

ACHIEVING SKILL RETENTION THROUGH APPROPRIATE TRAINING DESIGN¹

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Operating tasks tend to be learned quickly, but the acquired skill deteriorates very rapidly during periods of no-practice (Christina & Bjork, 1991). Surveys of the literature (e.g. Farr, 1987; Van den Bosch, & Versteegen, 1996) suggest that retention can be enhanced if training promotes *system understanding*, and if initial training includes *contextual interference*.

System understanding: To operate a system, the performer must have some sort of mental representation of system and task. The quality of this representation may vary from elementary and superficial (e.g. knowledge of the series of individual task steps without any reference to the system's behaviour) to extended and comprehensive (e.g. full understanding of system components and functions, knowledge of the relationships between system functions, task organization, and task execution, etc.). Some studies have found evidence for the importance of *task structure knowledge* for learning and retention of competence (e.g. Dixon & Gabrys, 1991; Elio, 1986), while other studies demonstrate that the long term retention of operating skills can be improved by fostering *conceptual understanding* (e.g. Catrambone, 1995; Kieras & Bovair, 1984; Mark & Greer, 1995).

Contextual interference: Contextual interference requires learners to overcome task difficulty during training, and is generally been manipulated by having subjects learn a task in either a random presentation mode (high contextual interference), in which task conditions vary from trial to trial, or in a blocked presentation mode (low contextual interference), in which each particular instance of task execution is repeatedly practised until mastery is achieved. Performers acquire more decay-resistant knowledge and skills if the training procedures includes high contextual interference (see Schmidt & Bjork, 1992), because this would induce memory retrieval and response reconstruction (Lee & Magill, 1983; Shea & Morgan, 1979), thus producing a higher level of initial mastery.

EXPERIMENT I

This study investigates which kind of explanations promotes the long-term retention of operating skill. It is argued that task structure knowledge and conceptual system knowledge affect learning and retention differently. When learning a task, the performer stores task-associated knowledge in long-term memory. If instruction provides information enabling organized storage of task knowledge, then this is likely to have a positive effect on acquisition. Thus, the process of task acquisition may be characterized as *constructive* in nature. In contrast, the processes involved when performing a task after a non-practice interval are primarily *reconstructive* in nature. recalling and/or reconstructing the action sequence is more easy if task-associated knowledge is embedded in a conceptual framework. Thus, the hypothesis tested is that task structure knowledge helps organizing new knowledge in memory, and therefore primarily facilitates learning. Likewise, conceptual system knowledge is believed to be necessary for successful retrieval of prerequisite task knowledge, and should therefore primarily facilitate retention.

METHODS

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SUBJECTS

44 scholars of advanced elementary education (age 15-17 years).

TASK

Subjects directed a ship from one side to the other of a simulated lock by mouse-clicking controls on a computer monitor. Four sets of procedures (14-17 steps) were to be learned.

DESIGN

The *linear* group memorized the procedures. The *structural* group (task-structure knowledge only) learned the subprocedures and their constituent actions. The *functional* group received additional conceptual information on system processes (task-structure *and* conceptual knowledge).

PROCEDURE

The acquisition phase involved instruction, guided practice and independent practice. After four weeks of no practice, subjects returned for a retention test.

DEPENDENT VARIABLES

Number of trials needed to reach criterion, number of errors, mean latency for correct actions were recorded during independent practice and the retention test.

RESULTS

LEARNING PHASE

An over-all effect of Type of Instruction was found. Subsequent analyses revealed that the structural group tended to perform better than the other groups. Furthermore, subjects of the functional group took more time between successive task actions, possibly because they were consulting their mental system representation.

RETENTION PHASE

The linear group needed more trials to relearn the task to criterion. The difference in number of errors on the first retention trial was substantial, but not statistically significant.

DISCUSSION

Results provide partial support for the hypotheses. A post-experiment interview showed that, compared to others, subjects in the functional condition did not show superior understanding of the system. Experiment II utilizes an instructional method achieving a more thorough conceptual understanding.

EXPERIMENT II

There is evidence that retention of skill can be enhanced by (1) fostering system understanding and (2) using training procedures including contextual interference, inducing memory retrieval and response reconstruction. However, the effects of these factors have been studied separately, and in the context of different tasks. The present experiment manipulates both measures in the training of one operating task and investigates the effects upon skill learning and retention.

METHODS

SUBJECTS, TASK, PROCEDURE AND DEPENDENT VARIABLES

See Experiment I

DESIGN

Effects of system knowledge (low or high), practice schedule (mixed versus blocked practice trials), and retention interval (4 versus 12 weeks) are investigated.

RESULTS AND DISCUSSION

Data are presently being collected. The results may provide a better understanding of the role of conceptual system knowledge for the acquisition and retention of procedural skill. Ellis, Whitehill, and Irick (1996) recently argued that, whereas task structure knowledge is essential for teaching maintenance tasks, functional explanations are often critical for teaching operator tasks. The present study may be used to address that statement. From a practical perspective, by investigating the effects of different training design factors in the context of one task, their relative contribution to skill retention can be determined, and may subsequently be used to assign priorities to training design. Furthermore, possible interactions between the factors may be discovered (one possible outcome might be that the impact of practice schedule on skill retention varies with whether or not system knowledge has been provided during instruction).

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