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Cognitive/Self-Regulatory Aptitudes and Instructional Methods for Complex Skill Learning

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Summary

The research described in the proposal has continued on-track, and on-schedule. To date three major studies have been completed, and are in various phases of write-up and submission for publication. The studies are: (1) Validation of a theoretical taxonomy of perceptual speed abilities; (2) A study of part-task training and aptitude-treatment interactions in transfer of training; and (3) A study of the ability and self-regulatory aptitude components of asymptotic skills. In addition (in collaboration with Dr. Dan Woltz), completion work is taking place on the ability and volitional components of knowledge acquisition in an associative memory/substitution task. No significant impediments to the progress of the project have been encountered.

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Research Objectives

The research plans for this project generalize a theory for ability and self-regulatory process interactions during skill acquisition (Ackerman, 1988, 1990, 1992; Ackerman & Kanfer, 1993; Kanfer, 1990; Kanfer & Ackerman, 1987) across a wide spectrum of task components, in order to model the dynamic relations between individual differences in cognitive and self-regulatory aptitudes and individual differences in complex learning/skill acquisition. Specific objectives of the research program are to: (1) Empirically validate a theoretical taxonomy of perceptual speed abilities (given that perceptual speed abilities have been recently implicated as critical predictors of complex skill acquisition); (2) Extend and test a theory that predicts interactions between *cognitive aptitude and self-regulatory aptitude components* (such as spatial rotation and perception of figural units in the cognitive domain, and emotion control/motivation control in the self-regulatory domain) and *task components* (such as memory demands, or proceduralization) for complex tasks; (3) Test the integrated theoretical framework in a series of experiments that focus on intelligent instructional/training procedures for the acquisition of air traffic controller skills.

Status of Research

Series 1. Perceptual Speed Abilities

The first large scale study has been completed -- it set out to test the taxonomic theory of perceptual speed abilities described in the proposal. Fourteen new tests of Perceptual Speed ability were created, and multiple (practice) versions of the tests were administered to 110 subjects in a ten-hour experiment across three sessions. The new tests represent a crossing of item content and consistency facets, as proposed by the theory. In addition, a reference battery of ability tests was administered, including multiple measures of psychomotor abilities, verbal abilities, numerical abilities, and spatial abilities. These tests allow us to put the results into a larger framework of cognitive and intellectual abilities. Although the final data analyses are still underway, the results have generally agreed with the theory, while providing evidence for several task dimensions that have overlapping ability demands. We hope to have this work written-up for publication in the next six months.

Series 2. Individual Differences in Asymptotic Skills and Skill Retention

In the first study for this series, asymptotic skill acquisition was studied in a large-scale study, using the Kanfer-Ackerman Air Traffic Controller (ATC) Task as the target skill. The experiment contained a comprehensive battery of ability, motivation, and self-regulation measures, in addition to a supplemental battery of self-concept, personality, interest, and knowledge structures -- in order to triangulate the individual differences determinants of initial, intermediate, and asymptotic skilled performance. Data from nearly 200 subjects have now been collected, and data analysis is proceeding. Initial results indicate that we have indeed provided sufficient practice on the ATC task, and that the data will

provide a decisive test of the theoretical predictions of ability-performance, and self-regulation - performance relations. Because data collection has only recently been completed, no additional detail on the results is currently available.

Series 3. Interactions between Component Aptitudes and Task Components

In the first study for this series, two experiments were conducted, and are now being prepared for publication. The investigation serves as a test of the Ackerman (1990) approach by making use of a complex procedural transfer task and training conditions that differ in terms of distance of transfer, underlying ability determinants, and nature of transferred knowledge. Two experiments were conducted with a combined total of 233 college students. Experiment 1 examined the effects of a length of pre-task training manipulation on the relationship between general reasoning ability and transfer task performance and the amount of transfer were evaluated. Experiment 2 evaluated the effects of two training tasks that differed in terms of similarity to the transfer task on general reasoning-performance relationships and the amount of transfer. The results provide support for the extensions of Ackerman's (1988) theory of underlying ability determinants of skill acquisition (Ackerman, 1990). This work will be submitted to the *Journal of Educational Psychology* within the next two months.

Finally, in collaboration with Dr. Dan Woltz (University of Utah), we have nearly completed revision for publication (in the *Journal of Educational Psychology*) of the series of studies that investigated how cognitive abilities, learning task characteristics, motivational and volitional processes combine to explain individual differences in performance and learning (this work was started during a project previously supported by AFOSR and Project LAMP). We studied a substitution task over practice and discovered that subjects used two different strategies: a learning strategy where subjects focused on memorization, and a performance strategy where subjects persisted in scanning the items. We conducted five experiments to investigate the ability and motivational correlates of task performance in general, and strategy differences in particular. Experiment 1 demonstrated ability correlates of performance and strategy use. Experiment 2 showed that reducing task difficulty increased subjects' use of the learning/memory retrieval strategy. However, ability differences and stimulus characteristics were not the only determinants of strategy use under difficult task conditions. By inserting periodic memory tests (Experiment 3), we increased subjects' effective reliance on the learning/memory strategy and lowered task performance correlations with reasoning ability. Finally, a combination of self-focus and goal-setting interventions increased general performance levels and use of the learning/memory strategy (Experiments 4 and 5). In the manuscript, we discussed these results, the multifaceted research strategy employed, and specific data analysis methods in terms of the general goal of developing a more comprehensive understanding of learner differences.

Technical Information

Publications published, in press, or in planning

Ackerman, P. L., & Kanfer, R. (1993). Integrating laboratory and field study for improving selection: Development of a battery for predicting air traffic controller success. *Journal of Applied Psychology*, 78, 413-432.

Kanfer, R. (1993). Education from a workplace perspective: Issues of self-management. Resources in Education ERIC Document Reproduction Service No. 348-717.

Ackerman, P. L., & Goff, M. (1994) Typical intellectual engagement and personality: Reply to Rocklin (1994). *Journal of Educational Psychology*, 86, 150-153.

Ackerman, P. L. (In press). Intelligence, attention, and learning: Maximal and typical performance. Chapter to appear in D. K. Detterman (Ed.) *Current Topics in Human Intelligence; Volume 4: Theories of Intelligence*. Norwood, NJ: Ablex.

Ackerman, P. L. (In press). Knowledge Structures: Successive Glimpses of an Elusive Theory of Adult Intelligence. Chapter to appear in D. K. Detterman (Ed.) *Current Topics in Human Intelligence; Volume 5*. Norwood, NJ: Ablex.

Ackerman, P. L. (In press). Learning, skill, and transfer. In R. J. Sternberg, S. J. Ceci, J. Horn, E. Hunt, J. D. Matarazzo, S. Scarr (Eds.) *Encyclopedia of Intelligence*. New York: Macmillan.

Kanfer, R., Ackerman, P. L., Murtha, T. C., Dugdale, B., & Nelson, L. (In press). Goal Setting, Conditions of Practice, and Task Performance: A Resource Allocation Perspective. To appear in *Journal of Applied Psychology*.

Kanfer, R., Ackerman, P. L., Murtha, T., & Goff, M. (In press). Personality and intelligence in industrial and organizational psychology. To appear in D. H. Saklofske & M. Zeidner (Eds.), *International Handbook of Personality and Intelligence*. Plenum.

Ackerman, P. L. (Under revision for re-review). Knowledge structures: A new framework for adult intelligence. Submitted to *Current Directions in Psychological Science*.

Ackerman, P. L., & Woltz, D.J. (Revision under review). Determinants of learning and performance in an associative memory/substitution task: Task constraints, individual differences, and volition. Submitted to *Journal of Educational Psychology*. (3/94)

Ackerman, P. L., & Goska, R. (in preparation). Performance: Acquisition, Maintenance, & Evaluation. To appear in E. C. Carterette & M. P. Friedman (Eds). *Handbook of Perception and Cognition Vol 17. Human Performance and Ergonomics: Cognitive & Perceptual Principles*. New York: Academic Press

Kanfer, R., & McCombs, B. L. (in preparation). Motivational issues in training. To appear in S. Tobias & H. F. O'Neil (Eds.) *Handbook on Training*.

Participating Professionals

Phillip L. Ackerman, Ph.D., Principal Investigator

Ruth Kanfer, Ph.D., Senior Investigator

Maynard Goff, M. A., Research Assistant

Robert E. Goska, M.A., Research Assistant

[M.A. Degree in Psychology, awarded 1994, thesis title "An aptitude-treatment interaction approach to transfer: A test of Ackerman (1990)"]

Todd C. Murtha, M.A., Research Assistant

[M.A. Degree in Psychology, awarded 1994, thesis title "Towards a taxonomy of psychological situations"]

Eric Rolffhus, Research Assistant

Interactions

Ackerman, P. L. (1993, June). *Cognitive and Perceptual Speed Ability Determinants of Complex Skill Acquisition*. Invited address presented at the 1993 meetings of the North American Society for the Psychology of Sport and Physical Activity, Brainerd, MN.

Ackerman, P. L. (1993, August). *Individual differences in skill acquisition: From basic to applied psychology*. Invited "Distinguished Scientific Award for Early Career Contribution to Psychology" address presented at the 1993 annual meeting of the American Psychological Association, Toronto, Canada.

Ackerman, P. L. (1993, August). *The future of computerized aptitude testing: "Back to Binet" or "On to Nintendo?"* Symposium paper presented at the 1993 annual meeting of the American Psychological Association, Toronto, Canada.

Schmidt-Nielsen, A., & Ackerman, P. L. (1993, October). *Acquiring computer skills: Individual differences in style and ability*. Paper presented at the 1993 annual meeting of the Human Factors and Ergonomics Society. Seattle, WA.

Ackerman, P. L. (1994, January) Participant at the Intelligent Teaching Initiative Meeting at U.S. Air Force Armstrong Laboratory (AL/HRTI), Brooks AFB and Lackland AFB, San Antonio, TX. Met with various U.S.A.F. personnel and contractors regarding merging of psychological and artificial intelligence approaches to technology for intelligent instruction.

Also, P. L. Ackerman participated in meetings with a variety of U.S.A.F. personnel at Armstrong Laboratory, including Dr. Malcolm Ree, Dr. Patrick Kyllonen, Dr. William Tirre, Dr. Scott Chaiken, and others, regarding ongoing and future collaborations.

Ackerman, P. L. (1994, February). *The Kanfer-Ackerman Air Traffic Controller Task: A program and database for the investigation of Artificial Intelligence/Hybrid Learning Architecture modeling*. Invited address presented at the ONR/NRL workshop on Hybrid Learning Architecture, Washington, DC.

Ackerman, P. L. (1994, February). *Learning and performance: Integrating cognitive abilities, task characteristics and motivational/volitional processes*. Invited colloquium presented to the Center for Research in Learning, Perception, and Cognition. University of Minnesota.

Ackerman, P. L. (1994, March). *Cognitive abilities and skill learning: A framework for selection, intervention, and the study of intellect*. Invited address presented to the Department of Management and Organizations, University of Iowa, Iowa City, IA.

Kanfer, R. (1994, July). *Motivation and volition in the workplace*. Invited address to be presented at the American Psychological Society meeting, Washington, DC.

Ackerman, P. L. (1994, July). *Theory and applications of individual differences in skill acquisition: Writing the new textbook for selection*. Paper to be presented at the 1994 International Congress of Applied Psychology. Madrid, Spain.

Ackerman, P. L. (1995, February). *Intelligence as process and knowledge: An integration for adult development and application*. Invited address to be presented at the Southeastern Center Conference on Aging and Skill Acquisition; Destin, FL.

Discoveries, inventions, specific applications from the research effort

Two specific applications from current and previous AFOSR funding are continuing, as follows:

1. Development and refinement of cognitive ability and self-regulatory skills test battery for the prediction of Air Traffic Controller success. (The work was funded directly by the Minnesota Air Traffic Controller Training Center, and indirectly by the U.S. Federal Aviation Administration). The initial work culminated in the following item:

Ackerman, P. L. & Kanfer, R. (1993). *Aptitude Assessment Battery*. [This is a battery of 10 aptitude tests and self-regulation measures developed for selection of air traffic control trainees at the Minnesota Air Traffic Control Training Center.]

2. Development of a *CD-ROM Database for Kanfer-Ackerman Air Traffic Control Learning Data*. This work, funded by the U.S. Office of Naval Research, entails a compilation of data from a large number of studies conducted by Phillip L. Ackerman and Ruth Kanfer, under support from AFOSR, AFHRL (now Armstrong Laboratory), and ONR -- including data from over 4,000 subjects. The database, to be completed in July, 1994, will provide a rich source of human learning data to serve as a test-bed for development and testing of psychological/artificial intelligence 'hybrid' models of learning.

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Joan Boggs
STINFO Program Manager