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An Integrated Approach to Modeling Concurrent Multitasking

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Threaded Cognition

Concurrent multitasking — performing two or more tasks at the same time — arises in many real-world situations, from mundane everyday tasks to the most complex work environments. Cognitive models, particularly those developed within the framework of cognitive architectures, have accounted for multitasking in small-scale tasks (e.g., psychological refractory period or PRP) and also in complex real-world tasks (e.g., aviation and driving). However, these models have generally required explicit specification of customized executives or supervisory attentional mechanisms to manage multiple tasks.

We have been working on a new general model of concurrent multitasking that specifies, for any two or more arbitrary tasks, the resulting behavior of performing these tasks concurrently. Our initial efforts focused on the types of multitasking that arise in two particular complex dynamics tasks, namely air-traffic control (Taatgen, 2005; Taatgen & Lee, 2003) and driving (Salvucci, 2001, 2006; Salvucci & Gray, 2004). In this work, we explored two different but related approaches to general multitasking models (Salvucci, 2005; Taatgen, 2005) as well as the effects of learning and practice on multitasking behavior (Salvucci, Taatgen & Kushleyeva, 2006; Taatgen, 2005).

We have recently integrated many aspects of this previous work into a new theory that we call *threaded cognition*. Under the assumption of a goal-directed, rule-based representation of cognitive skill, the theory makes several claims, including: (1) cognition can be expressed as processing threads that share underlying cognitive, perceptual, and motor resources; (2) cognitive skill is represented as production rules, which can be learned from declarative instructions; (3) threads acquire and release resources in a "greedy, polite" manner; and (4) when threads contend for the same resource, the least-recently-processed thread is allowed to proceed. All together, threaded cognition unifies a number of aspects of previous work (ours and that of others) into a domain-independent theory of concurrent multitasking, realized as a computational model that produces testable predictions of behavior and performance.

Illustrative Task Domains

We have tested the claims of threaded cognition in two ways, namely exploring how its qualitative predictions match with known empirical phenomena and developing rigorous models and predictions that match human data. To date, we have focused our efforts on two categories of domains. First, we have developed models of well-known laboratory tasks including PRP tasks and a manual tracking task. Second, we have developed models of driver behavior and distraction, matching model predictions to the performance of human drivers. In all cases, the models utilize the same computational model of concurrent multitasking, thus serving as first steps in demonstrating the generality and predictive power of threaded cognition theory and its realization as a computational model.

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