Skill Acquisition: Measurement, Theory, and Research

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Abstract

In recent times, training has become "big business", with most training carried out in educational, military and industrial settings. It is the aim of many training programs to optimise the performance of all trainees, with little regard for individual differences in abilities, skills and knowledge. Since there is usually a diversity of abilities, skills and knowledge in groups, it would seem crucial to ensure that trainers and educators are aware of these differences and for them to adapt their teaching methods accordingly. The present paper addresses the question of theory and measurement of skill acquisition, and how theory and measurement can be useful to practical problems in industry. Further, some summary findings are presented which concern the testing of an individual differences model.

Skill Acquisition: Measurement, Theory, and Research

In today's increasingly technical world, many jobs require the acquisition of a variety of simple and complex skills, for instance, word processing (Lane, 1987). However, the problems associated with how one acquires a skill are numerous and complex (Robb, 1972). An important aim of many training programs is to develop in trainees the capability to perform complex "real world" tasks, with a minimum investment of resources. Training could aim to raise the level of performance, and minimise the range of individual differences in performance, by revealing which abilities influence learning, and other possible moderating variables, (Ackerman & Kyllonen, 1991) and to identify the differing needs of trainees at different stages of practice, so that training programs can keep pace with different ability requirements at different stages (Mumford, Costanza, Baughman, Threlfall & Fleishman, 1994). Different theories and the precise measurement of skill acquisition are vital for ensuring the optimal application of training programs in the wide variety of settings that exist.

The Concepts of Skill, Ability and Theories of Skill Acquisition

Skill has been defined by Adams (1987) as a large behavioural domain, which can be learned, and usually involves a combination of cognitive, perceptual and motor processes. Since the 1960's there have been several attempts to develop theories that predict the relative importance of different cognitive and intellectual abilities over the course of task practice (Ackerman & Woltz, 1994). There is a general consensus in the literature that the learning of a complex task proceeds in accordance with approximate segments of practice and that there are three stages in this process. Most of the information-processing theories have approached skill acquisition as a process which begins with resource-dependency and ends in skilled performance or automaticity. Edwin Fleishman has been a prominent figure in the last fifty years in the domain of motor skill acquisition and abilities. Fleishman (1972) proposed that during perceptual motor tasks, cognitive abilities may be good predictors of performance early in learning, but with continued practice the influence of motor abilities increases. With the attainment of skilled performance, Fleishman proposed that an ability factor specific to the task itself becomes the primary determinant of performance (Fleishman, 1972). However, Ackerman (1988) has commented on several flaws in Fleishman's methodology and research methods. He re-analysed some of Fleishman's data, and found it didn't support Fleishman's hypothesis, i.e. that at the final stage of practice, some new, task-specific ability develops (Ackerman, 1987). Ackerman (1988) then proposed that instead of task-specific abilities, there were three broad classes of abilities underlying skill acquisition: (a) General intelligence (general ability), (b) Perceptual speed, and (c) Psychomotor ability.

Ackerman's (1988) Theory Of Ability-Performance Relations During Skill Acquisition

Ackerman's (1988) theory describes the relation of ability classes to phases of skill acquisition, and can be used to predict the association between individual differences in performance across levels of skill. The theory proposes that in the initial declarative stage of skill acquisition (general ability), substantial demands are made on cognitive abilities such as memory, reasoning, and knowledge retrieval (Ackerman, 1988). Figure 1 shows that this phase is associated with the general abilities at the top of the cylinder. Ackerman (1989) has shown how those with a higher general intellectual ability (which is equated with resource availability) demonstrate higher levels of performance early in practice. As practice progresses, measures of intellectual

ability become less related to task performance, a finding which is consistent with the development of resource independence. That is, resource availability has less importance in the final stage of skill acquisition. The associative stage (perceptual speed) is when learners develop rules for performance, and as seen in Figure 1, performance is more reliant on perceptual speed ability than general abilities, with attentional load reduced (Ackerman, 1990). In the autonomous phase (psychomotor ability), the individual has essentially automatised the skill, thus performance is fluent and relatively free of attentional demands (Ackerman, 1990). As seen in Figure 1, psychomotor ability then becomes more important for performance. Figure 2 illustrates a graphical summary of the roles of general ability, perceptual speed, and psychomotor ability in the performance of a perceptual-motor task.

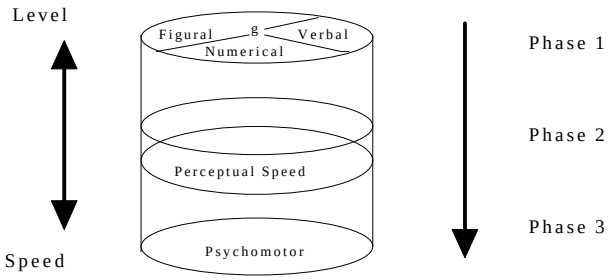

Figure 1. Ackerman's (1988) modified radex model of abilities and skill.

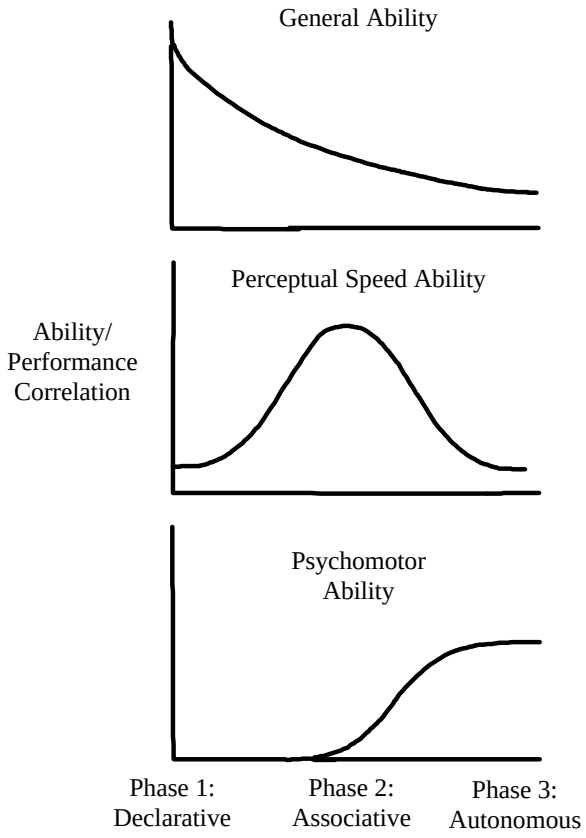

Figure 2. Ackerman's proposed ability-performance correlations underlying skill acquisition. (adapted from Proctor & Dutta, 1995)

Apart from studies by Matthews, Jones and Chamberlain (1992), Galna and Langan-Fox (1995), Waycott and Langan-Fox (1997), and Morrison, Lewis and LeMap (1997), there has been no research testing Ackerman's (1988) model outside his own work and that with his colleagues (e.g. Ackerman; 1988; Kanfer & Ackerman, 1989). Morrison et al. (1997) and Matthews et al. (1992) did not provide a direct test of Ackerman's model, as in the case of Galna and Langan-Fox (1995) and Waycott and Langan-Fox (1997), who found results which showed limited support for his model. These studies suggested a consideration of moderating variables to further develop Ackerman's (1988) model. Recently Kanfer (1989) and Lane (1987) have suggested that individual differences in learning and performance can't be solely explained by individual differences in cognitive abilities. Kanfer and Ackerman (1989) have proposed a model of ability-motivation interactions for attentional effort, which assumes that changes in the amount of capacity used, and policies for allocation of attention, are accomplished through motivational processes.

Kanfer and Ackerman's (1989) Resource Allocation Model

Kanfer and Ackerman's (1989) model describes how motivation, abilities, and information processing constructs operate simultaneously to affect learning and performance (Kanfer, 1990). According to this model, people allocate attentional resources to different processes during task performance. As seen in Figure 3, motivational processes can be seen as distal or proximal processes. Self-regulation is an important mechanism for initiating changes in resource allocation policy toward a task, and occurs when people adopt difficult goals, and correspondingly perceive themselves to have adequate skills to complete the task. Although self-regulation often aids performance, the process demands attentional resources, and therefore can hinder performance (Kanfer et al., 1994). This is especially true during initial stages of skill acquisition, (e.g. Ackerman's phase 1), when task-specific motivation may diminish performance as it interferes with resources available for on-task attention. Ackerman's (1988) theory of ability-performance relations during skill acquisition overlaps to a considerable extent with Kanfer & Ackerman's (1989) resource allocation model.

Self-regulation and goal setting are the motivational components of Kanfer & Ackerman's (1989) model. Twenty years of empirical research has established that specific, challenging goals lead to higher levels of task performance than no goals, vague goals or easy goals (Wood, Mento & Locke, 1982).

Self-Regulation: Action and State Orientation

According to Kanfer and Ackerman's (1989) resource allocation perspective, difficult and specific goal assignments stimulate self-regulatory processes, such as self-evaluation. Individual differences in cognitive abilities, dispositional tendencies, and task attentional demands may affect learning and performance through their influences on the character and quality of self-regulation during skill acquisition. The Kanfer and Ackerman framework is consistent with the theoretical foundation for action orientation, and suggests that individual differences in action orientation affect complex skill acquisition through self-regulatory mechanisms (Kuhl, 1994). Kuhl's (1985) model of action control describes strategies, goal-directed intentions and voluntary action, and research (Kuhl, 1994) has demonstrated that individuals may be oriented toward the environment (action, behaviour) or internal states (eg. rumination, introspection). Internal or 'state' orientation often has a task-irrelevant focus, which detracts from plan execution, while action-oriented individuals focus their attention on activities related to the immediate task and experience emotional and affective states that support goal-directed action.

Kanfer & Ackerman (1989) found that persons assigned goals during the early phase of skill acquisition demonstrated lower performance and reported more frequent emotion-related thoughts than persons who did not receive an early explicit goal assignment. Kuhl would suggest that such thoughts are symptomatic of a state orientation, which had been induced by the setting of a goal. In contrast, Antoni and Beckmann (1990) have found that action orientation is required to effectively screen the attention from distracting stimuli or competing action tendencies in order to maintain high performance on such tasks.

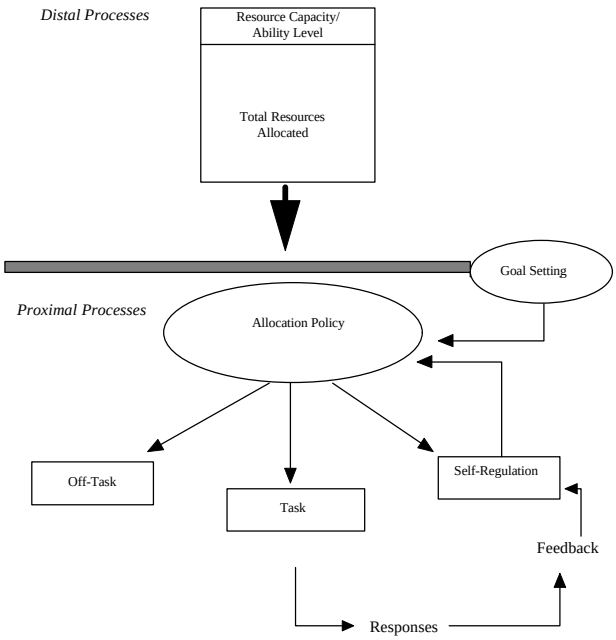

Figure 2. Kanfer & Ackerman's (1989) Resource Allocation model. (adapted from Kanfer & Ackerman, 1989)

Therefore, without explicit goal setting instructions, action-oriented individuals were found to outperform state-oriented individuals on a task (Antoni & Beckmann, 1990). Furthermore, the performance of state-oriented individuals improved when their attention was focused on the task by providing external goals and task-relevant feedback, and was then no different to that of action-oriented individuals. This led to the suggestion that action-control processes moderate the effects of goal-setting and that hard, specific goals will increase action orientation (Antoni & Beckmann, 1990).

A Test of Ackerman' s 1988 Model of Skill Acquisition - Some Summary Findings

This research sought to test Ackerman's (1988) theory of dynamic ability-performance relations during skill acquisition, and to investigate a component of Kanfer and Ackerman's (1989) resource allocation model, and used a sample of 68 university students. It was predicted that action orientation and goal setting would have a moderating effect on ability-performance relations over task practice on a computerised pursuit tracking task, via their influence on attentional resource allocation. It was found that ability-performance correlations differed considerably from the pattern predicted by Ackerman's (1988) model for the three different ability classes. The setting of a specific and difficult performance goal did not cause individuals to allocate more resources to self-regulatory activities and less resources to on-task activities, as predicted by Kanfer and Ackerman's (1989) resource allocation model. Only slight evidence was found of a disruption in the normal process of ability-performance correlations for subjects given a specific and difficult goal, as compared to subjects not given a goal. There was little support for an effect of action orientation on attentional resource allocation. As predicted, it was found that state-oriented subjects in the no-goal condition had significantly lower general ability-performance correlations than action-oriented subjects in the no-goal condition. Also as predicted, no significant difference in general ability-performance correlations was found between action and state-oriented subjects in the goal condition. As predicted, action-oriented individuals were found to have significantly greater general ability-performance correlations than state-oriented individuals. Action and state-oriented individuals were found not to differ on patterns of perceptual speed ability-performance correlations, but as predicted showed significant differences for psychomotor ability-performance

correlations. These results suggest further tests of Ackerman's (1988) model are vital, especially considering the effect of goal setting and moderating variables such as action orientation.

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