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The purpose of this research was to develop models of basic cognitive tasks developed in previous research. A model of choice reaction time was written in Simscript II.5 but development of this model made it clear that additional information was required before good models of basic cognitive tasks could be devised. Therefore, a number of experiments were conducted which were designed to provide the basic information needed. The experiments focused on several questions important to the construction of explicit models. Some of these questions were: How do subjects build mental models of instructions and to what extent do the goodness of these models affect subsequent performance? How do response complexity factors affect task performance? What aspects of stimulus structure are important in the encoding of the stimuli used in these tasks? Seven experiments addressing these issues were conducted. In general, results suggest that basic cognitive tasks are far more complex than had previously been thought.

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Summary

The purpose of this research was to develop models of basic cognitive tasks developed in previous research. A model of choice reaction time was written in Simscript II.5 but development of this model made it clear that additional information was required before good models of basic cognitive tasks could be devised. Therefore, a number of experiments were conducted which were designed to provide the basic information needed. The experiments focused on several questions important to the construction of explicit models. Some of these questions were: How do subjects build mental models of instructions and to what extent do the goodness of these models affect subsequent performance? How do response complexity factors affect task performance? What aspects of stimulus structure are important in the encoding of the stimuli used in these tasks? Seven experiments addressing these issues were conducted. In general, results suggest that basic cognitive tasks are far more complex than had previously been thought.

Final Report

Past Research. In previous work, I have developed a position which views human intelligence as a complex system (e.g., Detterman, 1980, 1982, 1984a, 1984b, in press). This system is composed of a finite number of independent (i.e., orthogonal) variables. If it were possible to measure each of these variables separately, the combination of these measures should be predictive of more complex tasks.

To test this theoretical position, a set of ten basic cognitive tasks has been developed to measure the orthogonal variables which compose human intelligence. These tasks were designed to test some aspect of basic mental functioning. All of the tasks are administered by computer and use the same stimuli and format. All instructions are administered to the subject by a voice synthesizer and all responses are made on a touch screen. All tasks were extensively pretested so that the parameters obtained from each task are reliable and are known to discriminate between groups differing in mean intellectual level.

The ten tasks are: *Learning(LR)* - In this task, subjects are required to learn sets of stimuli of from 3 to 9 items each. The task yields measures of learning rate. *Relearning(RL)* - Subjects relearn the same sets they originally learned in LR. Measures of savings are obtained. *Reaction Time(RT)* - Subjects are required to respond as quickly as possible to the onset of a stimulus. The task becomes increasingly complex by the addition of alternatives that must be attended to. Several measures of speed and accuracy may be obtained from this task. *Stimulus Discrimination(SD)* - This is a modified match-to-sample task. The task is to match a probe to one of six alternatives. This task yields measures of stimulus encoding and search processes. *Probe Recall(PR)* - Six stimuli are presented sequentially in 'windows' on the screen for 1 second each. The subject's task is to remember where each stimulus was presented and to indicate in which position a match to a probe stimulus appeared. Various parameters of memory accuracy and speed are obtained. *Self-Paced Probe Recall(SP)* - This task is similar to PR except that the subject can study each stimulus item for as long as desired. Measures of strategy use are obtained. *Recognition Memory (RC)* - A forced-choice recognition task uses stimuli from previously presented tasks. *Sternberg Memory Search(ST)* - Memorized sets of stimuli are tested by presenting stimuli which either are or are not in the .memorized set. *Tachistoscopic Threshold(TT)* - Two stimuli are presented for a very brief duration and then are covered with a mask. Subjects are required to judge if the stimuli are the same or different. If the decision is wrong, the next presentation is for a longer interval. Over a series of trials, a threshold for discriminating same from different is obtained. *Tachistoscopic Delay(TD)* - This task is the same as TT except that a subject must judge if there is a delay between the offset of the first stimulus and the onset of the second.

If these tasks contain the basic parameters of intellectual functioning then, in combination, they should predict more complex tests of human intelligence. That has been the goal of the research so far conducted. The basic paradigm has been to administer the set of ten basic tasks (about 3 hours) and a standardized intelligence test to a sample of subjects. Parameters from the basic task are used to predict performance on the standardized intelligence test. Three major studies have so far been conducted.

Mentally retarded/college students The initial study involved two groups of subjects: 20 mentally retarded young adults enrolled in special education classes and 20 college students.

Although this was a pilot project involving a small number of subjects and a large number of variables, it was possible to obtain a high degree of prediction of the Wechsler Adult Intelligence Scale even when appropriate corrections were applied.

High School Sample. Subjects for this experiment were randomly selected from the graduating class of a large suburban high school until a sample of 141 had agreed to participate. The sample contained mentally retarded subjects who had met the requirements for a certificate of attendance. The range of WAIS-R IQ scores was from 50 to 150 and the mean of the sample was 108 with a standard deviation of 15. The IQ scores of subject's in the sample were almost perfectly normally distributed. Because this sample so closely approximated the population, no correction for attenuation was applied.

When reliable parameters were included in a multiple regression equation to predict each subjects Wechsler Adult Intelligence Scale IQ score, a multiple R of between .75 and .85 was obtained (depending on methods used). This finding suggests that a very high proportion of the reliable variance common to intelligence tests is predictable by these very basic cognitive tasks. The finding is even more surprising in view of the fact that the average correlation of the individual basic parameters is .29 and that the same high degree of prediction can be obtained when only parameters with correlations with IQ less than .4 are included.

Air Force Enlistees. This study was a replication of the previous one with a few modifications. Most importantly, touch screens were not used for response input. Instead, subjects used the computer keyboard. To begin a trial, they touched the space bar and made a response by pressing the appropriately numbered key. Each "window" in the display had a number above it to indicate the appropriate response. Windows always had the same number above them which was their serial order (from the left) in the full set of alternatives. Instructions were written on the computer screen instead of spoken by a voice synthesizer. All subjects were administered the test in a computer laboratory with 30 stations.

Subjects were 860 Air Force enlistees. All subjects had taken the Armed Service Vocational Aptitude Battery (ASVAB) which is a group-administered, written intelligence test. The General composite score is regarded, for present purposes, as an IQ score. It should be noted that, unlike the previous two studies, the ASVAB was not administered concurrently but could have been given as much as a year before the subjects completed the choice reaction time task.

A definite problem with this sample is that it has undergone explicit selection. Almost no person in the sample is below the 40th percentile on national norms and proportionally fewer subjects are included at the high end of the enlistee distribution. Irregularities in the obtained sample were corrected by weighting cases. Explicit selection was corrected for by applying the appropriate correction for restriction in range.

The results from this study are in exact agreement with the last. Multiple regression indicated that combinations of basic parameters correlated between .75 and .85 with the IQ measure when appropriate corrections were applied. In addition, the magnitude of correlations between IQ and the basic parameters remained about the same despite the differences in test and methods of administration.

Taking these three studies together, there is little doubt that it is possible to predict complex measures of human intelligence using basic measures of cognitive functioning. Further, it also is clear that these parameters are at least partially orthogonal measures of separate parts of the human intellectual apparatus. If this were not the case they would not have combined to predict as large a portion of the variance as they did.

Data so far amassed support the contention that intelligence is composed of a number of independent abilities. But to fully support that contention it will be necessary to specify exactly what the independent abilities are and their interrelationships. This research was designed to take the next steps in identifying what the postulated independent abilities are.

Perhaps the simplest way of proceeding would be to use an existing model which specifies the processes involved in each of the tasks used. In fact, the original research was motivated by just such a model (see Detterman, 1982) but empirical findings were not consistent with the model.

There are several reasons that existing models of mental functioning would probably not be adequate to explain data from the research reported above. First, most models have been developed to predict group differences, not individual differences. Some variables which show substantial group differences over levels show no individual differences. Second, models are generally cast in terms that seem too complex to explain performance on any one of the tasks used here. For example, while capacity of working memory may well be an important variable in determining individual differences, there are a number of ways it could affect performance on any particular task. Finally, few models make quantitative predictions about what should happen as the variables in the model are modified.

For these reasons, it is necessary to develop models for the tasks which overcome these problems. A major part of this research was an attempt to develop of models for four of the tasks: Reaction Time (RT), Stimulus Discrimination (SD), Tachistoscopic Threshold (TT), and Probe Recall (PR).

This research project began by attempting to develop explicit models for reaction time. A model initially proposed by Jensen was programmed in Simscript II.5 and was compared to obtained results of past research. What was clear from this effort was that the model was far to vague to be of any use as the inference device originally hoped for. What was needed was a more explicit, broader model if information useful in designing experiments which would provide tests of the model was to be obtained. However, such models require more explicit information than presently available concerning many aspects of these tasks. As one example, if was completely unclear how subjects incorporate instructions into some sort of mental model to allow them to perform the task. It is entirely possible that all of the effects of intelligence on basic cognitive tasks could be due to how well subjects are capable of understanding the instructions presented to them and not at all due to differences in the elementary cognitive processes thought to be operating in the tasks.

Rather than attempt to devise models which were not based in reality, it was decided to attempt to resolve some of the critical issues for each of the four tasks identified as target tasks. To the extent possible, the issues investigated pertained to all of the tasks but in some cases special issues critical to a specific task were investigated. These issues revolved around three main themes: 1) the effect of instructions on basic cognitive tasks, 2) the extent to which response complexity affects performance on cognitive tasks, and, 3) the effects of stimulus and task complexity on performance of basic tasks.

Data collection for the studies summarized below was completed within the last few months. Therefore, data analyses are at a preliminary stage. However, it is already clear that these studies have gone a long way toward answering the some fundamental questions that need answering before basic cognitive tasks can be appropriately modeled. For each study, the basic design of the study is presented followed by a brief discussion of preliminary results.

The Effect of Instructions on Elementary Cognitive Tasks

Purpose. The purpose of the study was to investigate the effect of instructions on four elementary cognitive tasks. Interest was in determining to what extent differences in the degree of learning instructions affected the measurement of individual differences in basic cognitive abilities. Can differences in instructional learning account for differences across ability level in cognitive tasks.

Method. Four-hundred and sixty-six Air Force recruits from Brooks Air Force Base participated in the study. The elementary cognitive tasks were computerized tasks from Detterman's Cognitive Abilities Test (CAT, 1988). The four tasks used in the current study were the target tasks and included the reaction time, stimulus discrimination, tachistoscopic threshold, and probed memory tasks. All recruits completed all four cognitive tasks. Recruits were divided into two instruction conditions. Two-hundred and forty-five recruits received standard written instructions; two-hundred and twenty-one recruits received no instructions. Two subjects had incomplete data and were not included in the current analysis. Instruction conditions were identical in terms of number of practice trials, total number of trials, and feedback for correct or incorrect trials. General intelligence data was available for 238 recruits on the Armed Services Vocational Aptitude Battery (ASVAB).

Results. Both group and individual difference analysis were conducted. Significant differences between instruction and no instruction groups were found for time measures in all four tasks. In the reaction time task, significant effects were found in overall trial time as a function of both decision and movement time. Group differences in performance persisted longer for decision time than for movement time. In the stimulus discrimination task, the no instruction group was more variable than the standard instruction group. These differences were not maintained in the second half of the task. Time measures in the probed memory and tachistoscopic threshold task were affected by instruction and maintained for the entire task. Significant differences between instruction and no instruction conditions were found for number of errors on the stimulus discrimination and tachistoscopic threshold tasks. Differences were not maintained across blocks, however. In general, group differences between instruction versus no instruction conditions decreased with practice, with more significant differences found in the beginning of each task and fewer differences found in the latter part each task though in some cases differences did not disappear.

Conclusions. Patterns of individual differences between the instruction and no instruction conditions varied more with increased task complexity, with greater differences found for more complex tasks such as probed memory and fewer group effects found for the reaction time task. In sum, instructions have a significant effect on both individual and group performance patterns of basic cognitive tasks. Results indicate the importance of isolating the variance due to incidental measures such as instructions on basic cognitive tasks before precise measurements of basic mental processing can be obtained.

The Effect of Response Complexity on Reaction Time

Purpose. The purpose of this study was to examine the effects on reaction time of both response complexity and bits of information.

Method. Two-hundred and thirty-two recruits were tested on the Reaction Time (RT) task from the Detterman (1988) Cognitive Abilities Test. A 4 X 4 X 5 mixed factorial design was used. The between-subject variable was order of complexity levels. The within subject variables were response complexity (RN, RA, RS, RO) and bits of information or set size(1, 2, 4, 6, or 8).

In this task, the subject pressed the home key (space bar) with his finger until a light appeared on the computer screen. Upon the onset of a lit square in one of the response windows on the computer screen, the subject responded in one of four ways. The least complex response required was one where the subject simply removed his finger from the home key upon the onset of a lighted window on the computer screen. The next level of response complexity required the subject to touch either the D or G key on the computer keyboard with the onset of the lighted window. The third level of complexity required the subject to touch the same side of the keyboard as the side of the screen where the signal appeared, the D key if the was on the left and the G key if it was on the right. The highest level of response complexity required the subject to touch one key if the stimulus position was odd (D) and another (G) if it was even. Each subject in each group performed all four levels of complexity, but the order in which the levels of complexity were administered varied according to group.

The number of possible locations (bits of information) where the light signal could appear on the computer screen increased within each level of complexity, from one window, or box on the computer screen, to two potential locations, then to four, six, or eight possible windows in which the signal could occur. There were 24 consecutive trials for each level of the bits-of-information factor.

Results. Results of an analysis of variance indicated large main effects for both the level-of-complexity factor and for the bits-of-information factor. Response time increased as the level of complexity increased. Response time also increased as the bits of information increased. Order of presentation produced a small but significant effect. There were also interactive effects. Response complexity interacted with bits of information such that response time increased more as a function of response complexity as bits of information increased. That is, response complexity had a greater effect on response time when there were more possible windows to which the subject had to attend.

Conclusion. These results indicate that response difficulty not only affects movement time but also affects decision time. This means that response and decision stages of reaction time interact which implies that a simple serial model of reaction time is unrealistic. It also suggests that response characteristics can exert important influences on all stages of information processing and deserve an important position in any model.

The Effects of Response Mode Using Touch Screens and Key Board Response Methods

Purpose. Another way of gauging the importance of response mode on cognitive tasks is by altering input devices. Touch screens were compared to the use of key boards. Key board responding seems much more complex than touch screen responding. On a touch screen, the subject touches the correct stimulus and sees a change occur under his finger. With a keyboard, the subject must continually look at the screen, encode a response, look at the keyboard, translate the screen information to key board equivalent, and then respond on the key board. How do these differences affect performance on cognitive tasks?

Method. Subjects took 6 basic cognitive tasks including the four target tasks using either touch screens or key boards as response input device. All aspects of tasks administered under each condition were identical with the following exceptions: 1) Instructions were modified to reflect input mode. 2) In the key board condition, all response positions on the screen had a number above the position. This number indicated the key which the subject was to press to indicate a response for that position. 3) The space bar on the key board served as the home key for subjects who used the key board.

Results. Although results from this experiment have only been analyzed in a very preliminary way, it would appear that response difficulty has wide ranging effects even for subjects as intelligent as those found in the Air Force.

Conclusion. The obvious conclusion is that response input method has a substantial impact on the measurement of basic cognitive processes. As in the previous studies, this finding suggests that it will be important to account for the effects of response method in models of basic cognitive processes.

Reaction Time and Methodological Issues

Purpose. One suggested but unresolved potential explanation for the relationship between reaction time and intellectual functioning is that methodological factors produce the correlation. Two potential confounds in the usual reaction time procedure are the presentation of 1, 2, 4, 6 and 8 item set blocks in sequential order and the tendency to use successive positions near the center of the screen for active positions. This study tests these potential problems.

Method. The study consisted of a 2 X 2 factorial design varying set size order (random or sequential) and active positions (center of screen or random). All four conditions were presented to all subjects. There were four orders of presentation of conditions. There were 219 subjects tested.

Results. The preliminary results suggest small differences between the four conditions on the order of 3 to 6 msecs. The differences are systematic with the largest effects appearing for the conditions having the smallest set sizes (1 or 2 alternatives). Correlations with IQ do not appear to be greatly affected by the manipulations of this study.

Conclusion. It would appear from preliminary analyses that methodological factors are not responsible for the findings which have been obtained with the reaction time task.

The Relationship Between Perceptual Structure and Individual Differences on the Raven's Progressive Matrix Task

Purpose. The purpose of the study was to demonstrate that intelligence is highly related to the ability to recognize and utilize simple forms of perceptual structure. The role of perceptual structure has been investigated in the past with mixed results. Studies investigating the relationship between individual differences in intelligence and perceptual structure have generally manipulated the role of individual item complexity. The current study holds average item complexity constant while varying the relationship among items. The complexity of individual items is 'intra-stimulus structure'; the structure between items is 'inter-stimulus structure'. It is argued that inter-stimulus structure taps an important ability to encode perceptual information which is highly related to individual differences in intelligence.

Method. The first phase of the study was to develop a computerized progressive matrix task based on the perceptual principles described above. The task measured performance as a function of six levels of perceptual structure across a series of 3 X 3 progressive matrices. Average stimulus complexity of individual items (intra-stimulus structure) in the matrix was held constant across increasing levels of rule complexity. Rule complexity was defined by the structure between items in the matrix (inter-stimulus structure). Research was conducted at Brooks Air Force Base. Subjects were 220 Air Force recruits.

Results. Task reliability and validity were measured. Split-half reliabilities for time and accuracy were .78 and .86, respectively. Validity between the Raven's Advanced Progressive Matrix Task and overall performance on the computerized version of the progressive matrix task was .92. Correlations between the Raven's and the computerized progressive matrix task increased with increasing levels of inter-stimulus structure.

Conclusion. Overall results indicate a strong relationship between the use of perceptual structure and individual differences in performance on the Raven's Advanced Progressive Matrix Task. These results strongly suggest the importance of understanding how subjects encode and process stimulus information for a complete understanding of intelligence. Models of basic cognitive processes must include stimulus processing as important components.

The Role of Stimulus Complexity and Rate in Models of Discrimination

Purpose. This research investigated the influence of stimulus complexity measures and display duration on visual discrimination performance. The intent was to precisely quantify the way in which subjects make comparisons between stimuli. Complexity parameters have been shown to exert substantial influence in tasks similar to Tachistoscopic Threshold (TT). Four measures of complexity were employed: number of turns, subsymmetry, mean Euclidean distance between coordinates, and density differential (the latter measures were developed by us). This research focused on the following research questions.

1) What stimulus factors affect subject's performance on a Same-Different judgement task? Specifically, how do mean Euclidean distance between coordinates and density differential (two measures of stimulus similarity) affect performance on different judgements. How do number of turns and subsymmetry (two measures of stimulus structure) affect performance on same judgements. 2) In what way do stimulus duration and visual masking mediate these effects.

Method. The stimulus population was defined as all 4x4 binary matrix patterns containing 8 squares filled. A constant distribution of individual stimulus items was selected along each of the complexity measures. This was accomplished by searching the total population of 4x4 matrix stimuli for three levels of each measure (< -1.5 , -0.5 · 0.5 , > 1.5). These stimuli were randomly matched to form a large sample of stimulus pairs. These pairs were then sampled to form three distributions of the discriminability measures. In this way two sets of 90 stimuli represented three levels of each of the complexity measures.

Two experiments were conducted. In the first experiment masking was employed while in the second experiment there was no mask. Each task was a modified version of the Tachistoscopic Threshold task with complexity and duration varying along specified levels. There were 180 stimulus pairs presented tachistoscopically for 4 different durations (.03 sec., .08 sec.,.25 sec., .5 sec.). These 180 pairs consisted of 90 same and 90 different pairs varying along 3 levels of 2 complexity measures each. This design resulted in 10 stimuli per cell. In total, each subject made 570 discriminations.

Results. Preliminary data analyses support the finding from similar tasks of a fast-same effect (Farell, 1985). Under conditions of constrained duration the percent correct must be used in assessing this effect. 81% of same pairs were judged correctly, as compared with only 75% of different pairs. For the no mask condition subjects averaged 80% correct discriminations vs. 76.5% for the masked condition. The data for the comparisons along the 2 individual stimulus complexity measures and the 2 discriminability measures is presented below.

T1 (n=98, No Mask) T2 (n=123, Mask)

Number correct same pairs.

Number of Turns

		high	med	low	high	med	low
SS	high	4.51	4.06	4.03	4.11	4.05	3.94
	med	4.58	4.14	3.86	4.29	3.97	3.67
	low	4.37	3.69	3.96	4.39	3.70	3.82

Note: As hypothesized by Ichikawa, the difference between mask/no mask is most clearly delineated when symmetry is an important factor. Given stimuli with little symmetry, processing time is not quite as important.

Mean decision time for same pairs.

Number of Turns

		high	med	low	high	med	low
SS	high	0.30	0.31	0.33	.10	.11	.12
	med	0.30	0.32	0.32	.09	.11	.10
	low	0.31	0.31	0.34	.11	.10	.10

Number correct different pairs.

Mean Euclidean Distance between Coordinates

		high	**med**	low	high	med	low
ADJ	high	3.13	3.86	4.13	2.94	3.62	3.81
	med	3.74	3.79	4.08	3.38	3.79	3.85
	low	3.33	4.24	4.49	3.20	4.03	4.33

Mean decision time for different pairs.

		MDC					
		high	med	low	high	med	low
ADJ	high	0.32	0.31	0.32	.10	.11	.11
	med	0.33	0.33	0.32	.11	.11	.10
	low	0.34	0.32	0.32	.12	.11	.10

Data indicating an advantage for longer durations is shown below.

	Number Correct		Decision Time	
Duration (in secs)	Same	Different	Same	Different
0.03	35.3	32.1	3.9	3.8
0.08	35.5	34.4	3.4	3.5
0.25	37.2	35.7	2.5	2.6
0.50	40.6	36.9	1.5	1.7

Conclusion. Stimulus complexity measures are good predictors of correct responding. This study illustrates the potential for incorporating precise descriptions of stimulus structure into models of basic cognitive processes and for understanding the way subjects process these stimuli.

Probe Memory As A Single or Multiprocess Task

Purpose. The purpose of this study was to assess the ability dimension underlying memory tasks involving both primary memory processing and secondary memory processing. The question being asked was if memory performance on this task could be represented by a single dimension. Knowing this is important information if Item Response Theory is to be applied to this task.

Method. This preliminary analysis sampled more than two hundred forty five Air Force recruits. In the analysis, all variables from the standard probe memory task and variables from three modified probe memory tasks, i.e., P1, P2, P3 were included. In the standard probe memory task, each subject was presented 72 trials. In each trial, 6 different stimuli were serially displayed for one second each and then disappeared from the computer screen. The subject was required to identify the stimulus which was identical to a probe stimulus that appeared after all the 6 stimuli vanished from the screen. In the modified tasks, the number of stimuli to be displayed varied across trials (i.e., from 2 to 6). Level of stimulus complexity also varied with three levels. In the first level, stimuli were all well-organized and formed a "good Gestalt"; on the second level, stimuli were not as well organized, but were still simple by standard complexity indices (e.g., adjacency or symmetry); stimuli on the third level were complex by any criterion. In summary, the experimental task manipulated series length and stimulus complexity parametrically within-subjects. Each subject received all list lengths at all complexity levels.

Two hundred forty five recruits completed all tasks. Since the strongest evidence favoring the dissociation between primary memory processing and secondary memory processing has been obtained from studies involving marked recency and primacy effects, the variables which could demonstrate recency effects and primacy effects were analyzed in this preliminary analysis. All tasks showed marked recency effects both in speed and in accuracy. That is, the subject responded faster and more accurately to probes corresponding to the item in the last position of the presented series. There was a moderate primacy effect on response latency. However, the effect of primacy on response accuracy was not found, perhaps because the stimuli used are less amenable to rehearsal than the verbal stimuli often used in this research.

Results. In a previous analyses, the standard memory task was found to be difficult for high school students. In this analysis the standard task was again more difficult than the modified ones. And the split-half reliability indicated that the modified probe memory tasks were more reliable.

Conclusions. These preliminary results seem to suggest that the probe memory task can be characterized by at least two processes corresponding to primary and secondary memory. More detailed analyses should allow a more precise statement about exactly how these processes can be modeled and their relationship to mental processes.

General Conclusions

This research suggests two general conclusions. First, tasks of basic cognitive processes, sometimes called simple cognitive tasks, are not so simple after all. Attempts to model these tasks in any meaningful way will require substantial effort. Much of what needs to be known to build good models of individual differences in these tasks is not currently known. The research conducted during this grant period was an effort to begin the process of providing the necessary information.

Some of the questions addressed by this research were: How do subjects develop a mental model of instructions about how to perform a task and how does this model affect performance on the task? To what extent is response complexity related to task performance? How does stimulus encoding operate? What aspects of the stimuli used in these tasks are subjects sensitive to. All of these questions must have at least intial answers before useful models of elementary cognitive tasks can be constructed.

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Detterman, D. K. (Ed.). (in press). *Current topics in human intelligence: Vol. 2, Is mind modular or unitary*? Norwood, NJ: Ablex Publishing Corporation.

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Detterman, D. K. (in press). Changing intelligence? [Review of *The raising of intelligence: A selected history of attempts to raise retarded intelligence.*] *American Journal of Mental Retardation.*

Detterman, D. K., & Ramig, P. (submitted). Two disciplines of scientific psychology: A suggested resolution.

Detterman, D. K. (submitted) Factor analytic evidence concerning primacy and recency in short-term memory.

Detterman, D. K., & Daniel, M. H. (submitted). Correlations of mental tests with each other and with cognitive variables are highest for low IQ groups.

Detterman, D. K., & Andrist, C. G. (submitted). The effect of instructions on simple cognitive tasks sensitive to individual differences.

The above description of research provides preliminary results concerning a number of experiments which have been conducted during this grant period. At least four publications are anticipated from these data. The exact titles of these publications (except for the Detterman & Andrist publications listed above) are not yet known and will depend on how final analyses turn out.

Participating Professionals

The following graduate students have participated in this research: Charlotte Andrist, Kate Spry, Luo Dasen, Michael Khana, and Mary Persanyi. Support for participation was from a training grant provided by NICHD.

Interactions

Detterman, D. K. (1988, August). *A systems theory of mental retardation: Evidence in support.* Paper presented at the meeting of the 8th International Association for the Scientific Study of Mental Deficiency, Dublin, Ireland

Detterman, D. K. (1988, November). Invited participant, *Conference on PET applications to intelligence research.* Department of Psychiatry and Human Behavior, University of California, Irvine.

Detterman, D. K. (1989, March). *Differences in correlations between high and low IQ subjects.* Paper presented at a meeting of the Gatlinburg Conference on Research and Theory in Mental Retardation, Gatlinburg, TN.

In addition to the papers presented by the first author, students associated with the program have presented papers at several conferences.

Charlotte Andrist was supported by the University Graduate Alumni fund for travel to Brooks Air Force Base to work on this research project. She provided programming support and served as a research assistant.

Patents and Inventions

There have been no patentable inventions arising from this research.

Information for AFOSR Program Manager

In my opinion, this research program is an extremely cost effective one. For me to accomplish the same amount of research with a grant from NIH would require approximately five times the funds. In addition, I am relieved of many of the headaches often associated with research like the acquisition and maintenance of equipment, procuring space, setting up procedures for handling data, etc. These problems are all handled by Air Force program personnel to whom I am grateful. However, even when their time is figured in, I am sure this program would still be cost effective because it is averaged over a number of grantees and is required for Air Force research even if grantees did not use the resource.

Because large N research will be increasingly important for understanding individual differences, this unique grant program could be increasingly important to the progress of that research effort. It offers a true opportunity to combine the needs of the Air Force with the needs of academic researchers into an alliance that will prove useful to both. I hope that this program will be expanded.