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Psychomotor and Perceptual Abilities and Skilled Performance

F49620-96-1-0065

FINAL REPORT
(Period 2/14/96 - 12/15/97)

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Summary

The research in this project is aimed at three broad approaches to development and assessment of psychomotor and perceptual speed ability predictors of skilled performance: The first approach takes advantage of computerized touch-panel devices for assessment of a series of psychomotor abilities; The second approach links individual differences in psychomotor abilities with perceptual speed abilities, which have been shown to be important predictors of the acquisition of skilled performance. The third approach evaluates the new test batteries for predicting individual differences in complex task performance. The program of research is proceeding on-schedule, in that the touchpanel technology has been acquired, seven new families of psychomotor tests have been developed and subjected to empirical assessment, and perceptual speed tests have been developed and incorporated into a larger aptitude/ability framework. The new tests show substantial promise in accounting for important sources of performance variance, and are currently being subjected to validation trials for complex task performance criteria.

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I. Introduction

The research in this project is aimed at three broad approaches to development and assessment of psychomotor and perceptual speed ability predictors of skilled performance: The first approach takes advantage of computerized touch-panel devices for assessment of a series of psychomotor abilities; The second approach links individual differences in psychomotor abilities with perceptual speed abilities, which have been shown to be important predictors of the acquisition of skilled performance. The third approach evaluates the new test batteries for predicting individual differences in complex task performance. The goal of this work is to demonstrate the feasibility of using new technology for assessment of psychomotor abilities, to provide an integrated approach with perceptual and cognitive abilities, and to demonstrate the validity of new measures of psychomotor and perceptual speed abilities for prediction of complex task performance. Potential applications from this work will be in enhancing prediction of human performance in complex skill situations.

II. Current Research

Part 1: Assessment of Psychomotor Abilities with touch panel technology.

This part of the project involves the use of general purpose desktop computers and touch-panel displays to generate a software suite that assesses individual differences in psychomotor skills and aptitudes. To date, we have developed and collected data on the following seven test types: (a) Tapping Speed and Fitts' Law, (b) Choice Reaction Time (RT) and Simple RT, (c) Serial Reaction Time, (d) Maze Tracing, (e) Mirror Tracing, (f) Maze Pursuit, and (g) Rotary Pursuit. The tests have the advantage of ameliorating the four main obstacles that have historically prevented wide-spread use of psychomotor testing, namely: (a) Fabrication costs (this project involves off-the shelf equipment); (b) Calibration requirements (the new technology requires minimal time and effort for calibration); (c) Examiner training (minimal training of examiners is required, given the simplicity of operation and limited needs for adjustment and maintenance); and (d) Low examiner-to-examinee ratios (because the systems are highly self-contained, and include on-board intelligence for upkeep). The test battery has been fully developed and is currently being subjected to several empirical studies to demonstrate reliability, and validity (e.g., correlations with other psychomotor ability assessments).

Part 2: Integration of perceptual speed and psychomotor abilities.

Our current and previous AFOSR projects have involved an extensive investigation of perceptual speed abilities, including the development of a taxonomic representation of these domains. In several studies it has become clear that tests of complex perceptual speed abilities are important predictors of individual differences in learning and skilled performance. From a theoretical perspective, these investigations are important because they shed light on a domain of human abilities that is not well-understood. From a practical perspective, this work has demonstrated that substantial gains in the prediction of training success and performance can be accomplished by the proper selection of appropriate perceptual speed measures. For example, we have demonstrated that two measures in

particular (a variation of the old Army Air Force Dial Reading Test, and an FAA-inspired Directional Headings Test) provide substantial incremental validity in predicting performance of air traffic controllers, both in the laboratory and in the field. Moreover, our empirical work (Ackerman & Kanfer, 1993; Ackerman, Kanfer, & Goff, 1995) has shown that complex perceptual speed tests also capture aspects of personality and self-regulatory processes that may interfere with training success on complex skill tasks.

To date, we have developed and validated a large battery of paper and pencil perceptual speed tests. In a series of investigations, we have validated several aspects of the proposed taxonomy of perceptual speed. Specifically, we have determined there are, for most practical intents and purposes, three major factors of Perceptual Speed (PS) ability: PS-Scanning, PS-Pattern Recognition, and PS-Memory (Ackerman & Rolfhus, 1996; see also Ackerman & Cianciolo [1998, "Psychomotor abilities via touchpanel testing: Measurement innovations, construct, and criterion validity." Manuscript under review]). By integrating these measures with the new touchpanel psychomotor ability tests, we have started building a broad network of ability constructs, that includes cognitive, perceptual speed, and psychomotor abilities -- all clearly relevant in one way or another to predicting individual differences in skilled performance.

Part 3: Validation of Psychomotor and Perceptual Speed Abilities for Complex Task Performance

This final phase of the research project is under way, under the new grant to Georgia Institute of Technology. We continue our research and development efforts on the touch-panel psychomotor tests, and will be validating them, along with the perceptual speed ability measures against complex task performance.

III. General Discussion

This is clearly an ongoing project, and this "final report" represents an interim description, roughly two-thirds of the way into the program. In the larger context of the University of Minnesota and Georgia Institute of Technology grants, we are on-schedule and on-budget for completing the entire project described in the respective proposals.

Moreover, we have also obtained data from a sample of School of Dentistry students, including criterion training performance measures. This is particularly noteworthy, because operative dentistry is a psychomotor-intensive work environment, and as such, provides a directly relevant criterion against which to compare our new touch-panel tests. We have nearly completed data analyses on this project, but the results are very encouraging. Specifically, we have demonstrated significant incremental validity with our touchpanel tests in predicting individual differences in operative dentistry skills (over and above a traditional standardized cognitive and spatial ability battery, and a tailored spatial and perceptual speed ability battery). Such results, taken together with the other data we have collected so far, suggest that this new approach is promising for both theoretical and application purposes. Additional information will be presented in the final report at the end of 1998.

IV. Publications during the grant period

- Ackerman, P. L. (1996). A theory of adult intellectual development: process, personality, interests, and knowledge. *Intelligence*, 22, 229-259.
- Ackerman, P. L. (1996). Knowledge structures: Successive glimpses of an elusive theory of adult intelligence. In D. K. Detterman (Ed.) *Current Topics in Human Intelligence; Volume 5*, pp. 105-111. Norwood, NJ: Ablex.
- Ackerman, P. L. (1996). *Adult Intelligence*. ERIC/AE Digest Series EDO-TM-96-03. Washington, DC: Catholic University/U.S. Department of Education.
- Ackerman, P. L. (1996). Intelligence as process and knowledge: An integration for adult development and application. In W. A. Rogers, A. D. Fisk, & N. Walker (Eds.) *Aging and Skilled Performance: Advances in Theory and Applications* (pp. 139-156). Mahwah, NJ: Erlbaum.
- Goska, R. E., & Ackerman, P. L. (1996). An aptitude-treatment interaction approach to transfer within training. *Journal of Educational Psychology*, 88, 249-259.
- Kanfer, R., & Ackerman, P. L. (1996). A self-regulatory skills perspective to reducing cognitive interference. In I. G. Sarason, B. R. Sarason, & G. R. Pierce (Eds.), *Cognitive interference: Theories, methods, and findings* (pp. 153-171). Mahwah, NJ: Erlbaum.
- Kanfer, R., Ackerman, P. L., & Heggstad, E. D. (1996). Motivational skills & self-regulation for learning: A trait perspective. *Learning and Individual Differences*, 8, 185-209.
- Murtha, T. C., Kanfer, R., & Ackerman, P. L. (1996). Towards an interactionist taxonomy of personality and situations: An integrative situational-dispositional representation of personality traits. *Journal of Personality and Social Psychology*, 71, 193-207.
- Rolfhus, E. L., & Ackerman, P. L. (1996). Self-report knowledge: At the crossroads of ability, interest, and personality. *Journal of Educational Psychology*, 88, 174-188.
- Schneider, R. J., Ackerman, P. L., & Kanfer, R. (1996). To "act wisely in human relations:" Exploring the dimensions of social competence. *Personality and Individual Differences*, 21, 469-481.
- Ackerman, P. L., & Heggstad, E. D. (1997). Intelligence, personality, and interests: Evidence for overlapping traits. *Psychological Bulletin*, 121, 219-245.
- Ackerman, P. L. (1997). Personality, self-concept, interests, and intelligence: Which construct doesn't fit? *Journal of Personality*, 65(2), 171-204.
- Ackerman, P. L. (1997). What's intelligence got to do with it? A review of E. Hunt (1995). *Will we be smart enough: A cognitive task analysis of the coming workplace*. *Contemporary Psychology*, 42, 692-695.

- Ackerman, P. L. (1998). Adult intelligence: Sketch of a theory and applications to learning & education, pp. 143-156. In M. C. Smith & T. Pourchot (Eds.) *Adult learning and development: Perspectives from educational psychology*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Ackerman, P. L. (In press). Traits and knowledge as determinants of learning and individual differences: Putting it all together. Chapter to appear in P. L. Ackerman, P. C. Kyllonen, & R. D. Roberts (Editors), *The Future of Learning and Individual Differences Research: Processes, Traits, and Content*. Washington, DC: American Psychological Association.
- Ackerman, P. L. (In press). *Aptitude Tests*. To appear in A. E. Kazdin (Ed.) *Encyclopedia of Psychology*. Washington, DC/New York, NY: American Psychological Association/Oxford University Press

V. Presentations during the grant period

- Ackerman, P. L. (1996, March). *Intelligence, personality, interests, and knowledge: Overlapping traits and a theory of adult intellectual development*. Invited colloquium presented at the Department of Psychology, University of Washington: Seattle, Washington.
- Ackerman, P. L. (1996, June). *Personality and the attitude of the learner*. Invited address presented to General Motors Research/Hughes Training workshop "The Future of Learning." Arlington, Texas.
- Ackerman, P. L. (1996, August). *Psychomotor/perceptual speed abilities: New measurement techniques and trait overlap*. Symposium paper presented at the 1996 annual meeting of the American Psychological Association. Toronto, Canada.
- Ackerman, P. L. (1996, August). *Theory of adult intellectual development: Process, personality, interests, and knowledge*. Symposium paper presented at the 1996 annual meeting of the American Psychological Association. Toronto, Canada.
- Ackerman, P. L., & Rolfhus, E. L. (1996, November). *A Taxonomic Study of Perceptual Speed Abilities*. Paper presented at the 1996 annual meeting of the Psychonomic Society. Chicago, IL.
- Ackerman, P. L. (1997, January). *Trait complexes, adult intellectual development, and knowledge structures*. Invited colloquium presented to the School of Psychology, Georgia Institute of Technology: Atlanta, Georgia.
- Rolfhus, E. L., & Ackerman, P. L. (1997, March). *Knowledge structures and traits: Aptitudes, interests, and personality*. Symposium paper presented at the 1997 annual meeting of the American Educational Research Association. Chicago, IL.
- Ackerman, P. L. & Kanfer, R. (1997, May). *Trait approaches to adult development and performance*. Joint Invited Address (with R. Kanfer) presented to the annual American Psychological Society convention, Washington, DC.

- Ackerman, P. L. (1997, July). *Trait complexes, adult intellectual development, and Knowledge structures*. Symposium paper presented at the International Society for the Study of Individual Differences convention, Aarhus, Denmark.
- Ackerman, P. L. (1997, July). *Personality, self-concept, interests, and intelligence: Which construct doesn't fit?* Invited Symposium paper presented at the International Society for the Study of Individual Differences convention, Aarhus, Denmark.