11:46:51 OCA PAD INITIATION - PROJECT HEADER INFORMATION 08/17/88

Active

Project #: G-42-610 Cost share #: Rev #: 0
Center # : R6369-1A0 Center shr #: OCA file #:
Work type : RES
Contract#: 5 R01 AG06826-03 Mod #: Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N
Main project #:

Project unit: PSYCH Unit code: 02.010.154
Project director(s):
SALTHOUSE T A PSYCH

Sponsor/division names: DHHS/PHS/NIH / NATL INSTITUTES OF HEALTH
Sponsor/division codes: 108 / 001

Award period: 880801 to 890731 (performance) 891031 (reports)

Sponsor amount	New this change	Total to date
Contract value	67,794.00	67,794.00
Funded	67,794.00	67,794.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: ADULT AGE DIFFERENCES IN REASONING AND SPATIAL ABILITIES

PROJECT ADMINISTRATION DATA

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Security class (U,C,S,TS) :
ONR resident rep. is ACO (Y/N): N
Defense priority rating :
supplemental sheet
Equipment title vests with: Sponsor GIT X
NO EQUIPMENT MAY BE PURCHASED IN THE LAST 6 MONTHS OF THIS GRANT PERIOD.

Administrative comments -
INITIATION. 3RD YEAR OF GRANT RECOMMENDED FOR 3 YEARS OF SUPPORT.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Date 8/14/89

roject No. G-42-610 Center No. R6369-1A0

roject Director T. A. Salthouse School/Lab Psychology

ponsor DHHS/PHS/NIH

ontract/Grant No. 5 R01 AG06826-03 GTRC XX GIT ___

rime Contract No. N/A

itle Adult Age Differences in Reasoning and Spatial Abilities

ffective Completion Date 7/31/89 (Performance) 10/31/89 (Reports)

loseout Actions Required:

___ None
X Final Invoice or Copy of Last Invoice
X Final Report of Inventions and/or Subcontracts - Patent questionnaire sent to P/I.
X Government Property Inventory & Related Certificate
X Classified Material Certificate
___ Release and Assignment
___ Other ___

ncludes Subproject No(s). ___

ubproject Under Main Project No. ___

ontinues Project No. G-42-632 Continued by Project No. G-42-646

istribution:

x Project Director
x Administrative Network
x Accounting
x Procurement/GTRI Supply Services
x Research Property Management
___ Research Security Services
x Reports Coordinator (OCA)
x GTRC
x Project File
2 Contract Support Division (OCA)
___ Other ___

PROGRESS REPORT

Research conducted during the first 2.5 years of the previous grant has been described in 10 published or in-press articles, and in 4 manuscripts currently under editorial review (see list at the end of this section and copies of articles in the appendix). Twenty-six separate studies have been conducted, involving a total of 1,768 different adults participating for an average of 1.5 hours each. Because most of the studies fit within four broad categories, the major findings in each of these categories will be briefly summarized instead of attempting to describe all the results of every study.

A category concerned exclusively with theoretical issues is represented by one article (5). The focus of this article was the development, and initial examination of the plausibility, of a formal model based on the assumption that age-related differences at elementary levels of processing could have important consequences in both quantitative and qualitative aspects of performance. Although I believe that the arguments in this article were reasonable, they were admittedly quite speculative. As a consequence, there is still a considerable gap between the hypothesized differences in elementary aspects of processing such as rate of propagating activation or the number of simultaneously active units, and observable aspects of cognitive behavior. One of the motivations for focusing on working memory as a primary explanatory construct in the current proposal is a belief that many cognitive phenomena may be easier to interpret in terms of an intermediate-level construct such as working memory.

A second category of completed research consists of attempts to determine the interrelations among age, reasoning and spatial ability measures of cognition, and indices of processing-resource constructs such as rate of processing or capacity of working memory. Five articles (3,6,7,8,10) have employed correlational procedures in attempting to determine the extent to which the age differences in certain measures of cognitive functioning might be attenuated by statistical control (via partial correlation, hierarchical multiple regression, or path analysis procedures) of an index presumed to reflect either processing rate or capacity of working memory. The major finding in these studies, as summarized in a recent review article (8), was that statistical control of various univariate indices of processing speed or memory capacity reduced the correlations between age and performance, but it did not completely eliminate them. Estimates derived from path analysis procedures revealed that age differences in the hypothesized processing resources may be able to account for only between 1/4 to 1/3 of the observed age differences in a variety of cognitive tasks.

Although these results with statistical control procedures have been informative, most of the studies shared two major limitations. One is that the hypothesized resource constructs have been indexed by single variables rather than with multiple indicators which would increase measurement reliability and maximize construct-relevant variance. The second limitation of most of the previous studies is that little attempt has been made to specify the mechanisms by which the hypothesized processing-rate or working-memory resources influence cognitive performance. Without more explicit information about how and why factors such as a slower rate of processing or a less efficiency working memory contribute to lower levels of cognitive functioning, it is difficult to know whether existing measures of the resource constructs, or of reasoning and spatial ability aspects of cognition, have been the most appropriate ones with which to evaluate the magnitude of possible relations between these entities. Both of these weaknesses are addressed in the studies planned in the current proposal by examining several measures of working memory, and attempting to be more precise about the mechanisms by which cognitive performance is dependent on working memory.

Several studies completed in the previous funding period have included various assessments of working memory, and thus together they can be considered to represent a working-memory category of research. The same theoretical definition of working memory - storage of information during concurrent processing of the same or different information - was implicit in all of the studies, but two quite different methods of assessment were employed.

In eight of the articles (1,3,4,6,9,10,12,14) the conventional practice was followed of attempting to measure working memory in tasks specifically designed for the purpose of evaluating memory, which I will term isolated or out-of-context assessment. Because of concerns that processing requirements were relatively uncontrolled in existing procedures for measuring this type of working memory, two new procedures were introduced to assess working memory with verbal/symbolic information and with visual/spatial information. These involved requiring the research participant to solve arithmetic problems while remembering some of the digits in those problems for the *Computational Span* task, and connecting lines while remembering the positions of other lines for the *Line Span* task. In both cases, a minimum level of processing is ensured by measuring storage capacity only when participants have been successful in performing the designated processing operations. The measures in each task have been found to be moderately reliable, and significant age differences favoring young adults have been reported with both the Computational Span Task (4,6,9,10) and the Line Span Task (12). In addition, we (14) have recently found that the correlation between the measures of verbal working memory and spatial working memory is significantly greater than that between primary memory measures involving the same information without the requirement of simultaneous processing. This finding serves to validate the concept of working memory as distinct from primary memory in that it seems to involve a common, or modality-independent, central processor not essential for primary memory functioning.

In five recent studies (9,10,11,12,13), age differences in working memory were assessed with measures derived during the performance of on-going cognitive tasks. These within-context assessments were motivated by the view that it may be more fruitful to attempt to measure working memory by assessing characteristics of the storage of information while research participants are actually engaged in the processing required in specific cognitive tasks. Among the procedures employed for this type of within-context assessment were randomly interspersed probes of the accuracy of recognizing earlier presented information in a spatial integration task (9), and unobtrusive recording of the number of repetitive information requests in a successive version of a cube comparisons task (12). A particularly interesting finding from a recent study (13) was that the pattern of age differences was quite different when recognition memory of exactly the same information was assessed in the context of a spatial integration task, compared to its 'isolated' assessment as a conventional recognition memory task. Consistent with the interpretation that there are age differences in working memory, and that working memory involves storage during concurrent processing, young adults were found to be superior to older adults only with the within-context assessment of working memory.

A number of the earlier studies have attempted to identify the processes used to perform specific tasks, and hence they can be grouped together as comprising an analytical category. Several different cognitive tasks have been investigated, ranging from series completion (4,7), geometric analogies (3,6,7), and verbal integration (10,11) reasoning tasks, to spatial integration (1,6,9,13), block design (2), cube comparisons (12), and paper folding (6,7,10) spatial tasks. The results from such a diverse collection of tasks are necessarily rather complex, but several general patterns can be identified.

One negative outcome is that although age differences in performance were found in most of the tasks, in none of the tasks was there any indication of age differences in performance strategies. This was evident in the similar profiles of subject-controlled processing durations across successive phases of the task in analogical reasoning (3), series completion reasoning (4), spatial integration (9), paper folding (10) and verbal integrative reasoning (10). Young and old adults also did not differ in the sequential pattern of information requests in a special version of a cube comparisons task (12).

A second pattern apparent in many of the analytical studies was the age-complexity effect, or the tendency for the magnitude of the age differences to increase with the complexity of the task. Some of the complexity variations leading to greater performance differences between young and old adults were when decisions involved: more stimulus frames to be integrated (1,6,9), more elements per analogy term (3,6), more abstract relations among series elements (4), more paper-folding folds (6,10), and more premises in verbal integrative reasoning (10,11). No single cause was identified as being responsible for all of these age-complexity effects, but it was speculated that one contributing factor may have been lower-quality internal representations on the part of older adults, which in turn may have been attributable to limitations of working memory. Among the evidence consistent with this interpretation was the finding that the internal representations of older adults apparently incorporated less information than those of young adults about patterns on the hidden faces of blocks used in a block design task (2).

Some of the most informative results concerning the role of working-memory factors in the age-complexity effect were obtained from a recently completed study which has not yet been published (10). Because several of the proposed studies will employ procedures and analytical approaches similar to those of this study, the procedures and major results of that study will be described in some detail. The study involved a total of 120 adults, 20 in each decade from the 20s through the 70s, who each participated in three different tasks. One task was the computational span task described earlier in which participants were asked to remember a series of digits while also solving arithmetic problems involving those digits. With the assessment procedures employed in this study, the computational span had respectable reliability ($r = .78$), and it was found to be negatively correlated with chronological age (i.e., $r = -.46$).

The second task in the study was a verbal integrative reasoning task in which one to four premises describing a relation between two variables were presented, followed by a question concerning the status of one variable given a specified change in another variable. Decision accuracy was examined as a function of the number of premises presented both when all of the premises were relevant to the decision, and when only one of the premises was relevant to the decision. Trials with a single relevant premise are all similar in that the same type of decision is required, involving a question about the status of one variable when the relation between that variable and the causal variable had been described in a single premise, and only the context in which the relevant information is presented changes. Because when only one of the premises is relevant to the decision the integration and decision processes can be assumed to remain constant regardless of the number of premises actually presented, any reduction in decision accuracy when additional premises are presented but only one premise is relevant can presumably be attributed to a loss of necessary information from some type of working memory.

Average accuracy in the reasoning task was negatively related to age ($r = -.53$), as were the slopes of the functions relating decision accuracy to number of presented premises for all trials (r = -.46), and for trials with only one relevant premise (r = -.42). The very similar age trends in the slopes from all trials and from one-relevant trials can be interpreted as indicating that most of the age-related increase in the effects of additional premises (i.e., the complexity effect) is attributable to age-related increases in the loss of relevant information from working memory.

A spatial paper-folding task was the third task performed by participants in this study. Successive displays in the paper-folding task represented a square piece of paper folded from one to four times, the punching of a hole in the folded paper, and a pattern of circles indicating the locations of the punched holes in the unfolded paper. The research participant was asked to decide whether the pattern of holes in the final display was consistent with the pattern that would result from the earlier sequence of folds and punch location.

Because the spatial paper-folding and verbal integrative reasoning tasks were designed to be structurally equivalent, direct analyses of the role of working memory in the paper-folding task were possible in a manner analogous to the reasoning task. That is, memory factors would be implicated if similar effects of the number of presented folds on decision accuracy were evident across all trials, and on trials when only one fold was relevant to the decision.

The results from the paper-folding task were very similar to those from the reasoning task. That is, increased age was associated with lower levels of average accuracy in paper-folding decisions (r = -.53), and, just as with the reasoning task, the complexity effects for all trials and for one-relevant trials were both larger with increased age (i.e., the slopes relating decision accuracy to number of folds had age correlations of -.47 for all trials, and -.45 for one-relevant trials). The comparable age trends with all trials and with one-relevant trials suggests that, as with the reasoning task, much of the age-related increase in the effects of task complexity is apparently attributable to a loss of relevant information from working memory.

One of the most interesting findings in this study was that the complexity slopes from the verbal integrative reasoning and the spatial paper-folding tasks were significantly correlated with one another, both for the values from all trials (r = .63), and for those from one-relevant trials (r = .45). These findings therefore suggest that a similar construct of working memory is involved in the reasoning and spatial tasks, and that increased age is associated with reduced levels of effectiveness in both measures of that construct. Somewhat surprising, however, was the finding that although both the within-context (i.e., one-relevant slopes) and the out-of-context (i.e., computational span) measures of working memory were lower with increased age, the correlations between the two types of measures were not significant. Both of these sets of results will be pursued in the proposed studies because they have important implications for understanding the nature of the relations between age and working memory, and between working memory and cognitive performance.

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PUBLISHED OR IN PRESS

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(3) Salthouse, T.A. (1987). The role of representations in age differences in analogical