

Executive Processes in Individuals with and without Mental Retardation

Research Grant Proposal to the Faculty Development Committee  
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## **I. Project Summary**

I have three goals for my research program this summer. The first is to initiate a new line of research on executive control mechanisms underlying cognitive impairments in mental retardation. I propose to begin the first study in this line this summer. Only a modest amount of funds are necessary to complete this study. The study will compare the performance of 30 young adults with mild mental retardation (IQ range 55 – 70) with that of 30 non-mentally retarded young adults in a hybrid choice, go/no-go reaction time (RT) task. The plan is to conduct the experimental sessions early this summer with the individuals with mental retardation and then, because they have to be matched on chronological age, test the non-mentally retarded participants in late summer and next fall. I have started the process for obtaining formal permission to recruit participants with mental retardation and conduct the study on site at the Lambs Farm facility for adults with developmental disabilities in Libertyville. At the present time I have received informal permission for the study. I have also been working on the feasibility of the study with staff members at Lambs Farm. It is clear there will be enough clients available (within the mild range of mental retardation) and who are likely to volunteer for the study. Space is available (a quiet office) where I can set up the computer and collect the data. I will be meeting with administrators of Lambs Farm in the next few weeks to finalize and secure formal permission for the study. A staff member at Lambs Farm has volunteered to help us recruit participants, schedule them for the experimental sessions, and help us process and analyze the RT and error data. She is an expert in conducting statistical analysis using SPSS and will be a significant member of our research team. I have also been training and working with two Elmhurst students (one senior and one freshman). Both would be able to work on this project this summer if funds are available so that they can reduce the time they spend on their summer jobs. One of these students will run the experimental sessions and then help in the data processing and analysis. The second student will also help collect and process data as well as assist me with the data analyses described below.

The second goal for my research program is to write a research article for publication. This article will be based on one of a series of studies I have conducted that examined event-related brain potentials (ERPs) and visual fixation performance in six-month-old human infants. Data have already been collected and the statistical analyses have been completed. My goal here is to write the article based on this study and submit it in September for publication in the journal *Developmental Neuropsychology*.

The third goal is to conduct the statistical analyses of data for another study in the series of ERP studies of infants. This study was a partial replication and extension of the study mentioned above. Data collection is complete but we need to perform the statistical analyses. The goal here is to complete these analyses this summer and then begin writing a journal article for publication (to be submitted to the journal *Child Development*).

## **II. Narrative**

### **1. Current Situation**

Research in cognitive psychology and cognitive neuroscience has shown an increasing interest in the problem of how neurocognitive mechanisms mediate flexibility in coordinated, purposeful behavior. This concern is with how humans make plans and then follow them in the

face of changing environmental demands and the neural mechanisms that mediate such cognitive processes. These information processing processes are called executive control systems (e.g., see Dejong, 1995; Logan, 1985) and evidence is accumulating that these systems are mediated by neural systems in the prefrontal cortex (e.g., Freeman, 2000; Holroyd, Dien, & Coles, 1998; Miller & Cohen, 2001; Shallace, 1988). Recent work on this problem has also shown that event-related brain potentials (ERPs) provide useful measures of executive control processes (e.g., stimulus evaluation, stimulus-response mapping, preparatory and monitoring processes, error detection, see e.g., Coles, 1989; Fournier, et al., 2000; Gehring, et al., 1993; Holroyd et al., 1998; Low & Miller, 1999; Scheffers & Coles, 2000; Sheffers, et al., 1996; Wascher, et al., 1996).

With the exception of one pilot study conducted for a master's thesis by one of my students several years ago (Jaroszewki, 1997), there have been virtually no studies conducted with individuals with mental retardation that have included ERP measures of executive control mechanisms. Thus there is a significant gap in the literature on mental retardation on neurocognitive executive control processes. My long-term goal is to take advantage of the utility of ERPs for studying cognitive impairments in mental retardation. However, before launching these studies, it will be necessary to develop the appropriate behavioral tasks that can be used in this approach. Therefore, the aim of the present study is to develop these tasks by further pursuing the approach we used in Jaroszewki's (1997) thesis. I plan to pilot test and then determine feasible task parameters (task difficulty, timing and number of trials, stimulus parameters) by studying overt behavioral performance in individuals with mental retardation and non-retarded controls. For the purposes of the present study, the interest in executive processes is in examining their influence on organizing and controlling more elementary cognitive processes used in the performance of a hybrid, choice RT task in individuals with and without mental retardation.

There is a long history of research on the possible cognitive mechanism or mechanisms underlying the impaired performance of individuals with mental retardation (Baumeister, 1997; Berkson, 1993; Brooks, Sperber, & McCauley, 1984). One dominant experimental approach to this problem has been to use a variety of RT tasks to examine processing speed and efficiency in individuals with mental retardation. One of the main assumptions of this approach has been that RT reflects the fundamental biological efficiency of the brain for processing information such that faster and more accurate performance underlies higher levels of general intellectual ability. General support for this contention has been found in studies showing moderate, positive correlations between measures of speed of processing and IQ, even when the participants are within the normal ranges of IQ. Furthermore, the results of RT studies of individuals with mental retardation have clearly established that their performance is slower, more variable, and less accurate than that by individuals without mental retardation (for reviews see Baumeister & Kellas, 1968; Maisto & Baumeister, 1984; Nettelbeck & Brewer, 1981; Nettelbeck & Wilson, 1997; Stanovich, 1978). Nevertheless there is little agreement as to the nature of the specific cognitive deficit or deficits that produce these differences in processing speed.

Theoretical explanations of slower less accurate performance of individuals with mental retardation have ranged from those that have suggested there is a deficit in a global mechanism within the central processing system that affects all aspects of cognitive processing (e.g., a slower central cycle time, Kail, 1992) to those that have attributed slower processing to dysfunctions in a particular cognitive process (e.g., stimulus encoding, central comparison mechanisms, assorted memory process, response selection or execution, or an attentional

mechanism, see Baumeister, 1997; Detterman, 1992; Maisto & Baumeister, 1984; Merrill, 1990; Merrill, McCown, & Kelly, 2001; Nettelbeck & Brewer, 1981; Nettelbeck & Wilson, 1997; Stanovich, 1978). It has become clear in recent years, however, that none of these theoretical views provide a satisfactory or compelling account of the differences in processing speed between individuals with and without mental retardation.

One, and perhaps the most fundamental problem undermining these proposals is what is known as the speed-accuracy trade-off in choice reaction time tasks (see Coles, Smid, Sheffers, & Otten, 1995; Meyer, Osman, Irwin, & Yantis, 1988; Nettelbeck & Wilson, 1997; Pachella, 1974; Wickelgren, 1977). The critical idea here is that it is possible for individuals to trade off accuracy for speed and research has now established that as speed increases, accuracy decreases and vice versa. Furthermore, individual may elect to favor one response strategy over the other. This, of course, undermines interpretations of differences in reaction times between conditions or between groups of subjects such as that found between those with and without mental retardation. One group may have elected to emphasize speed over accuracy while another may have elected to emphasize accuracy over speed. Unfortunately, except for only a few studies by Brewer (Brewer & Nettelbeck, 1979; Brewer & Smith, 1984, 1990), the problem of speed-accuracy trade-off has been largely ignored in the literature on mental retardation (see also Nettelbeck & Brewer, 1981; Nettelbeck & Wilson, 1997). Brewer's studies do suggest, however, that individuals with mental retardation can and do select speed-accuracy trade-off strategies as evidenced by the conditional error functions showing that error rates increase with increases in response speed (decreases in RT). When compared to the conditional error functions of non-retarded controls (of similar chronological ages), their errors rates were substantially higher for all levels of speed and increased more rapidly with increases in speed. These results have been interpreted as reflecting impaired executive functions in individual with mental retardation in that they appear to have greater difficulty in controlling regulatory processes (executive functions).

One specific aim of the currently proposed study is to follow up this work on speed-accuracy trade-offs in choice RT in order to more fully explore the possible role of executive control processes in individuals with mental retardation. This study is designed to provide a more direct tests of the hypothesis by Brewer and others that impaired performance on RT tasks in individuals with mental retardation is a result of an impairment in supervisory executive functions that govern more elementary cognitive processes and influence trial-to-trial task performance. Our approach differs from that by Brewer and colleagues in that we will employ task manipulations designed to influence these execution control processes by testing participants under three different experimental conditions that are expected to influence speed-accuracy trade-off strategies. The task in all three experimental conditions will be a hybrid choice, go/no-go RT task. In the first condition, participants will perform the RT task under neutral speed-accuracy instructions and serve as a baseline condition. A second experimental condition will emphasize, via task instructions and practice, a speed-over-accuracy strategy whereas the third condition will emphasize an accuracy-over-speed strategy. Alternating the second and third conditions (blocks of trials) across the second and third sessions in the present experiment will allow us to examine how well and to what extent individuals with mental retardation are able to alter their control strategies. In addition, we will be able examine within conditions, patterns of RT and errors (e.g., with conditional error functions) which will allow us to determine trial-to-trial fluctuations in control strategies and performance-monitoring functions.

## **2. The Project Plan**

We will pilot the tasks with about five individuals with mental retardation during the first two weeks of the summer. Although the tasks we plan to use have been employed with non-mentally retarded subjects, these specific stimuli and task conditions have not been used with individuals with mental retardation. We used a similar procedure in Jarosweski's (1997) thesis so I am reasonably confident that we will be able to use the tasks as described below. Nevertheless, the specific stimuli and trial-to-trial timing, and amount of necessary practice, need to be pilot tested and fine tuned before we launch the formal study.

**Participants.** There will be two groups of participants. Informed consent will be obtained from each participant prior to their participation in the experiment. The first group will be 30 young adults with mild mental retardation (IQ range 55 – 70). These participants will be residents of Lambs Farm in Libertyville. None of these participants will be receiving drug treatments nor will they have any physical disability that is likely to affect their responding, or have a secondary diagnosis of a psychological or seizure disorder. They will also have normal or corrected-to-normal vision. All participants with mental retardation will be \$5 per hour for their participation (three hours total participation time). This is a relatively standard amount used to compensate individuals with mental retardation for their participation in research studies.

The second (control) group will be 30 young adults without mental retardation. These participants will be of similar chronological age as the participants with mental retardation. Most of the control participants will be Elmhurst College students but because of the expected age range (20 to 35 years of age) of the participants with mental retardation, older volunteers who are not Elmhurst students may have to be recruited. Similar exclusion criteria will be used for the control group, i.e., they will not be receiving drug treatment, and not have a diagnosed psychological or seizure disorder, and have normal or correct-to-normal vision. Participants in the control group will not be paid for their participation.

**Stimuli and Task.** The participants will be seated in front of a computer monitor and response box. They will perform a discrimination task in which one of four visual stimuli will be presented on each trial which will map onto one of four experimental conditions (trials) of a hybrid go/no-go task. The four trial types are: go left, go right, no-go "left" and no-go "right." The stimuli will be similar to those used by Scheffers, et al. (1996) and will consist of an arrow centered in a rectangle. The arrow will indicate which the hand to be used for the response (e.g., arrow pointing right signals a right-hand response) and the orientation of the long side of the rectangle (vertical or horizontal) will indicate whether the participant should respond with a button press by the hand indicated by the direction of the arrow (go stimulus) or withhold their response (no-go stimulus).

All subjects will participate in three sessions with each session lasting up to one hour. Each session will consist of a block of practice or warm-up trials (100) and then 16 blocks of 40 trials per block of experimental trials. Each trial will last approximately 2 seconds and there will be 2-3 minute breaks between successive blocks. Within each block the four trial types will be presented randomly but with equal probability. Thus within each block of trials, 20 will be "right-hand" trials and 20 "left-hand" trials with one half of each of these go trials and the remaining half no-go trials. The first session will be the neutral speed-accuracy condition and the last two sessions will consist of, following practice trials, 8 blocks of the speed condition and 8 blocks of the accuracy condition. The order of presentation of the speed and accuracy conditions will be random within a subject.

This study will have a significant impact on my research program. It will allow me to pursue a line of research that has been long in planning but waiting for the appropriate opportunity. One of the greatest obstacles to pursuing this type of research is securing the cooperation of individuals and institutions so that sufficient numbers of participants with mental retardation are available and willing to participate in research. I now have the opportunity. This line of research will allow me to pursue and develop my interests in cognitive neuroscience. This summer's work on my previously conducted research will allow me to publish results of these studies. In addition, these projects will allow me to further train and collaborate with two Elmhurst students. Both started working with me this semester and are eager to continue. I believe this summer's research activities will provide an invaluable educational experience for both of them.

### **3. Faculty Expertise**

I believe I am more than qualified for the projects that I plan to pursue this summer. Beginning with my graduate school training and then my post-docs and subsequent research career, I have been involved projects during the past 22 years of the type I will be conducting this summer. I have a reasonable number of publications in these areas and have previously secured internal and external grant support for these research activities. I have been the editor and co-editor for a five-volume series on psychophysiology that included scholarly publications on research related to my own work. Although they have not appeared in past three years, I have provide a partial list of my related publications in Appendix A. Finally I would note that over the years I have also served as a reviewer for journal articles in psychophysiology and mental retardation supervised graduate student thesis research in these areas.

### **4. Plans for Evaluation and Dissemination**

I plan to share the outcome of these research projects to the college community through presentations to the faculty and students as the opportunity arises.

The ultimate evaluation of this summer's projects will be when the research articles are reviewed for publication and conference presentations. I plan to submit the results of the study of the participants with mental retardation for a presentation at next spring's Gatlinburg Conference on Mental Retardation and Developmental Disabilities. This is main professional conference for basic research in mental retardation. I will also submit a journal article to the American Journal on Mental Retardation which is the best research journal in this field with a national and international audience. Finally, I plan to use the results of this study as a basis for an external grant proposal to NIH to more fully fund the follow up studies using ERPs in conjunction with the performance measures.

As I noted above, the article on my infant work will be submitted to the journal *Developmental Neuropsychology*. I plan to submit the article based on the analyses we conduct this summer to the journal *Child Development* as well as present it at the meeting of the Midwestern Psychological Association in May of 2003.

### **III. Time Line**

I have just completed writing a program for the tasks to be used in the study of individual with mental retardation. We will be testing it (mostly on ourselves and anybody else we can get to volunteer) for bugs and possible problems during the next few weeks. The plan is to have it ready so we can begin at Lambs Farm in June. We will spend the first two weeks of project pilot testing with individuals with mental retardation and making the final adjustments to our protocol. Once the formal study begins we should be able to test five-seven participants with mental retardation per week and complete the data collection protocol within the next six weeks (by the end of July). During the month of August and early in the Fall Semester we will complete the data collection with the control participants and data analyses for both groups.

Throughout the summer (including the month of August) I will be writing the manuscript on the infant-ERP study and analyzing the data, with the Elmhurst student, for the second infant-ERP study. Although this is a relatively ambitious plan, it will be possible if I am able to hire the two Elmhurst students.

### **IV. Budget**

Faculty Salary	\$1,000
Subject Costs	\$ 600
Undergraduate student salary	\$ 900
Undergraduate student salary (\$10/hr, 20 hrs/wk, 8 wks)	\$ 600
Supplies, Xeroxing, Printer cartridges, Diskettes	\$ 100
Travel to conference for presentation	<u>\$ 300</u>
Total	\$3,500

I am only requesting a partial summer salary because I requested a summer course so that I will only be able to work part-time on the projects during the months of June and July but fulltime during the month of August. At the time I requested the summer course I didn't know that this grant program existed. If I had, I wouldn't have requested the course. It is a new course here (Mind, Brain, and Behavior) but one that I have taught many time before so I believe it shouldn't interfere with this summer's research program. We are not certain that enough students will register for the course and it may be cancelled. The study with mentally retarded participants simply cannot be done without the help of the two undergraduate students. They will be working 12-15 hours a week during June and July.

### **V. Current and Previous Grants**

1995-1996	Information Processing and Cognitive-Related ERPs in Infants. Campus Research Board, University of Illinois at Chicago, \$15,000
1989-1994	Information Processing and Long-Latency ERPs in Infants. NIH-NICHD, \$330,294.00
1988	Cognitive-Related ERPs of the Brain in Young Down Syndrome Children Center for Research in Mental Retardation, Little City Foundation, \$7,500

## **VI. Publications**

My only publication in the last three years is the book:

Ackles, P. K., & Conley, P. R. (2000). *Testbank to accompany R. J. Sternberg's: In search of the human mind (3<sup>rd</sup> ed.)*. Fort Worth: Harcourt Brace College Publishers.

I have included a partial list to some of my prior publications related to the projects in this proposal in Appendix A.

## **Appendix A: Related Publications**

- Ackles, P. K., & Cook, K. G. (1998). Stimulus probability and event-related potentials of the brain in six-month-old infants: A parametric study. *International Journal of psychophysiology*, 29, 115-143.
- Ackles, P. K., & Karrer, R. (1991). A critique of the Dannemiller and Banks (1983) neuronal fatigue (selective adaptation) hypothesis of infant habituation. *Merrill-Palmer Quarterly*, 37, 325-334.
- Karrer, R., & Ackles, P. K. (1990). ERP evidence for expectancy in six-month-old infants. In C. H. M. Brunia, A. W. K. Gaillard, & A. Kok (Eds.), *Psychophysiological Brain Research (Vol. 2, pp. 157-160)*. Tilburg: Tilburg University Press.
- Karrer, R., & Ackles, P. K. (1988). Brain organization and perceptual/cognitive development in normal and Down syndrome infants: A research program. In P. Vietze and H. G. Vaughan, Jr. (Eds.), *Early identification of infants with developmental disabilities (pp. 210-234)*. New York: Guilford Press.
- Karrer, R., & Ackles, P. K. (1987). Visual event-related potentials of infants during a modified oddball procedure. In R. Johnson, J. W. Rohrbaugh, & R. Parsuraman (Eds.), *Current trends in event-related potential research (EEG Suppl. 40, pp. 603-608)*. Amsterdam: Elsevier.
- Yokoham, K., Jennings, J. R., Ackles, P. K., Hood, P., & Boller, F. (1987). Lack of heart rate changes during an attention-demanding task after right hemisphere lesions. *Neurology*, 37, 624-630.
- Porges, S. W., Ackles, P. K., & Truax, S. R. (1983). Psychophysiological measurement: Methodological constraints. In A. Gale & J. Edwards (Eds.), *Physiological correlates of human behavior: Volume 1: Basic Issues (pp. 219-240)*. London: Academic Press.
- Zimmermann, R. R., Schroll, E., Ackles, P. K., Barrett, R. P., & Auster, M. (1978). Performance of institutional retardates on new and standard forms of the Quick Test. *Perceptual and Motor Skills*, 46, 325-333.

## **Book Series**

- Ackles, P. K., Jennings, J. R., & Coles, M. G. H. (Eds.). (1985, 1987, 1988). *Advances in psychophysiology (Volumes 1-3)*. Greenwich, CT: JAI Press.
- Jennings, J., R., Ackles, P. K., & Coles, M. G. H. (Eds.) (1991, 1994). *Advances in psychophysiology (Volumes 4 and 5)*. Greenwich, CT: JAI Press.

## **Appendix B: References for Narrative**

- Baumeister, A. A. (1997). Behavioral research: boom or bust? In W. E. MacLean (Ed.), *Ellis' handbook of mental deficiency, psychological theory, and research* (pp. 3-45). Mahwah, NJ: Erlbaum.
- Baumeister, A. A., & Kellas, G. (1968). Reaction time and mental retardation. In N. R. Ellis (Ed.), *International Review of Research in Mental Retardation (Vol. 3, pp. 163-193)*. New York: Academic Press.
- Berkson, G. (1993). *Children with handicaps: A review of behavioral research*. Hillsdale, NJ: Erlbaum.
- Brewer, N., & Smith, G. A. (1984). How normal and retarded individuals monitor and regulate speed and accuracy of responding in serial choice tasks. *Journal of Experimental Psychology: General*, 118, 71-93.
- Brewer, N., & Smith, G. A. (1990). Processing speed: Influence of speed and-accuracy regulation. *Memory & Cognition*, 18, 443-450.
- Brooks, P. H., Sperber, P. H., & McCauley, C. (Eds.). (1984). *Learning and cognition in the mentally retarded*. Hillsdale, NJ: Erlbaum.
- Coles, M. G. H. (1989). Modern mind-brain reading: Psychophysiology, physiology, and cognition. *Psychophysiology*, 26, 251-269.
- Coles, M. G. H., Smid, H. G. O. M., Scheffers, M. K., & Otten, L. J. (1995). Mental chronometry and the study of information processing. In M. D. Rugg & M. G. H. Coles (Eds.), *Electrophysiology of mind: Event-related brain potentials and cognition (pp. 88-131)*. Oxford: Oxford University Press.
- DeJong, R. (1995). The role of preparation in overlapping task performance. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 48A, 2-25.
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- Fournier, L. R., Scheffers, M. K., Coles, M. G. H., Adamson, A., & Abad, E. V. (2000). When complexity helps: an electrophysiological analysis of multiple feature benefits in object perception. *Acta Psychologica*, 104, 119-142.
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- Jaroszewski, K. A. (1997). *Cognitive and motivational aspects of performance in individuals with and without mental retardation*. Unpublished master's thesis. University of Illinois at Chicago.
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