-condition interactions at O2

(F(2,36)=3.15, p=.0551) and Oz (F(2,36)=3.58, p=.0382), both of which were because of differences among conditions within the pilots (p<.05), but not the nonpilots. Subsequent contrasts indicated there tended to be less theta under the resting condition than during the maneuvers (the resting-versus-descending turn comparison was significant) (see figure 11). There also were main effects on the grouping factor at P3 (F(1,18)=4.24, p=.0542), P4 (F(1,18)=5.31, p=.0333), Pz (F(1,18)=6.20, p=.0228), O1 (F(1,18)=5.30, p=.0335), O2 (F(1,18)=9.24, p=.0071), and Oz (F(1,18)=7.96, p=.0113). In each case, there was more theta recorded from the pilots than from the nonpilots. In the alpha band, there were group main effects at C3 (F(1,18)=6.15, p=.0233), C4 (F(1,18)=8.31, p=.0099), Cz (F(1,18)=9.93, p=.0055), P4 (F(1,18)=6.65, p=.0189), and Pz (F(1,18)=4.53, p=.0473), due to the fact that more alpha was recorded from the pilots than the nonpilots. In the beta band, pilots produced more beta activity than nonpilots at C3 (F(1,18)=6.29, p=.0219), C4 (F(1,18)=8.33, p=.0098), Cz (F(1,18)=6.22, p=.0226), P3 (F(1,18)=6.57, p=.0196), P4 (F(1,18)=7.36, p=.0143), Pz (F(1,18)=10.40, p=.0047), and O2 (F(1,18)=5.34, p=.0328). There were no other main effects or interactions involving beta activity.

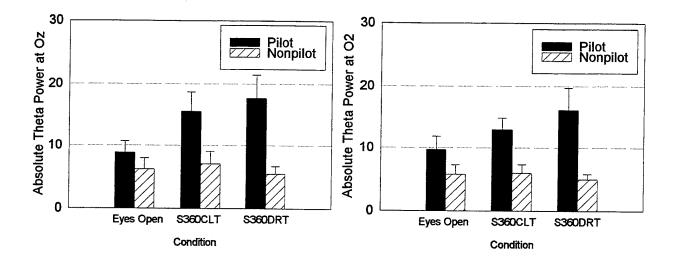


Figure 11. The effects of condition on theta activity at Oz and O2 in the pilots versus the nonpilots during the climbing and descending turns.

EEG effects across the flight maneuvers

The set of ANOVAs conducted to determine whether or not the EEG activity would be sensitive to changes in workload across the flight maneuvers excluded a resting condition. These analyses examined the effects of subject groups (pilots versus nonpilots) across both iterations (one versus two) of the various flight maneuvers (standard-rate turns, straight and levels, straight climb/descent, steep turns, and climbing/descending turn).

Delta activity

Within the delta band, there were interactions between the grouping factor and maneuver iteration (first versus second) at Oz (F(1,18)=6.87, p=.0173), and marginally at C4 (F(1,18)=4.15, p=0.0567). Simple effects showed that at C4, this was due to an increase in delta activity from the first to the second iteration of maneuvers only within the pilots, and at Oz, this was due to a decrease in delta activity from the first to the second iteration only within the pilots (p<.05). In addition to the group-by-iteration interaction, there was a maneuver main effect at Cz (F(4,72)=2.77, p=.0337) and P4 (F(4,72)=2.49, p=.0510). Contrasts at Cz showed delta activity was greater during the standard-rate turns than during the straight climb/descent or the steep turn. Contrasts at P4 showed more delta during the standard-rate turns than during straight climb/descent and more delta during the straight and levels than during the steep turns or the climbing/descending turns (p<.05). In addition to these effects, there were overall differences between the pilots and nonpilots which were similar to those presented in the previous section. Specifically, there was more delta activity recorded from the pilots at C3 (F(1,18)=6.34. p=.0215), C4 (F(1,18)=16.35, p=.0008), Cz (F(1,18)=6.44, p=.0206), P3 (F(1,18)=4.26, P3) (F(1,18)=4.26, P3) p=.0537), P4 (F(1,18)=18.73, p=.0004), Pz (F(1,18)=16.46, p=.0007), and O2 (F(1,18)=10.97, p=.0039). There were no interactions between the grouping factor and maneuver which would have indicated differential effects of small changes in workload on delta activity at any electrode. As can be seen in figure 12, the fluctuations in the delta band across the various maneuvers were not systematic.

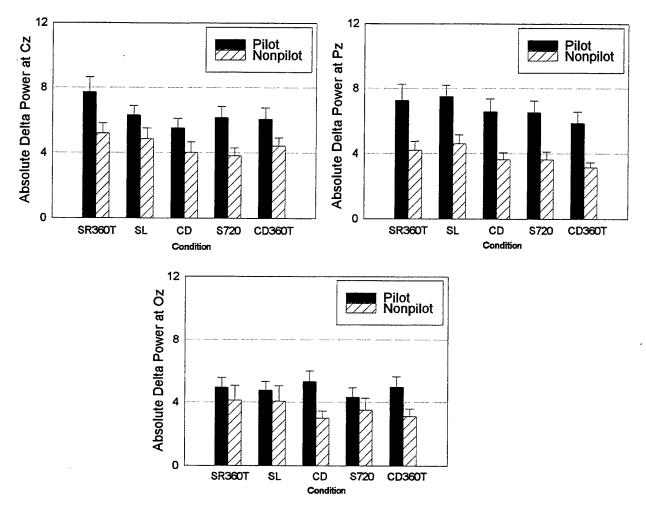
Theta activity

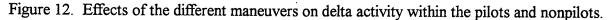
The 3-way ANOVA on theta activity indicated only a single 2-way interaction which was between maneuver and iteration at O2 (F(4,72)=2.45, p=.0539). This was attributable to the fact that, for some reason, there was more theta activity during the first than the second iteration of the straight and level (p<.05), but no differences in the other maneuvers. Otherwise, there were group main effects at C4 (F(1,18)=6.36, p=.0213), P3 (F(1,18)=5.91, p=.0257), P4 (F(1,18)=11.37, p=.0034), Pz (F(1,18)=10.30, p=.0049), O1 (F(1,18)=7.53, p=.0134), O2 (F(1,18)=11.71, p=.0030), and Oz (F(1,18)=10.22, p=.0050), all of which were due to the presence of more theta in the pilots than in the nonpilots. As was the case in the delta band, there were no systematic differences in theta activity as a function of whether the pilots were flying one maneuver or another (see figure 13).

Alpha activity

The analysis of alpha activity indicated a group-by-maneuver-iteration interaction at Pz (F(4,72)=2.86, p=.0294), and a maneuver-by-iteration interaction at C3 (F(4,72)=2.45, p=.0539) and Pz (F(4,72)=2.85, p=.0300). The 3-way interaction was because of a maneuver-by-iteration interaction within the pilots (p<.05), but not the nonpilots. Further examination of this effect showed that, within the pilots, there was significantly more alpha activity in the first versus the second iteration of the standard-rate turns and the straight climb/descent, but no differences in the

other maneuvers. The 2-way interaction at Pz was because of substantially more alpha at the first versus the second iteration of the straight climb/descent. At C3 there was a similar tendency, but it was not statistically significant. There were no interactions between the grouping factor (pilots versus nonpilots) and maneuver indicative of changes in alpha activity as a function of small changes in workload (see figure 14).





Beta activity

The analysis of beta activity revealed an interaction between group and iteration at O2 (F(1,18)=4.90, p=.0400) which was due to the presence of a decrease in beta activity from the first iteration to the second iteration in the pilots (p<.05), but not the nonpilots. Also, there was a consistent overall difference between the first and second iterations at this same electrode (F(1,18)=5.41, p=.0319). Finally, there were group main effects at C4 (F(1,18)=4.92, p=.0397), Cz (F(1,18)=5.20, p=.0351), P3 (F(1,18)=4.54, p=.0472), P4 (F(1,18)=5.69, p=.0283), Pz (F(1,18)=5.20, p=.0350), O2 (F(1,18)=6.04, p=.0244), and Oz (F(1,18)=4.80, p=.0418). All

were due to the presence of more beta activity within the pilots than within the nonpilots. There were no group-by-maneuver effects suggestive of differences in beta activity as a function of the different maneuvers flown in the flight profile. As can be seen in figure 15, the differences in the beta band across the maneuvers were essentially random.

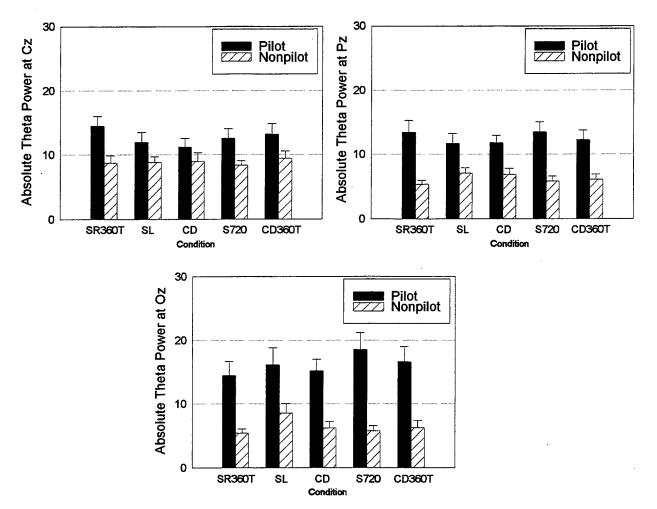
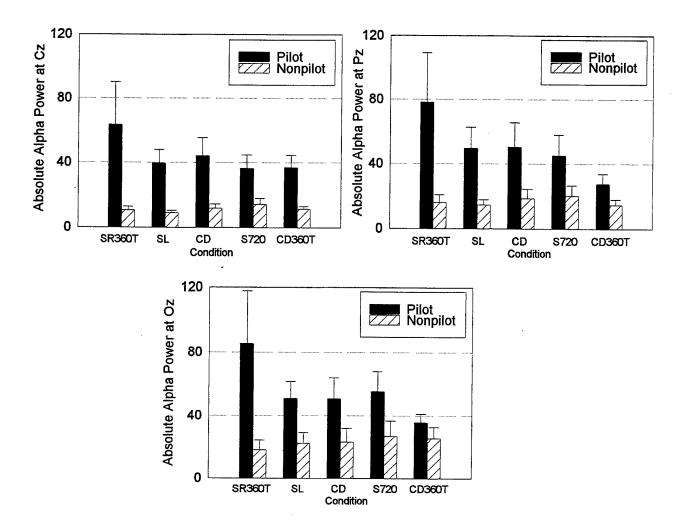
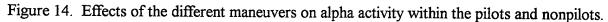


Figure 13. Effects of the different maneuvers on theta activity in the pilots and nonpilots.

Discussion

This study in which 10 pilots and 10 nonpilots telemetered multichannel EEG data from a helicopter during a standard series of flight maneuvers indicated the feasibility of monitoring the brain activity of pilots during the performance of actual flight duties. Furthermore, there were clear indications that telemetered EEG activity was sensitive to work-related changes in cognitive activation (resting versus "on-the-controls" conditions). However, the EEG did not appear sufficiently sensitive to differentiate between the smaller changes in workload (comparing one maneuver to another).





Sensitivity in differentiating resting and "on-the-controls" conditions

Although, as discussed below, occipital theta seemed to be reliably affected by workloadrelated factors in flight, there were some overall changes apparently unrelated to cognitive demands. There were overall effects across the in-flight conditions (resting versus maneuvering) in both groups of subjects (pilots and nonpilots) with regard to the amount of central and sometimes parietal delta activity, central theta activity, and occipital alpha activity. Central delta was affected in three cases, parietal delta was affected in one case, central theta changed in three cases, and occipital alpha was affected in three cases. These effects, in which delta and central theta decreased and occipital alpha increased from the resting to the maneuvering conditions, apparently resulted from some factor other than workload changes because they were observed in both groups of subjects. Sterman et al. (1987) found that the onset of in-flight G-forces was generally accompanied by increases in slow-wave EEG activity both in pilots and passengers. Thus, perhaps vestibular effects were responsible for the differences in the alpha band; however, the general impact on delta and theta recorded from the central region of the scalp is opposite of what would have been predicted based on the earlier study. Reasons for such a discrepancy are unclear at this point.

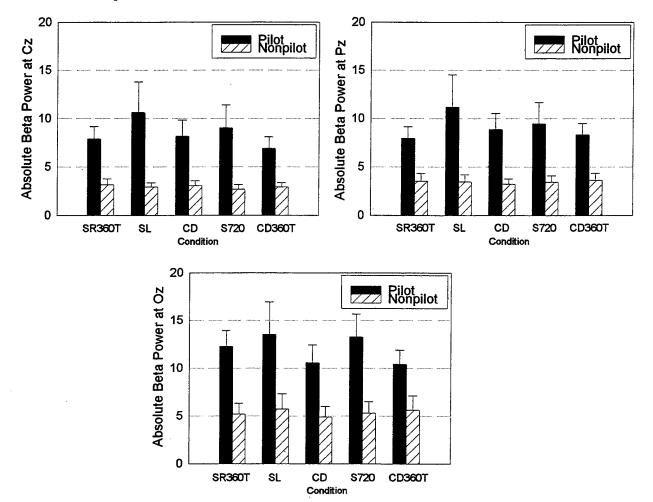


Figure 15. Effects of the different maneuvers on beta activity in the pilots and nonpilots.

In contrast to these overall, non-work-related EEG effects, occipital theta activity in the present investigation did seem to be clearly affected as a function of whether the pilots were resting or "on the controls." This was the case in the standard-rate turns, the straight climb and descent, the steep turns, and the climbing and descending turn, where in each case, one or more of the occipital recording sites (O1, O2, or Oz) evidenced a substantial increase in theta from the condition in which pilots were resting to the ones in which pilots were flying the aircraft. That these changes were not simply a result of vestibular effects, low-level G forces, or other extraneous factors was obvious when the data recorded from the pilots were group-by-condition interactions due to the fact that condition differences were observed only in the

subjects who were actually flying the helicopter. No differences in theta occurred during the transition from resting conditions to maneuvering conditions in the nonpilots.

This finding is partially consistent with the results obtained by Sterman et al. (1987) where theta activity recorded from the visual cortex of fixed wing pilots increased as a function of workload. In addition, these results tend to support those of Wilson (1994) who found that theta activity increased during more demanding in-flight maneuvers (although the observed effects in Wilson's study were seen in the parietal region of the scalp). However, the present research did not confirm the report by Sterman et al. (1987) that similar changes (i.e., increased theta) occurred in the sensorimotor (central) scalp region as well. Instead, the present investigation suggests that the changes in central EEG activity may have simply been a function of some extraneous factor (such as vestibular or G-force effects) since they were observed both in the pilots who were actually flying the aircraft and in the nonpilots who were only passengers.

Sensitivity in differentiating one maneuver from another

Analyses of delta, theta, alpha, and beta activity across the various maneuvers offered no indication that telemetered EEG data were systematically reflective of small changes in workload (as a function of whether the pilots were flying one maneuver versus another). There were several minor effects such as overall differences between the pilots and nonpilots irrespective of task performance, but these were essentially meaningless in the present context. These results were somewhat surprising based on the earlier findings that theta activity was sensitive in discriminating between resting and "on-the-controls" conditions within the pilots. Of course, there is a much larger change in cognitive demand between a resting eyes-open EEG task and flying a helicopter. Perhaps if the differences among the maneuvers had been greater or the subjects had somehow been compromised (by medications, sleep loss, or other factors), significant workload effects may have appeared. However, it is not possible to offer a definitive resolution to this issue based on the data collected in this study.

Conclusions

The present investigation offers clear evidence that it is quite feasible to collect valid EEG data on pilots while they are engaged in actually flying a rotary-wing aircraft. In addition, there are preliminary indications that some types of EEG activity (4-7 Hz occipital waves) can offer information about significant changes in pilot workload. However, it does not appear that telemetered EEG is sensitive to the sorts of small shifts in cognitive demand which are produced by standard higher-altitude flight maneuvers such as routine turns, climbs, descents, and straight-and-level flight (at least in well-rested, fully-functioning subjects).

Unfortunately, despite the fact that 21 channels of EEG data were collected, only those which were over the central, parietal, and occipital regions were useable because the frontal (and some temporal) channels were filled with eye-movement and/or muscle artifact. In fact, the removal of

artifact-contaminated data led to the requirement to estimate approximately 80 percent of absolute power values from the frontal leads (they were excluded from analysis because of this). Due to the fact that flying an aircraft is a visually-dependent task, it is unlikely that these types of artifacts can be avoided by limiting the activities of aviators while they are on the controls. In the future, it may be possible to implement some type of automatic artifact correction system or filtering mechanism to remove enough artifact to make the frontal channels more useable. At present, however, only the EEG channels which are further away from the influence of eye movements should be analyzed.

A follow-on investigation should be conducted in order to: 1) verify the findings that theta recorded from the visual cortex can reliably discriminate between resting and "on-the-controls" conditions in rotary-wing pilots; and 2) establish whether the EEG might be more sensitive to small workload-induced changes in cognitive demand when compromised (i.e., sleep-deprived) pilots serve as subjects.

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Appendix.

Examples of EEG data collected from each subject.

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Figure 1. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 1.

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Figure 2. The EEG epochs selected for analysis from flight maneuvers 6-10 for subject 1.

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F8-R182 F3-R182 F1-R182 F1-R182 T3-R182 T4-R182 C3-R182 C1-R182					
F8-R1A2 F3-R1A2 F1-R1A2 F1-R1A2 T3-R1A2 T4-R1A2 C3-R1A2 C1-R1A2 C1-R1A2 C1-R1A2 T5-R1A2					
F8-R1A2 F2-R1A2 F2-R1A2 F4-R1A2 F4-R1A2 T3-R1A2 T3-R1A2 C3-R1A2 C4-R1A2 T5-R1A2 T5-R1A2 T5-R1A2					
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F8-R182 F2-R182 F1-R182 F1-R182 T3-R182 C1-R182 C1-R182 C1-R182 T5-R182 F3-R182 F1-R182 F1-R182					
F4-R1R2 F3-R1R2 F1-R1R2 T3-R1R2 C3-R1R2 C4-R1R2 C4-R1R2 T5-R1R2 F3-R1R2 F3-R1R2 F3-R1R2 F4-R1R2 F4-R1R2 O1-R1R2 O1-R1R2					
F8-A1A2 F3-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 T3-A1A2 C1-A1A2 C1-A1A2 C1-A1A2 C1-A1A2 T5-					

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Figure 4. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 2.

	Clapsed Time 60:12:22	Elapsed Time 90:13:24	Elapsed Time 89:11:33	Elsperd Time 09:15:51	Elapsed Time Ba: 16: 11
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The EEG epochs selected for analysis from flight maneuvers 6-10 for Figure 5. subject 2.

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	F9-A1A2 F2-A1A2 F4-A1A2 F4-A1A2 T3-A1A2 T4-A1A2 C3-A1A2 C3-A1A2 C4-A1A2 T5-A1A2 T5-A1A2					
an and a second	F8-A1A2 F2-A1A2 F4-A1A2 T3-A1A2 T4-A1A2 C3-A1A2 C4-A1A2 C4-A1A2 T5-A1A2 T5-A1A2 F3-A1A2 F3-A1A2					
02-ALAZ	F9-A1A2 F2-A1A2 F4-A1A2 F4-A1A2 T3-A1A2 C3-A1A2 C1-A1A2 C1-A1A2 T5-A1A2 F3-A1A2 F2-A1A2					
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	F9-A1A2 F2-A1A2 F4-A1A2 F4-A1A2 T3-A1A2 C3-A1A2 C4-A1A2 C4-A1A2 T5-A1A2 F3-A1A2 F3-A1A2 F3-A1A2 F3-A1A2 F4-A1A2 F4-A1A2 F4-A1A2					
	F 0- A 1 A 2 F 3 - A 1 A 2 F 1 - A 1 A 2 F 3 - A 1 A 2 T 3 - A 1 A 2 C 3 - A 1 A 2 C 1 - A 1 A 2 T 6 - A 1 A 2 T 6 - A 1 A 2 T 6 - A 1 A 2 F 2 - A 1 A 2 P 1 - A 1 A 2 P 1 - A 1 A 2 P 2 - A 1 A 2 Q 2 - A					

Figure 6. The EEG epochs selected for analysis from flight maneuvers 11-14 for subject 2.

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F3-A182 F3-A182 F4-A182 T3-A182 T4-A182 C3-A182 C3-A182 C4-A182 T5-A182 T5-A182				Land a second se	
F3-ALR2 F4-RLR2 F4-RLR2 T3-RLR2 C3-RLR2 C4-RLR2 T5-ALR2 F5-ALR2 F3-ALR2 F3-ALR2 F3-ALR2 F4-RLR2					
F3-4182 F4-8182 F4-8182 T3-8182 T4-8182 C4-8182 C4-8182 T5-8182 F5-8182 F2-8182 F2-8182 F4-8182 F4-8182					
F3-4182 F4-8182 T4-8182 T3-8182 C3-8182 C4-8182 C4-8182 T5-8182 F5-8182 F2-8182 F2-8182 F2-8182 F2-8182 F2-8182 F2-8182 F2-8182					
F3-4182 F4-8182 F4-8182 T3-8182 T4-8182 C4-8182 C4-8182 T5-8182 F5-8182 F2-8182 F2-8182 F4-8182 F4-8182					

Figure 7. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 3.

	Elapsed Time 80:10:04	Elapsed Time 00:14:14	Elapsed Time 06:15:53	Elapsed Tim. 88:16:14	Elspeed Time 99:17:28
Tp1-ALAT	When Muthim my my my	1 min will month them when	And Management Man	Munday Multimenter Marken M	annumplesaments thing shit
Fp2-AIAZ	I'm www.my with	1 month marine	Mer MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	MANNA MANA MANA MANA MANA MANA MANA MAN	MWMM human my
F7-8182	Munier Timmergham my	Human who was here when the	ALMUMALI MONDAW WWWW	MAY MANAMANA HAVAN - MANY	Mumphimment with and the
F8-8182	Manufactor of Manual Manua Manual Manual	1 March With With M. with	the Minute almost in the most	MANNAMAN MANAMANAMA ALEA	Minhorman human
F0-8182	manningmunghung	Alway warder how a ward ward ward how ward	minummul muchan minu	Anno and a second a	MUMMUMUMUMUMUMU
Fz-ALAZ	for marken marken miner of the marken of	al man with the providence of the second	-for at he was dis which we every his should be	Mur sahara his hard a the share why by	Musther Museum white have a
F1-8182	moundmumber	al man well month well man when	the Antonia and a strain the second strain the s	Man May Man We want have	Mushman white in
T3-8182	mun Munn Min Min Min Min Min Min Min Min Min M	WWWWWWWWWWWWWWWWW	MANAMANA ANAMANA MANAMANA	NMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	Mathamananananananan
T4-8182	mannonmann	Annon Willimmunne	ANN WWWWWWWWWWWW	MANY MARY AND WANT HOW AND THE	MMMMMMMMMMMMMMMMMM
C3-A182	mountermuniter	Antomin With Ministry of the market	marthanner anner an annound	mon granned and the property of the street	Mumumumumumum
Cz-#1#2	mountannally	for many month and the market	main manufacture way man	Manus manufally in the	Mur man have a stranger and
C4-8182	manumhumuhum	elimin Mr. Marin Muning	the hundrent when him many	many marker and a second state of the second	Minthoman of monor
T5-8182	mound	HUMMING Chine HUMMING	en and the shrink his to be when the	manillan human and human has	Multimeter and the second second
T6-R182	mmunitering	Marin Marin Marin Marin Marin	Hummen Menter His Low and	MUNIMAN MANY MANY MANY MANY MANY MANY MANY M	Mun Min Min Min Min Man
PJ-8182	many an an an an and a stand	1 MM million mound in a mark	Anorth Multin mental Marian	Annahar march march march to march as mere	mummum humming
Pz-8182	him were more thank	prover and in more thanks	Annument with the designation of	manufal man and a second of a second	mummunitionin with
P1-8182	moundmininguest	Hours and him with moning high	Another when the part when and	muniferent of manual winds to as	any maniful man marked
01-818Z	monimum	The Anthe Marine Marine Marine Marine	Michighter Minamer with And M.	mouth work which which we want	WWWWWWWWWWWWWW
02-8182	mon www.man.man.man.man.man.man.man.man.man.man	HUWMUNIC MANNAM	AN AN AMANA AN AN AN ANA MANAMA	Mummum Mummum	world white man when when
02-8182	mon manufalland	WWWWWWWWWWWWWWWW	Acould many man wind with	manun mun mun mun	with man how when have
	Elapsed Time 98:17:53	Elapsed Time 09:13:51	Elapsed Timp 00:20:02	Elanced Time	Finesd Time
				Elapsed Time 00:21:32	Elapsed Time 00:23:24
FPI-AIAE	hundred and warding the	+ Marine Manual Marine Marine	Warmen Municipant 1	Munhamming and M	manning manning /
FPZ-8382	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	Month Manager Man	An man with the man of	hummmund	Hannahan Manut V
_F7-8182 F8-8182	Mannaly III a shake where	+ Manna Man Marina and a	Million Manus Manus	Munimumunum	Martin Martin Andrew Martin
		and a second sec	12 MY WALK WANNA MANAGER	of the second se	Manus Maran with Mary
FJ-ALAZ	Kyu Missingh with man Min	Anthrophy and and the second	Mundulanianianianiania	den martin and a state of the s	minimum minimum and
F2-8182 F1-8182	Know we show here with		M. Row Mount many man	Your manufacture with	Phone was a ward with a way of
T3-8182		April Anima to be a second of the second of	Minute and a second and the second and	the and allowed and the state	Marin Way Marin Contraction of M
	WWW. W.	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	MARK MANY MANY MARKAN	Mary Mary Mary Mary	WWWWWWWWWWWWWW
T1-A182 C3-8182	howwalthering		WHAMMI regar manination	- further when the many work of the	MMMMMMMMMMMMMMM
C2-8182	how when the month and the	Antime and the second second	Mannahan	the manufacture of the work of the	monumphymeter
C1-8182	humbarlaurenhunenalle		Mandallan	American and a for any Mr.	Manu Manu Manu Manu Manu Manu Manu Manu
	mmuniterrounder		di Las Balan Adu ben Administra	American and a second s	Manung Minhalen in the
T5-8182	mound	Antonia Marting Alimonia the	Ministron Muser Window Contraction	for the second for the second of the second	Marine as a fair a fair and the second
P3-8187	monumentering		Mannehummenneh	- warming a second of a summer of a	annon anther have been and
Pt-AIAZ	moundersonantersonality	Any were and the second s	Munununun	The second secon	Mr. M. M. M. M. M. M. M. M. M.
			MAN Markey Manus	- mining - man - discounter	Mr. Michael Marken Marken Mill
P4-8182 01-8182	mmunummunu	Man Manu Manu Manu Manu		AND A MARKED AND A M	And a line and and
02-A1A2	mmunitermini	And the state of the second state	Winter Multiments	And when when a firm when	Man Mahmman Manman
0z-8182	mmuniummun		All man a community and	man for and have here will	Man with Mary Mary
		Tour and a substantian strategies,	In the second seco	Marine Marine Marine Marine	april and the second of the second of
	warming the second s	million million in the second			

Figure 8. The EEG epochs selected for analysis from flight maneuvers 6-10 for subject 3.

	Elspeed Time 00:25:26	Elsped Time 00:26:03	Elspied Time 80:27:23	Elapsed Time 00:29:13	Clapsed lame 08:30:21
F#1-8182	for any man way wind MM	Jaw winny wormunet	- hundry many many many many	Manuf manufant	Winner with the winner
r#2-#1#2	han man man man man	The will working	American Marken Marken Marken	Warman Mark March	M. M
F7-8182	mannenmon	have when a proper the second	when have been been and the allow of the second sec	Manual Barman Manual Manual Manual	Tamanahan
F8-8182	mannewwww.	And March Marin marine	Manun Manun Manus	- Marine Marine Marine Marine	Hour Million Martin Martin Martin
F3-8182	for many more thank with	1 and Marine marine manus	Manhow Jon March March March	- man man man man	here with the second of the second second
72-8182	m	Any many was a second way was and	++++++++++++++++++++++++++++++++++++++		The for the second and the second sec
F1-8182	han manner manner manner	when when the way was and	Aunier from the first when the second	- And a state of the state of t	Mining man from the
T3-8182	handhamantantanta	whim which which which we wanted	Non many many many many many many many man	March	MWWWWWWWWWWWW
T4-8182	tour approximation of the second of the second s	1 Any www. www. www.	Marine marine and Marine from by	my man many man	WWWWWWWWWWWWWWWW
C3-8182	man and man man man MM	1 marsh marsh marsh	- And Marine and Marine and Marine and	-have marked the marked and the second	Man Munupriman Man Man Market
Cz-8182	funner mound when we will be	1 unin man man man man	Annow many more property and	- Manun Manun	ane metal man have more the
C4-R182	have and the work of the work of the	1 min min min min mining mining and	Anny war of the plant of the plant of the plant	man man prise man man and	Man May man Man with
T5-8182	in mentermanen minum	when my high for the warden to	- warming and a market warder of	Mary mary to a with the way will	Mr. Mullin Manus Maring
T6-R182	mannentertune	which any how many many	mumming with many	when my when the when the second	We Wilton when the work
F3-A1A2	an any mummer where Mark	man man man	man	Marine Marine Marine Marine Marine Marine	Man Mulum and And Maring My
Pz-R182	have been what have have	mannonmanne	mary mary mary marker thank	-hand and a second and the second an	Way Wind way and this will
P4-8182	home compressioner when when	1 min man man man man with	-unmer white white me	my way of a white warder and	May William Mar Mary My
01-81 MZ	In mound with mound with	when the for the strategic the	Muning many many all many	Winner Martin Martin Martine Mill	W. M. W.
02-8182	monumentation	Man Man Man March March	un many many and my my	manum have my attended	WayManman annall
0:-A182		Multiment martine	when when when the way	mount white with march the	WWWWWWWWWWWWWW
			<u>A IIIIIIIIIIIIIIII</u>		
	flagged Time	Clapsed Time 88:31:18	Clapsed Time 80:31:26		
	Elapsed Time 88:30:46			r	
Fp1-8188	mar want when a	I wanter hanner wanter and	W Jayan Marina Marina Marina	1	
Fy2-8182	min manufant	h WMr. Minner Million M	M. Manus war M. M.	1	
F7-8182	mon man man man	- Warding Willing & Morter and Brand	N in many many many many	7	
58-8182	mmanymmmmm	+ munimplimminum	W y mannen wir with Milling	1	
F3-8182	with man man with a second	- white was him and have a simil	N - Filmine Martin and Mart Mart	1	
Fz-8182	man man man and a second and a second and a second a se		W white white white white white	Ţ	
F4-8182	within the with the within the		He Warner and the second se	1	
T3-8182	munimum	a promision with the property of the	a mound wanter with	1	
T1-8182	munum man man	4 pp and the manufactures and the second	of a feat water a start of the William William William	1	
C3-8182	manning and man of		H Manager And Marine Winner Marine Million	1	
Cz-8182		h him hills have a hour and have		1	
C4-8182	- 1, 2, 2, 2, 2, 1, 2, 4, 4, 3, 1, 3, 3, 3, 7, 1	+ from the f		3	
T5-8182	have been and the second of th	he for many high and the man have	he approximate the second of the second s	1	
T6-8182	him hours and hours			1	
P3-8182	man man man man man			7	
Pz-8182	www.www.www.www.www.			1	
P1-8182	him Manna Munn	4 frindliver han which my man	N toman monowith MUM	ት	
01-R182	www.whinewerkithum	f for Manufactor and the market and	h many many many ment	ĵ	
02-A1A2	monthmanthman	A had man have marked and the	WWW. MWW. monthly white	ት	
02-8182		Hadren Mar		4	
				J	

Figure 9. The EEG epochs selected for analysis from flight maneuvers 11-14 for subject 3.

Elsesed Time #0:01:38

Tp1-8182

Fp2-M1M2

MUNIMINI

F7-8182 F8-8182 F3-8182 Fz-8182 nm F4-8182 T3-8182 14-0102 C3-#1#2 winny Mannah Cz-8182 C4-8182 Min Marine Marine Marine T5-8102 Minter homet T6-8182 P3-8182 white Pz-MINZ ΛŴ nvnr P1-8182 whimme within 01-8182 02-A1A2 0z-#182

WWW Ňr all many Monun uninin Mm nomin VA W Vinnehmen Minh

Elspeed Time 80:01:53

Clapsed Time 60:03:10

um harriver wayar 1,00 han marker www. analy white and a with the second s the water which which where the ŴŴ mm mm. www.www.www minishmannihman www.whitewww.

Elapsed Time 00:03:20

I. M. W. W. WWW wind of and with the first of the second of www.www.uhw.mhlinhaw.mhr mininter they way for my Mw mar www hann JAN Miny how in the mon when we will have the

Elapsed Time 80:85:56

^vγN\ unmann www.hww.hw 1m

Elapsed Time

Elspied Tine 60:07:28 Elapsed Time 00:00:43 Elapsed Time Elapsed Time MWWWWWWW m Man Munu AAM LWN m Milling MMMMMMMM July MAN FPI-BIRE F#2-8182 Muldure F7-8182 F8-8182 F3-8182 ŵŵ Fz-8182 MAMAMAM in the have mmm vwww F4-8182 her suprima general her with Munumpant T3-8182 in the work of the second T4-8182 mmmmmm march from the from the start hmight C3-A1AZ month A Mumhin M win/win Cz-8182 Ŵ min an manufacture of the C4-8182 mith and Manual Marine Manna MM MMMA/ лMM WWW мÏ T5-8182 Municipation man Mining Mulanamark T6-8182 ninim innin 73-818Z miling MMAA Pz-8182 init بمامانين Ŵ 71-8182 MM MM Munn MMM. ahi. Annownerstrand menument 01-818Z NUMAN HWY MUNANTAN MAN minin Winner ALAINA 02-8182 -thing well AMM MA NWWW 01-8182 Mullenn

The EEG epochs selected for analysis from flight maneuvers 1-5 for Figure 10. subject 4.

Elersed Time

T5-#182 **16-8182**

73-818Z

P1-8182

P4-8182 01-8182

02-8182 01-8182

	Elapsed Time 99:11:50	Elapsed Time 00;10:19	Elapsed Time 98:14:16	Elapsed Time -	Elapsed Time 00:15:33
	TWWWWWWWWWWWW	LAMMAN MUMANY WIT	ALLINA WYWA. WETWHAN	MANN I JULY MANNA I NH	MANIMUT YIMAM
Fp2-MIM2	mounter many man the	for any marking the	Wint W We was Marines	Manual Manual M	which we want the second
F7-8182	[un marging with a second of marging and	hammen man market	Now some station man which we want	A manufactor to a home highlight	Mary will minimum rea
F8-8182	and a property and the second	William when when the will be the	Hummer Minhumm	m minner minner	where the second states and the second state
73-8182	here we have a second of the second	. Inderson Municipan Mary	warmen warmen to warmen	when a for the many when	white share and
F1-8182		· have been a set of the set of t	mon man man man	,	Mun Miran Marine
F4-8182	Hummen markhum and	WWWWWWWWWWWWW	www.www.www.	MMMMMMMMMM	Munumum
T3-8182	have been the the test where the should be the second seco	Human Mumber History	When when when when the	When with the attended to an a start of the	manner
T4-8182	mapping and markener	min many many marked the		Manha Mala Manha	4 Martin Martine
CJ-8182	Maria and and a second second second	A. Martin Martin	mmmmmm har har hun	A state of the sta	Min mar manufacture
Cz-8182	have a show a sh	1 and a second a free of the product	Martin Martin Martin Martin Martin	A WAY WAY WAY WAY	How WWW Mary war
C4-8182	f-minight my inter for my		WWWWWWWWWWW	Annah manufamerica	Mummin Mining William
*******	polin meny short men and have been been and	for many many many		And	Man and a second and a second second
76-A1A2	- man mountaine	have a support of the second o	www.www.www.www.w	Laborardo	mound
P3-8182 P1-8182	Man and a second and the second	1	Month Martin Martin		mannentreman
	minimum		MMMMMMMMMMM	mannen under	Min mun Margan
P1-8182 01-8182	mannenhunder	Unin Manueller Marth	+ HANNEN More Marsh Marsh	mounderman	ANNIN MANY MANY MANY
02-8182	Mannerahaman	Anter a state and a set a state of the set o	- MANAMAN MANAMANAMANA		MARKAM AND MARKA
0z-R182	MA WAANA AMAKA MAMMA LA ALULA AAAM		- ALAA MAAAAMA MAMAAMAA MAY MAY WALAAAA	I shall be the should be the should be the	Manman Mins William
		1 The second sec			
-				· ·	
	Clapsed Time 90:15:86	Elapsed Time 98:19:44	Elapsed Time 90:20:31	Elapsed Time 00:23:06	Elspeed Time 89;22:35
	WWWWWWWWWWWW	WATALAL AT PROVING AND AN IN A MINING	and also more thank the way of the	TYLLINGS AMWWWWWWWWWWWW	VIN MANNAMAN
F#1-8182	which where the second second	man man man when the	Minine and March	With which we want with the	Mary mary and
F#2-8182	when why man when when	Menon many march without	an an an and the man and the	a mummummerer with	University and the second of the
F7-8182	1 manual manual	Home many manufacture and the second second	Hanney war when he	h warmen mound mu	" Marine Marine Marine
F#-8182	manumpermentermenter	your manager and and	hand a second and the second and the second se	I for an	. Many mummer
FJ-MIN2	manhamment	Man Man Man Marken Mark	for any and the second second	· how-many many and	. And have the
F2-8182 F4-8182	Mannuhamman	Www.mannahamm	mound	1 minung manning	4 mining the second
T3-8182	MMM JAKA MANANA MANANA	and the property and the function of the		a second contraction of a second second second	WWWWWWWWWWWW
	future up when when when the	Martin Martin Martin Martin Martin	mummum	weinter an and an and	William William and a second
T4-8182 C3-8182	Munhamman	man man grant and the second of the	when when a start when the start whe	1 min finner	, Junior management
Cz-RIRZ	MMMMMmmmmM	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	mmmmmmmmmmm	a from white man	- The manus of the second of the
CI-RIAZ	marine www.	Warner	1 March 1 Marc	1 Min Marine Marine	when the property was a set of the
	KAM MALMANA MANA	MANAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	A BITALL ALL AND MANANA MANA	A Strategy of the state of the

Monte Manual WWW mannin nin AM اشمامشا min MARAN innin NWWW man

Mr.m www hum min m vinni

Figure 11. The EEG epochs selected for analysis from flight maneuvers 6-10 for subject 4.

	Elapsed Time 00:25:07	Elapsed Tine 00:25:33	Elapsed Time B0:27:03	Elapsed Time 09:20:07	Elapsed Time 90:31:50
*-1-0100	MMMMMMMMMMMMMM	TWO MANY THEY ALL	11. M. M. Andre Million 1.	LIN MAN MAN LIMMA	I.WWW.WYWWW.I
rp1-4141 rp2-8181		Mar man when the	THE WAY WAY AND	Jum much with a with a with	When the same man for y was
F7-A1A2	Wardy type & Munther strong and the	Mar Multimeter and		transforming production in the	T. MILLER REALIZED AND MALANI
F8-8182	hours and a for the former	How May way of many	Demander and the state of the	the manufacture of the second	Turner that the the the the the
F3-8182	more in which we make	he second in a construction of	Many marker many marker was	him mound when he was the	Lanne Harry Lie Marian
73-8182 F2-8182	mannen www.	himmed and and	man man man	monorman	I sale and a second a line war way
F4-8182	mmm hummmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmm	mount	Hanning many many me	1 man from the Margan	when a sume is like the
T3-#1#2	HARAMAN KANALAMAN AN A	What man way when when the	Unit As a Introduction I lid his adding	To the an address of the Library of	In which was and the work of
		Mary William Mary Mary		The way way wind have a	HALL THE RED DAY AND THE THE REPORT OF
T4-8182	M Webster (Malle Martin Marry)		Hummerum	Manshingan manufactures	MUNUM MANY WINNING
C3-A1A2 C1-A1A2	Million Million Million	Marin Marin Marin Marin	an march march march	1. M. Humment	Inprasting Marsh with MMMM
C1-A1A2	- Man Man Man Man	mmmmmmmmmm	Mushinger manufactured		1 Mun provident with the
	man man man Min Amile		Jan production of the state of	an in the state of	man university with man
T5-8182	WANNA WALL HANNING	- MWWWWWWWWWWWWWWWWWWWWW	M. M. M. M. M. M. M. M. M.	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	for the second s
76-A1A2		あわたち さてもとちを望られる しんしゅう た		Bimmer and Werly	to and many proprior with www.
PJ-AIAZ Pz-Alaz	mmmmmmmhhhmmh		NW WWWWWWWWWWWW	monormanit	Millin Marken Markin Mark
72-ALK2	mmmmmmmmm	THAT TANK A TANK TANK TANK TANK TANK TANK		man much mil	Munimum and Minnet
P4-8182	F-MMM WWWWWWW	MMMMmmhmmm			A Man of Marine Here and Monson the
01-A1A2	W. W. W. W. M.	Munimum Munimum			Mr. Warner Hor and Waller Mr.
02-8182	per no man and a man	1 Min Marin Marin and Marine and Ma	Anny and the mist since the	Mr. M. W. W. M. M. M. M. M. W. W.	Will an the first and the first of the first
0z-8182	munder white which the will	Mushing Manuna and Manuna	mumminum	um white when the second	the manufally and be and the second and
	Etapsed Time 00:32:00	Elsped Time 00:32:23	Elapsed Time 00:33:43		
	AN INTY THE LANDING		TENLE LOLLY MINUTERT		
Fp1-B182	Man the first mer	- Marine Ma	Mr - Will Will Will war war with a start		
Fp2-818 <u>2</u> F7-8182	an marth well as with a monthly through	allin whether want with the state	WILLIA WAY AMMA MALANTA PARAMANA AM		
F8-A1A2		from hundered with	Here and the second s	7	
	how when any when any when a	has me have been it a method when	May many many many many many many many ma	1	
TJ-8182 Fz-8182	forming manufactured.	Month and a second second	furning and	,	
F 2-8182	Mummun mound	munimment	In a make marked with the	1	
TJ-8182	Transmission, 1961. Contraction and Contraction.	Manumenter Manuscher H	MAN MANY MANY MANY	L	
T1-8182		mound have sugar by MAN	An with Mary Mary Mary Mary	ł	
C3-8182	Menny month month	have been been when the	have an an an an an		
Cz-8182	MMMMMMMMMMMMMMMM	Munimum Marin Mari	MMMMMM Munhmmm		
C4-8182	Minum minuted and with	moundand	annie www. minh		
T5-8102	MMM - March MMM May Merry .	ANALAMANAMANAMANA	month manus min.		
T5-8182	M. mandara man Minut	Mr. M. manufacture and a market	full man who we want the way		
P3-8182	mmmmmmmmmm.	Munnimum	Mummun mummer		
P=-#1#2	mannethinghoused.	MMMmmmmMM	handhannahanna		
P1-8182	Manhamman	mound when when when the	howwwwwwwwwwwwww		
01-8182		how when have well and	from monoral monoral		
02-8182	Www.happers. M. Williams	Harmon Man Man Walk Warry	fritten when her bernowing		

Classed Time

0z-8182

Figure 12. The EEG epochs selected for analysis from flight maneuvers 11-14 for subject 4.

Munhann

	Elspeed Time 00:01:22	Elapsed Time 88:82:14	Clapsed Time 80:02:10	Elspsed Time 68:03:03	Glapsed Time 80:05:01
F#1-8182	Frank the the	from many for a start of the start	and all im a mander	- universality of	In and a motion of
FPZ-BLAZ	Januar Martin	John Mary Mary Mary Mary	Theman Unit months	Turken han with mit	way when when
F7-8182	for some from a port of the	- from the minute for the state	attender of the superior line	Anton Window and and which which	Engeneration and a second
F8-R1A2	Langer Jack	19 Merilian Miran Maria Maria	"Complexing " Live proper lives	Harton Variation and and a shift with a	forman America
73-818Z	[]] Juli un france	1 Milling and	Lui lui lui	L'induction of the second	List hand the second
Fz-8182 F4-8182	Manus man man	Mundan alera menarchand	in the subminuters	for mind on a stand on the stand of the	homen when marine
T3-8182	and an an and a second and the second	Multipermuneretinenter the ment	mound and the property and the second	from the the stand of the stand	feighern and the the water the the
T4-8182	he marine manuful and a second of	manual properties and how and the water	Mummin Wym Minon march	filler man hor which in my have	anorthe mentioner white the new word
C3-8182	- and a second and a second	Hundrey marken war and the second	africation of the states of the states of the states	franking war and war and the second	Menser win bernard the Revenuer
Cz-8182	for provident of the provident of the stand	the strange and the strange with the strange	province and a second	france warmon and march	how we have have a second
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ry2-A1A2 r7-A1A2 r3-A1A2 r3-A1A2 r1-A1A2 r4-A1A2 r3-A1A2 r3-A1A2 r3-A1A2 c3-R1A2					
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Figure 13. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 5.

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F9-8182 F3-8182 F2-8182 F1-8182 T3-8182					
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Figure 14. The EEG epochs selected for analysis from flight maneuvers 6-10 for subject 5.

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Figure 15. The EEG epochs selected for analysis from flight maneuvers 11-14 for subject 5.

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Figure 16. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 6.

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Mummer hummer with	M. Multimeters	MANY MANANAMANANANANA		
		AA WALL WY WORK WALKARY AND A WALKARY I T		a shart to it is highly a character
HTW/W/PW-MWPWWW	ANT MALANIA MALANA AND AND AND AND AND AND AND AND AND	Talashi (1997) (1997) (1997) (1997) (1997)		
	E1 86 : 2 f : 1 /			
			╨╜ ╨╜ ******* ┶┖╆┿┿┿┿┿┿┿┿┿┿	
	E1 86 : 2 f : 1 /			

Figure 17. The EEG epochs selected for analysis from flight maneuvers 6-10 for subject 6.

Elapsed Time 00:32:25	E1spsed Time 80:35:31	Elapsed Time 80:36:53	Elapsed Time 98:37:30	Elspsed Time @:37:52
· manana ·	month for the man	proper from home	when and I have a	WIN ENGLINE
new what was a start	warrant - france - monther	fragmente - have marked	home in the second second	Frund Tuning Hart
- market i i i i i i i i i i i i i i i i i i i		to you want of you want want you	Harmonia Transition and the month	Hund Harris annumber of
William	simple to a manuful	wine and wine any her man	with my my transition with a first the state	Danie in winner minister
	the first of the formations	for a second of the second sec	a same a second and a second s	when the farming he was have
Multine and a start	and the second	from the second of the second	╘╍╂╍┿╌┿╍┾╍╄╺╆╲┥╍┥┿╋╍┿╍┿	when a function of the second
and mathy marked	And a share the second standing of the second	Water Mary Manus and an and and	and the second and the second second	when have have a second and the second of th
979G': 312 11 1 1 1		all will demonstration with	manument of my manuffrances	por worked and an energy and literary menergy
	the state of the s	for the former of the second stand and the second s	reference and a present of the second second	min and francischer human former
marine marine	and further have been	free man from a free from the	-Junion from the second	frent for the man have
Mart I I	manuf function	from the second of the second	-1	And have been and the second and the
I the section is all it is and	in high the the	the state of the s	adamate a final and a first second	Any were from the man way was the
WAA WAANNA MAATANA ARAA	the start of the second second	grander and Advantation and the advances	Marchive truly the manifesting for the service	with the state of the second o
Maria Mar	Marine to the marine marine	and the all all all and the second	and Weiner and Arthore are here and	and the second of the second way when a second the
March Martin Martin	and furning	from the for the second stands	man and the second second second	And the second of the second o
In the second second	the first the second second	from Margaret after and margaret	- margarent Annan a failing	Mariner have many hours have
	No. 11. 1 A State Martin	for a function of a family of a family of the state of th	- transver builded and a free for the barry of	Manual france in the second of
White When When he was a start of the second s	ATA WAY WAY WAY WAY	WHIT WANNAMMAN	MMMMMM HAAAMAAAAA	house and the second have been and by
IN MARTIN AND AND AND AND AND AND AND AND AND AN	GENERAL AND A REAL AND AND AND A REAL AND A SHORE A REAL AND A SHORE AND A SHORE A REAL AND A SHORE A REAL AND A	I I MARINA AND I MARINA I MARINA I LA	ikatologi kultik Kilolo Miku Martik (1933), Alawa 1, 11 Si K	kaluka na si si ang si si mkasi a na si
MARIEN SAUCER	MANNIN MANANAMINING	an an ann an the the for build when	what have and the when he have been a second of the	
C' 657 56. 34	CI SESSI SI-	(15:60.40.40) (15:60.40.40) (15:6		ANYON INTERS LALANDAL ALVIN WALLAND AND ANY

Figure 18. The EEG epochs selected for analysis from flight maneuvers 11-14 for subject 6.

	Elapsed Time 00:01:50	Elapsed Time 80:82:56 f	Elapsed Time 88:00:21	Elapsed Time 08:01:27	Elapsed Time 68:06:88
i 7.1.0100	James and a stranger	Man I was I was	The and manufacture of	Inner uninforment	True many man
Fp2+8182	mon so for any many of	Jum the man has the	The manufacture of the	have herman	[man man man man
F7-8182	mar man when have an	annua manufacture and	1 menter manufacture	1 manufacture and	Mang Munistration
F#-8182	marine marine marine	Monum in the work of the	There we want the second	handrenter	Jundan Marine Marine
T3-8182	and many fringer	for the second s	James March 1		Immericant
Fz-8182	Amphip man hand a	A service and a	1 incrementation and	hand the manual services	ALL ALL ALL MALL MAN
F4-8182	have all here we want to be a second of the	from the second second second	Mr. manufant sugar war	Immunication when the	American and the second stands
T3-8182	manning have been and the	participation and a second share when the second	the state of the state of the	An and manusching and	and all and a more thank
T4-8182	a hand mether was here with	MANNA MANA ANA MANANA MANA		david and how have been	Harmon and and and and and and and and and an
C3-8182	and the second second	freedom in manufacture	The second second	I am have been and in the second	man month and a market
Cz-8182	and the month of the second		The stand is a set to be a set	man and an and the stand	And merchander and a month
C1-8182	Mun Aman man Muner	- Marine	TILIT	him hand have been been been been been been been be	hum have been the
T5-8182	mining with a second	dames a stationary and the	Three a war war war war	have have more thank	from how have
T6-8182	ming-man win win with a	monant for marchine have	Tuning a stand when her	- Automorphismer francisco	Annahan
P3-8182 Pz-8182	Municipal and marketing	American months and	In month in month	. And and and a second	man man
	Mannahan	Americanonamerican	[man hour hand	. for a second for the second	Annon marker and a second a second a second a second a second and a second a
P1-8182	www.mmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmm	unmonten with a	Termelinmummum	, for the second way to be a second	manufan when when
01-8182 02-8182	mutum mumum	for the month of the second	Mount when Month marken have	, marine marine marine way	month many the most of
02-A1A2	Warmen war war warmen	May man for many	. Innew wormware with	- And the second of the second	- more hours for more
			X III X I		
	Cardina - Ingeneration - Contraction - Contr				
	Elspsed Time 08:87:40	Elspeed Time 00:08:16	Clapsed Time 00:05:31	Elapsed Time 00:11:34	Elapsed Time 00:12:52
	MWWMMM.		51 55 51 54 51 TO	- Lienser hard million at M. M. M.	Eissiig Igar
Fp1-R182	Fring hand have have a	Mary restar mention will		Municipal and Andrew Martin Contract	fring a fun on the officer
Fp2-8182	Frank hand har h			rent a server and a server and a server and a server and a server a server and a server a ser	Martin and a spectral and and a spectral and a spec
		they wanter wanter war		alugaran an a	fring a fun on the officer
Fp2-8182 F7-8182 F8-8182	Frank hand har h	Anny way or Anna way and a set of the set of		aluganan an an har share an har share an	Martin and a spectral and and a spectral and a spec
F92-8182 F7-8182		Anny way or Anna way and a set of the set of			Martin and a spectral and and a spectral and a spec
Fp2-8182 F7-8182 F8-8182 F9-8182					Martin and a spectral and and a spectral and a spec
Fp2-M1A2 F7-M1A2 F8-M1A2 F3-M1A2 F3-M1A2 F2-M1A2					
Fp2-H1AZ F7-H1AZ F8-H1AZ F3-H1AZ F3-H1AZ F1-H1AZ					Martin and a spectral and and a spectral and a spec
Fp2-A1A2 F7-A1A2 F8-A1A2 F3-A1A2 F2-A1A2 F1-A1A2 F3-A1A2					
Fp2-818E F7-8182 F8-8182 F2-8182 F2-8182 F2-8182 F4-8182 T3-8182 C3-8182 C2-8182					
Fy2-R1A2 F7-R1A2 F8-R1A2 F2-R1A2 F2-R1A2 F1-R1A2 F3-R1A2 T3-R1A2 T3-R1A2 C3-R1A2					
Fy2-8182 F7-8182 F8-8182 F2-8182 F2-8182 F2-8182 F4-8182 T3-8182 C3-8182 C2-8182					
Fy2-A1A2 F7-A1A2 F8-A1A2 F8-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 T3-A1A2 C3-A1A2 C3-A1A2 C3-A1A2 C4-A1A2 T5-A1A2 T5-A1A2					
Fy2-8182 F7-8182 F8-8182 F2-8182 F2-8182 F4-8182 F3-8182 C3-8182 C3-8182 C4-8182 F5-8182 F5-8182 F3-8182					
Fy2-A1A2 F7-A1A2 F8-A1A2 F8-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 T3-A1A2 C3-A1A2 C3-A1A2 C3-A1A2 C4-A1A2 T5-A1A2 T5-A1A2					
Fy2-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Cy-A1A2 Cy-A1A2 Cy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2					
Fp2-A1A2 F7-A1A2 F8-A1A2 F8-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2					
Fy2-A1A2 F7-A1A2 F8-A1A2 F8-A1A2 F1-A1A2 F1-A1A2 T3-A1A2 C3-A1A2 C3-A1A2 C4-A1A2 F3-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2 F1-A1A2					
Fy2-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Fy-A1A2 Cy-A1A2 Cy-A1A2 Cy-A1A2 Fy-A1A2 Fy2-A1A2 Fy2-A1A2 Fy2-A1A2 Fy2-A1A2 Fy2-A1A2 Fy2-A1A2					

Figure 19. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 7.

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	Elapsed Time 80:13:39	flapsed Time ##(14:15	Elspeed Time 98:14:58	Elapsed Time 00:16:55	Elapsed Time
Tyl-RIRT	- Munhum hall and	ability man man in a ser marked the ser the	Jumment mary from the	Inerimmerin and and the second second	The mountain with
Tp2-RINE	mu hour hour with	Just martin and for a strate	June when when her have be	free we have a free way of a	
F7-8182	Munhammen M.	person manus many	funtion from the mathematical and the second	Marine and a second a property of the	1 M Leven marches
F8-8182	frank frank the	Am month for and man the	June marger may for the more	funne frender have f	Jan han hand hand the for
F3-8182			A man intermediation of the second	<u>↓</u>	munter the second second
fz-RIRZ		Anter the second	And a property of the second	┟┯┯┯┯┿╖┯┿┥┩╼┅┥┩╧╄╺	
74-8182	have been and a second	Anomen alter anone and the	man han have been been been been been been been be	from the second weather a second seco	and the second second second
T3-8182	have a survey and the way of	Amand for which have been all all all all all all all all all al	-Angle + All and - really - and the second .	for the second s	
T4-8182	monen manuf Manufacture man	Aver the work for a work of white with	Marrien Mr. Marken .	- for a second s	-land and a second and a second
C3-8182	how when he had	approximate principal and principal	And and the second s		-hum-r-h-m-m-t
Cz-8182		- Annow have a provide the	Annual francing for the second	for a second sec	where the second water
C4-8182	hand a second when a second se	- However marken and the second	. Annow the second seco	from the second s	man from the former of
TS-8182	production of the second of th	formation of an and an and a second	for a verified at the production of the second s	┼┽┿┿┿┿┿┿┿┿┿┿	Mu - mar
T6-8182	man where a survey	Amphiliphing and marging	for the second of the second o	-propries for a second provide of	M
73-8182		An weather and the second and the	from the property of the second secon		Mutil and a second second
P1-8182		Any Mundry and my more thank and the	from the second of the second	from the second of the second of	Munificant and a second
F1-8182	Warden warden warden with	+ Antraphilip - Antraphy - Antrap	. Annan man was a second of the second of th	-franking -	Mary - hand - have -
01-A182	prover and marked and a second	. المايام بريادي الماري المؤمو عام الماري المواجع المعالي .	to all which the way when the way when the	from the state of the second of the second s	Mr. Warren warren war
72-8182	Warren to Marker and a warrent	- And manufactor and a function of the formation	have a strange when the second of the second	for any provide the second of a	My have a second a second and a second a se
7z-8182	have been been and the second	+ many man for man all marked	to have been and the second of the second se		Mr. marine war and a second and the second s
			<u>, </u>	<u>, </u>	
		£1;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;	· · ·	£1;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;	
Fp1-8182		۲۰:۲۰:۲۰:۲۰۰ ۲۰:۲۰:۲۰:۲۰۰ ۲۰:۲۰:۲۰:۲۰:۲۰۰	- - - - - - - - - - - - - - - - - - -	Ling municipation	
[p]_A]A2 [p2-A]A2			fundation in the second		
F#2-A1A2 F7-A1A2			from monowing	Ling municipation	mundun mary month
Fp2-8182		Manufacture in the manufacture of	the for the second second		mundun mary month
F#2-A1A2 F7-A1A2			the for the second second	Ling municipation	mundun mary month
Fp2-A1A2 F7-A1A2 F8-A1A2 F3-A1A2 F3-A1A2 F1-A1A2			the for the second second		mundun mary month
F#2-8182 F7-8182 F8-8182 F3-8182 F3-8182 F4-8182			the for the second second		mundun mary month
F#2-8182 F7-8182 F8-8182 F3-8182 F2-8182			the for the second second		mundun mary month
F+2-A1AE F7-A1A2 F8-A1A2 F8-A1A2 F2-A1A2 F2-A1A2 F1-A1A2 T3-A1A2 T1-A1A2			the for the second second		mundun mary month
Fy2-A1AE F7-A1A2 F8-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F1-A1A2 T3-A1A2 T1-A1A2 C3-A1A2			the for the second second		mundun mary month
Fy2-A1AE F7-A1AE F3-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F4-A1A2 T3-A1A2 T4-A1A2 C3-A1A2 C1-A1A2			the for the second second		mundun mary month
Fy2-A1AE F7-A1AE F8-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F4-A1A2 T3-A1A2 C3-A1A2 C1-A1A2 C4-A1A2			the for the second second		mundun mary month
FR2-A1A2 F7-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F3-A1A2 F3-A1A2 F3-A1A2 C1-A1A2 C1-A1A2 F3-A1A2 F5-A1A2			the for the second second		mundun mary month
Fp2-A1A2 F7-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F4-A1A2 T3-A1A2 T4-A1A2 C3-A1A2 C4-A1A2 T5-A1A2 T5-A1A2			the for the second second		mundun mary month
Fr2-AIA2 F7-AIA2 F2-AIA2 F2-AIA2 F2-AIA2 F2-AIA2 T3-AIA2 T3-AIA2 C1-AIA2 C1-AIA2 T5-AIA2 T5-AIA2 F2-AIA2			the for the second second		mundun mary month
F2-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 T3-A1A2 C3-A1A2 C3-A1A2 C4-A1A2 C4-A1A2 T5-A1A2 F3-A1A2 F2-A1A2			the for the second second		mundun mary month
F2-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F2-A1A2 F4-A1A2 T3-A1A2 C1-A1A2 C1-A1A2 C1-A1A2 F5-A1A2 F2-A1A2 F1-A1A2 F1-A1A2					mundun mary month
F72-8182 F7-8182 F2-8182 F2-8182 F4-8182 T3-8182 T4-8182 C3-8182 C4-8182 T5-8182 F2-8182 F2-8182 F4-8182 F4-8182 F4-8182 F4-8182			the for the second second		mundun mary month
Fr2-AIA2 F7-AIA2 F7-AIA2 F2-AIA2 F2-AIA2 F2-AIA2 T3-AIA2 T3-AIA2 C3-AIA2 C4-AIA2 F5-AIA2 F2-AIA2 F2-AIA2 F2-AIA2 F1-AI					mundun mary month
F72-8182 F7-8182 F2-8182 F2-8182 F4-8182 T3-8182 T4-8182 C3-8182 C4-8182 T5-8182 F2-8182 F2-8182 F4-8182 F4-8182 F4-8182 F4-8182					mundun mary month

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Figure 20. The EEG epochs selected for analysis from flight maneuvers 6-10 for subject 7.

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	Elapsed Time #0:26:04	Elspeed Time 88:27:58	Elspsed Time 80:28:18	Elapsed Time 88:29:50	Elapsed Time 00:30:55
Tp1-8182	mine manufamente	- for purpose monthemp with	-hummer and a for the second s	How my how and the of	myuman
Fp2-A182	and an in min	my mound when here	how when we want the	March Three March and Mr.	my untran
F7-8182	-mumming man -1	- manutanter manutanter and	- munimum with	Hand Mark Branky Branky and marked	manna Lunia
F8-8182	mennementer	- marine marine marine	man minimum may /	4 mounter man manuful	Immuntering
FJ-ALAZ	mannan	minumum	- manufarman and the	framming in the	formentation
Ft-8182		- harden and the second	-human har	from the second	the the second
F4-8182	marmin marking in	Manhanaparapara	how when the second	als as respectively when we have	minum
T3-8182	for manufacture shares the	- intering and when the second of the second of	man	Mining hours water and the second	of a man the state of the state
T4-8182	mannemment	, he program with the man of the second of t	Aproximation house the	1 min manun hanne	min mount
C3-8182	manny In	munine manufacture	And have been and the second	munine have been and the second of a	himmin
Cz-8182	hand while a whole of	May man man man market		from monor and the second .	Lanning
C4-#1#2	hunderland	munimment	hamment	from and	Limmun
TS-8182		mountainmaning	- Antonia - Anto	monoral approximation and	human
T6-R1A2	humanhmmumut	martine for mary promised	hand many market	herring between my ment of	human
P3-8182		- minimum human	In many more many with	from months and .	Immun
Pz-8182	human	Lumbermanning	- manun manun manun	forman hand.	I mannen
21-818Z	human man man man VI	mere water monthmoment	hannen man man	funningen and man d.	Lungun
01-8182	many may wound the worked		and a more thank they	hannen an an an a	mannon
02-A1A2	hannahannahannah	Marine marine marine a	hand a find a start of the star	human my my my	Inmontheman
02-8182	mannaman	1		function with a start	1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -
	and a set of the set of the set of the	Maria and a specific for the second	for a second sec	Anne hand here a second of the	
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	9		33	۱:	2	1	

minim

FPI-BIAR Tp2-8182 F7-8182 F8-8182 F3-8182 Fz-8182 F4-8182 T3-8182 T1-8182

C3-R1 R2 C2-8182 C4-8182 T5-8182 T6-8182 P3-8182 Pz-8182 P4-8182 01-818Z 02-8182 0z-8182

Elapsed Time 88:33:86

Elapsed Time 80:33:11

394 Time 333:86	Elapsed Time 00:33:11	Elapsed Time 00:35:32
un manung the	mundul when her have	
motor motor mat	- manual man	month
mon manufactures	-manand providing	minute
	The second secon	, Januar
marken marken Mark	for a property way and a second	. Ammun
man man production	Mar man man man and and and and and and and and and a	, Am Manutan
for many many	Munichanter	. from how
	The manufacture water and the	Am Am
My may prove and real way	Minere Mary way and a way and	. An martin
making white white	- min man man man man	American
mot mon mummer with	mounderman	montin
mon man marked with the	transmith and the second	American
An manufacture and a second of the second of	- munitor many	. Dimmont
- manufacture and a second	- Andrew Andrew March Ma	. Marganahara

Figure 21. The EEG epochs selected for analysis from flight maneuvers 11-14 for subject 7.

	Elapsed Time 80:00:34	Elapsed Time 90:01:48	Elapsed Time 00:03:18	Elapsed Time Q0:03:34	Elapsed Time 80:87:16
rpi-Aint	Maler and the Man Marker W	kenner and work of the work of the	Wryny Wryn More MM	and the and the second and the second se	Two hannen my
Fp2-8182	non manufacture	Theman March March		man my uninen min MM	Winner Ineman Muny on
77-8182 Γθ-8182	man many many many many	man man man man	h h h h h h h h h h h h h h h h h h h	A marine many way of	1 who is man who when the
10-0102	Manus of the second of the sec	humming many many many	. Way way way and a set	mountain mountain al	- manning was
F3-8182	in a second s	The state of the second se	· A man manufant	And a second	1 minuter march my tor
Fz-8182 F1-8182	menning and and the second	mountermount	and	africation of the second drive of the second with	mound man white
TJ-8182	- Statut de la la la la la la la statut de	Two when the way	when when a hard with	-from with our manufaction of	month man man Ard
T4-8182	the print of the second s	- Million and a second a secon	male and many window many		Were work and when were worked
C3-A1A2	Withmirth annound and the	hunnannin	Manus marker mon a marker of the	Allow and a show the second of	Month an arrow white Martin
Cz-AIA2	When a monor man man	Marin mar Marin way and marked miles	Home when my when he was	Ano man the scarpe parts in the	miner a harman from the
C4-8182	Min Hope warming when when the	MM WM HW WWW	Hundrey Martin Martin Martin	Hummint mouth and	Munder Manager and Market
T5-8182	Mennenenenenenenenen	WMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	An man Marine Mun M	Min Min Man Market	unner with the shirt
T6-8182	monumenting	Moninghamming	Aman marine Marine Marine	many manufactures of	AD AM 14 4
PJ-8182	With and with more with	humanmunican	Normalian warment	William market the initial fills	1 multime and mart
Fz-A182	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	10000000000000000000000000000000000000	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	MMMMMMMMMMM	Ann Alt man market month
P1-8182	how we we we we we we want	from monorman and	man man when my	fundade manufacture of	And many many met
01-8182	With which we want	mounderman	1 minun marine marine	munimum	Munummun munum
02-8182 0:-8182	Marine man from Mark	for manufacture for the second	And the here was the	In many many many many	montemperation
02-4182	and marked and and and	mummum	showing my man with a second	Any march the march any mil	windy how when we way
	Elapsed Time B8: 07: 16	Elapsed Time 98;93:88	51apsed Time 80:20:05	Elapsed Time 88:12:25	[]apsed Time 00:12:56
T#1-8182	Lundon MMMMMMM W.	and remaining my	In announder the	under how we want the second	Mond Theman hand and
Fp2-8182	- in the second with the second secon	The manufactory of the	hornor have been the	t.m. wm plan mw	The wind with the second of the
F7-R182	Lawar an red month with the	1 min min mining	and month many manual the	Winner and with the stand of th	Www promonthe in mining
F8-8182	[mmmmmmm	man man man man	And a	1 man manne	the mount of malingly
F3-8182	Frank man when when the	L'unan and a start of the	and more than the	muniter M	and the mount of
F2-8182 F1-8182	have a second the second	www.	man and a second and and and and and and and and and a	two & and the man	for and a second and a second
TJ-ALAZ	merelin manufictures of a manufic	the search environmental and	har music har an all har and	1	How a south of the south of the south of the
T4-8182	mound way way when the	Margan winn marging and		John man	and the second of the second o
CJ-8182	him in the second with the second s	mummin in months TTT.	Interning monthand and	1 million when the strength	Miles American marcher
Cz-8182	hum when a part in a short	Winning manufactures and	MMMMMMMM ALMMANN	There was a provide the second of the second	Mohaman Marine rem Mohaman 1.
C1-8182	Warmen With Man price and a start	Werther the south and with .	have my man with the man with the	man was been with the man with the second states and the second st	Mithing and Mining and Mining Mining and
T5-8182	how we wanted a strain water and the	MAAMMAAMMAAMMAAMMAAMMAAMMAA AMMAA	monthemaning	Inverting when the state of the	M. Marshell un general and marshing
T5-A182	mound was superior	putinent manution with.	fur manufarman and the	of MMM man prant man market	Muniship whiming many in and
P3-8182	han and her which have the	have a second with the second and the second s	have manufaired seals	him when his more stand and the second is	minimum
P2-8182	mount with the work of	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	MMM MANY MANY MANY	Tom Man Min Min Man Man Man Man Man Man Man Man Man Ma	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
21-8182	mm monthemant.	have an a second when the second of the seco	- www.whenter.	and the work of the second the second of the	
01-8182 02-8182	month a start of the	mountermonth	montermannet	munumumum.	monormanimment
02-8182	human human Mine	hand the start of	have been and the second secon		have
		protocondormante marching	Jane marker and a second constrained of the	promine manufant ,	human

Figure 22. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 8.

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5+2-8182

F7-8182

F8-8182

F3-8182

Fz-8182

T1-8182 T3-8182

T4-8182

C3-8182

Cz-#182 C4-8182

TS-8182

T6-R182

P3-8182

Pz-BIRZ

24-8182

01-8182

02-8182

01-R182

F.1-8182 F#2-0182

F7-8182

F8-8182

73-8182

Fz-8182

F4-8182

T3-8182

T4-8182 C3-8182

Cz-8182

C4-8182

T5-#1#2 16-A182 PJ-8182

Pz-ALAZ

74-8182

01-8182

02-8182

01-8182

Clapsod Time 00:15:06

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E1spsed Time 00:21:54

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The EEG epochs selected for analysis from flight maneuvers 6-10 for Figure 23. subject 8.

Elapsed Time 88:26:22

যায় whynthere Fp1-8182 k FP2-8182 Millin F7-#182 F8-8382 Annon Manna w F3-8182 F1-8182 F4-8182 Mining T3-8182 mentillium 11-8182 HWWWWWWWW WWWWWWWWWWW WWWWWWWWWWWW C3-8182 CT-8182 C4-8182 T5-8182 humun humun T6-8182 P3-8182 mpromini Pz-8182 MMM Marine 24-8182 01-8182 month 02-8182 MAN 0z-8182 ww

Elspeed Time 00:27:18

worthin m mmmmm, Minut nm Mining ywww www.www. minint Winningman mm лM www.m MM humm Wini WW

E1 apsed Time 60:20:36

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A when a superior and
Elapsed Time 90:31:24

Tp1-A1A2 Fp2-A1A2 F7-A1A2	Million March 1990	much many the wind	Why where where we have the month
Fp2-8382	Muniter Market Lang	B de Munapan No dans In	heid wall wall was a solution of the
	The state the state		
	LANA AND	Man Martin Turkey	march provident and and a second
T8-8182 .	Mehneright Mary	1 mile 1 en son Millicharthan	mint montant in the
	Mar Whoman -	with the way of a manufal	must have been and many much
F3-8182	www.intelligenter	many how when him him had here	mant of the manual of the second of the seco
F1-A182	mman home him	mund dissortion when and	mut monoral many the many
T3-8182	M.M. MWWWWWWWWW	Markey with Marine Marine and	many AWAWAWAWAWAANA MANAMANA
i	monthly white	a work as a such har the without	when Hull Multiment from the
T4-8182	M.M. Went Million	warmy with more marine	mind unmontheminent
C3-8182	Manmanulalasing Man	Montan Managaranana ana ana ana managana	must musimment with
C2-8182 C1-8182	MANNAM RAILE ALMA	A. A. A. A. A. AL AMAGAMAAN	must mount much mount
01-1112	a manu montality	martin when a second when the second	ワイ モー・レススト にしゃ 特権が正式 につればい
T5-8182	monument	m. Min alan Mara William	
T6-8182		www.h. www.www.hithink.h	W The Latter of Canada Direct Lata Cally State
r 3-1112	AN AN AN	itatifi bi kasifati kabatah sebah sebah sebah sa	the state of the s
PI-RIAZ	Manual Contraction of the second s		Maren e la la companya de la company
P4-8182		would work which we we	K (C) E E E E E E E E E E E E E E E E E E E
01-8182	Murray marker 100	way which a first way that was a first of the	mun approximation and
02-8182	www.hhundhw		9 12 12 1 12 2 3 4 1 E E E E E E E E E E E E E E E E E E
01-8182	Wind www. Mar	mouth minimum	han - what was the way and the

Figure 24. The EEG epochs selected for analysis from flight maneuvers 11-14 for subject 8.

	Elapsed Time 60:02:09	Elspied Time 00:02:42	Clapsed Time 80:93:37	Clapsed Time B8:01:55	Elapsed Time 88:95:57
3	There was a second of the second	TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT	In anti-many	- when when when	In many man winn the
Fp1-8182 Fp2-8182	The man and the second se	The second secon	Ladred branching	- my winning winning	MMWWWW
T7-8182	1 manual 1	honnest with MUN	my my manuf	Antonio Manual Manual	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
F8-8182	hoursemminumbert	WWW and www.	Mr. Winny Winning	Handler and the second second	Anna Manna Manna
F3-8182	transmin 1		for the first when the second	frammuniter	Manufacture
Fz-8182	humany	1 The house which which	Mummen min white	mannen and mound	1 mon mon month man
F4-8182 T3-8182	Wath Win policy with the Many's	Maril	Hunnika pour and the big and a second	AMAR MAN HALAMA MAR AND	al united flyinder to man in the most
T4-8182	Michon Minus Mine with which the	Alterne opphen with the With with	Mali Marin Marin and Marine and	I JEVYVERIA AAA AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	and a survey of the second start and the second sta
C3-8182	L'anno anno anno anno anno	Ming under marine mer	Jun Margan Margan	Markey warman warman	In many in which which
Cz-8182	mound and many mound	mounting	manhand	many in many	In mount mount
C4-8182	hour manufacture	mumment	AND STATISTICS AND	month a manner a month	hundred minister and the start
T5-8182	Mushimment manual	6 martin martin and and the second	. The man manufacture	Minney where the month	munite seven month theman
T6-A1A2	Man Man Man Man Man	- MANN TO 1990 WAR IN COMMENT	. hun menton manufamber	. Human when the man when the	- monthing and the second
P3-8182 P1-8182	Manufacture and and and	Mun man montion	· you wanter and with the	. Minerin him him have ment	- I monitor and all all all all all all all all all al
	ni reparti with reparti and	Montemport	. How month when when	, manin manager	LANNA AND AND AND AND AND AND AND AND AND
P4-8182 01-8182	human man wanter and	Munhummun	. An man man han hand hand	MANNIN MAULIAN MANNING	ULAMONIA HA AKKAMAMAA ANAMAA
02-8182	MILLINMINIMUMINIM	MINTAMANAMAWAY	. MANHAMMANMAMAM	· John Martin Martine Martine	werman werman
02-8182	man	A WALK WWWWWWWWWWWWWW	. Menning man man and the	March March and Mar	
	Flanged Time	Clarsed Time BU:00:59	Elapsed Time 88:89:29	Clapsed Time 00:10:32	Clapsed Time 00:11:93
		MMMMM WMMM	T Tommumminimm	TA INTERNET	I why la min with
F91-8182	here have been been been been been been been be	ule www.mennemy.mennemy	TT mummer more hundren	All working my Marine	I the mount when the much
Fpl-AIAZ FpZ-AIRZ	here have been been been been been been been be	mound in the second		N And the man with the	- Munichan Marking
Fyl-AlAt Fyz-AlAt F7-AlAt F8-AlAt	former way way and and	mon with which we have	TT mummer more hundren	W AND A CONTRACT WALL AND	- mining - which - mining - mi
F8-A1A2	here have been been been been been been been be	mon with which we have	The providence of the second s		White Marine Marine Marine
				WARMAN WA	I man han her her man Man her han her han her
F8-A182 F3-A182 F1-A182 F4-A182		mon with which we have	The management of the second s		Minimum Anno MI
F8-A1A2 F3-A1A2 F1-A1A2			The management of the second s	SIL THE HANDER WANTED	Minimum Anno MI
F8-A1A2 F3-A1A2 F1-A1A2 F4-A1A2 T3-A1A2 T3-A1A2				Will a north Multimen with	Annon antiga conta an CT Manager and an an anno Manager and an an anno
F8-A1A2 F3-A1A2 F1-A1A2 F4-A1A2 T3-A1A2 T4-A1A2 C3-A1A2			The second secon	M. M	Anima and a contra so the
F8-A1A2 F3-A1A2 F1-A1A2 F4-A1A2 T3-A1A2 T3-A1A2			To an		
F8-A1A2 F3-A1A2 F1-A1A2 F4-A1A2 T3-A1A2 C3-A1A2 C3-A1A2 C2-A1A2 C4-A1A2			To an		
F8-A1A2 F3-A1A2 F1-A1A2 F4-A1A2 T3-A1A2 T4-A1A2 C3-A1A2 C2-A1A2				And a second sec	
F8-A1A2 F3-A1A2 F2-A1A2 F4-A1A2 T3-A1A2 T4-A1A2 C3-A1A2 C2-A1A2 C4-A1A2 T5-A1A2 T5-A1A2 F3-A1A2				And a second sec	
F8-A1A2 F3-A1A2 F1-A1A2 F4-A1A2 T3-A1A2 T3-A1A2 C3-A1A2 C3-A1A2 C1-A1A2 C4-A1A2 T5-A1A2 T6-A1A2				And a second sec	
F8-A182 F3-A182 F4-A182 F4-A182 F4-A182 T3-A182 C3-A182 C2-A182 C4-A182 F5-A182 F5-A182 F1-A182 F1-A182				And a second sec	
F8-A182 F3-A182 F1-A182 F4-A182 T3-A182 C3-A182 C1-A182 C4-A182 F5-A182 F5-A182 F1-A182 F1-A182 F1-A182 F1-A182 C1-A182				And a second sec	
F8-A182 F3-A182 F4-A182 F4-A182 F4-A182 T3-A182 C3-A182 C2-A182 C4-A182 F5-A182 F5-A182 F1-A182 F1-A182					

Figure 25. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 9.

	Elspood Time 40:11:35	Elspsed Time 80:13:14	Elspeed Time 88:14:49	Clapsed Time	Elapsed Time .00:17:36
Fp1-8182	my we have my	my my man	In manufunnant	The man was a	Juniel Where we way the
Fp2-mint	Fringer Mary Theme	In marken in my	Transferrance	The must by F	Jelan burg was man store we
F7-8182	monthing mentioner month	William alucian with the t	Ammunumment		TIMMAMMAMMAMMAM
ra-#182	mannamman	Arrent prover and and and	himmony I'm	MMM MMM MM	TUNNY WANNAW WAY WAY
73-8182		from the second second second	farmen have been a far a far	www.	from more way and
F2-RÌAZ	the state of the state of the		hummuning	man www.man.man.www.www.	Annon Aline and a second
T4-8182 T3-8182	he where the state of the	March March March March March	human human han han han han han han han han han h	win minimum minimum	Marile all and the and the set of the
	when when the second of the se	White with the with the with the	And the state of t	Manner Hanner Manner Hanner	
T4-8182 CJ-8182	Moren what a seal as a such	all was an a later a state and a state	Millime when when when when when	ANA MANANA MANANA MANA	Man Man Man Man
C2-8182	- mounter when when	I have been have been and	mmmmmmmm	Man man man man man man	-ummulanevid mound
C4-8182	have an and a second and a second	- I marge manuely and	harmonial in the second of the	any many marine and marine	mar man man man
T5-8182	MARINA MANAGENERAL	ALTRANSMAN AND WIND DOWN MARK	Munummum min		Many Music marine
T6-A182	When medal which is write in which in	where we allow the stand of the work of the	huse many marker we we	mummmmmmmmmmmmm	and an and the second second second second
PD-RIAZ	manuthattanhamment	Moundannam	mounderman		munummun
Pz-8182	mannenturn	menning manufactures and	mounderman	vuummmmmmmmmmm	furning when ment
24-8182	prove in a providence of the second of	Alun un and many Murray .	man man man man mark	where where where have a strange the strange of the	also marine marine marine in the
01-8182	MMMMMMMMMMMMMMM	MARARAMANA WANAAA MAAAA A	Mumuhamana	MANNA MANNAMANA	WARMAMAN AN MANALAN
02-A182	MANANA MANANA MANANA	MANA MANANANANANA MANANA M	4 Martin Martin Marthan Martin	MAN MANNA MANA	
0z-8182	WWWWWWWWWWWWWWW	WWWWWWWWWWWWWWW	Mun	MANMAMMIMMAN MM	Manana any particular
		F 1			
	Clapsed Time 00:17:50	Elapsed Time #0:20:20	Elapsed Time 08:21:20	Elspied Time 00:22:01	Elapsed Time 88:22:44
TPI-MINE	Minine Marine	E1 35 226. 26	(money and more more for		
rp1-8182 rp2-8182	Wind and the mark	anne anne anne anne anne		Elisizzi ila	
rp1-0102 rp2-0102 r7-8102 r8-0102	Winner Winner Winner	Manine handel and the former of the second s	Manager and a start a		
Fp1-A1A2 Fp2-A1A2 F7-R1A2 F8-A1A2	Wind and the mark	manine handeline and have a second and the second	(money and more more for		
Fp1-A1AE Fp2-A1AE F7-R1A2 F8-A1A2 F3-A1A2 F3-A1A2	With the second se	Manine handel and the former of the second s	Manager and a start a	- Munimulanta filing	
Fp1-8182 Fy2-8182 F7-8182 F8-8182 F3-8182 F1-8182 F1-8182		Manine handel and the former of the second s	Manager and a start a	- Munimulanta filing	
Tp:-AIAE Tp2-AIAE T7-AIAE T7-AIA2 T0-AIA2 T3-AIA2 T1-AIA2 T4-AIA2 T3-AIA2					
		Manine handel and the former of the second s			
T3-R1R2 T4-R1R2 C3-R1R2 C1-R1R2 C4-R1R2 T5-R1R2 T6-R1R2					
T3-R1A2 T4-R1R2 C3-A3A2 C1-A3A2 C4-R1R2 T5-R1R2 T5-R1R2 F3-R1R2					
TJ-RIR2 T4-RIR2 CJ-RIR2 C2-RIR2 C4-RIR2 T5-RIR2 T5-RIR2 PJ-RIR2 P2-RIR2					
T3-A1A2 T4-A1A2 C3-A1A2 C4-A1A2 C4-A1A2 T5-A1A2 P3-A1A2 P3-A1A2 P4-A1A2					
T3-MIA2 T4-MIR2 C3-MIA2 C4-MIA2 C4-MIA2 T5-MIA2 P3-MIA2 P4-MIA2 01-MIA2					
T3-A1A2 T4-A1A2 C3-A1A2 C4-A1A2 C4-A1A2 T5-A1A2 P3-A1A2 P3-A1A2 P4-A1A2					
T3-A1A2 T4-A1A2 C3-A1A2 C4-A1A2 C4-A1A2 T5-A1A2 T5-A1A2 F3-A1A2 F1-A1A2 O1-A1A2 O2-A1A2					

Figure 26. The EEG epochs selected for analysis from flight maneuvers 6-10 for subject 9.

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	Clapsed Time 99:24:38	Elapsed Time Bu:24:51	Elapsed Tine 89:27:36	Elspied Time ##: 27: \$2	Elsped Time 88:30:15
Tpl-AlAt	1 mmmmmm	1 minhow marker a profe	I man man man man		Further when the
Tp2-8182	11 minute Marian	a winner winner with	Turmingunununun	man marker and	amprovement who is
F7-A182 F8-8182	And a standard and and and and and and and and and an		down when when when when when when when wh	TOWNWARA MANANANA	and when we
F3-8182			I man Man man man	- month man from the	a min manual and a second and a second
F2-8182	Deference of the second of the ofference of the second of		And when the provide the second of the secon	(The manufacture and
F4-8182 T3-8182	Martin William and Martin Comment	TUNNINUUM TYTY WINNY WE LINE .	Winning Milling Man Man	and a stranger of the second	Phylophylophylophylophylophylophylophylop
T4-8182	1 ALIANNIM ALAMANNAN	Any man want want want	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	Manuthin Manuthin Manuthing	HAMMAN HUNNY MUMANNA
C3-8182	have have been when the second	Alexandra and a second with	Muniment Manut	Junion manufactures of the second second	humming
C1-8182	Municipal marine with	Manny many many	Turmen manut	Lange and the second of the	for any mentioned
T5-8182	under worm mouth	Samerica Mr. Marine And	Mummum manufunna	Manna and a start way the	Marily and a second and a second
T6-A1A2	han the second and the second	Munine Munine Manus	min month man min man	Multime with the first with	Man how have
P3-8182 P1-8182	hand have been well		Normannahannahannah	moundand	1 min him have
P4-8182		mon hanne hanne	monumente annahammente	AMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	WWWWWWWWWWW
01-A1A2 02-A1A2	mmmmmmmmmmm	WANNAWA AND AND AND AND AND AND AND AND AND AN	ANALAN ANALANA ANALANA ANALANA	AN White in Haling the work work in the of	maker www.manner.
02-8182	MANNA MANNA	Manual Manual Contraction	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM	M. M	W. W
	Elspsed Time d0:31:02	Clapsed Time 00:31:02	Elapsed Time 98:34:17		
	Twinnhurwhinnh	hummmun	Throwwww.		
Fp1-M1ME Fp2-M1M2	Mond man Charles which which	hundren	- manufarman had		
F7-A1AZ F8-A1AZ	WWWWWWWWWWWWW	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM			
F3-8182		www.www.www.	- for manufacture and		
Fz-8182	hand man hand have	friend and a second second	my internet when the most		
T4-8182 T3-8182	Wehley leader when when when we way	Anorthal and a further and man the hard	she stratto the an internal sources		
T4-8182	WWWWWWWWWWWWWWW	munumum	Jur mun mun mun mun		
CJ-8182	min him hours	Thinking	The manufacture of		
C2-8182 C4-8182	wind we will be with	mannerman	Amount man marked		
T5-8192	unidentimenter	funnighter granter from the	- fut was a fut the second of the second		
T6-8182 73-8182	And the many and and and	the manufacture of the second	- Margan Margan Margan	·	
73-8182 72-8182	Contraction and the first	. In manufamenter	hum how and with	,	
71-8182	here have been and here and	· Minimum	+ manus and manus and the		
01-8182 02-8182	WWWWWWWWWWWWWWWWWWWW	1 The show which we want	1 man	1	
01-8182	mannummun	for many many many	mound with	1	

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Figure 27. The EEG epochs selected for analysis from flight maneuvers 11-14 for subject 9.

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	Elapsed Time BE: 03:18	Elapsed Time 88:84:25	Elapsed Time 98:01:54	Elspard Time 00:05:34	Clapsed Time . 00:07:09
Fp1-AIAE	man manufactured south	Waynoundary	Winy haven by	The second second second second	how have the
F#2-8182	monomenon marge	how have have a	Two and standard the work	and and and the second	1 - marine marine more marine
F7-8182	man mumuling and	the strength of the strength o	Many mountained	Warmon mentioned	and the stand of t
F8-8182	Man Man Man Man Marker Ma	M.M. Mary monther Unit	And the second second	Mary Mary Liver Car Manual	1. in manus Mary much
F3-8182	-monthe marken and	for the home many many	formanter man has met.		Mitimum un un were were heren
Fz-A182	him have been been been been been been been be	And many many many many many many many many		a substantiation of the second s	
F4-8182	have an an an an an an and the	porman and some many	Hull for the company of the start of	and the second second	Have a set of the owned to the loss of the set of the s
TJ-8182	Hundenholmment when the server	human helder the should be the state of the	Miller manufacture allowed as allow .	My my Muchael marked be all all the strategy and the stra	Martin Martin Lewis Low Martin 1
71-8182	MANNA MANNA MANNA	Marrial Hundrid Maria Maria and	Murther Aller Martin Marting	MALANALAN WWW.WWW.	HILLE MALANTING MANAGENER
C3-8182	for month of the provide for the second		Hummon hand and		n han man han han har
Cz-8182	monormy when and	here II and marked	annon manufanting	1 min Min Marine Marine Marine	Mr. Mary Manut
C4-8182	humments the funder	a month a mandata at	I and have all months	1 marginetime the way and	Man Margar Margar Margar Margar
T5-8182	hannand hannahannan hal	Latening and marking and a			An and him more set of a loss of a loss of a loss of a
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TS-A1A2 T6-A1A2 P3-R1A2 P2-A1A2 P4-A1A2 01-A1A2					

Figure 28. The EEG epochs selected for analysis from flight maneuvers 1-5 for subject 10.

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Figure 29. The EEG epochs selected for analysis from flight maneuvers 6-10 for subject 10.

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The EEG epochs selected for analysis from flight maneuvers 11-14 for Figure 30. subject 10.