Task Switching, Multitasking, and Errors: A Psychologic Perspective on the Impact of Interruptions

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When considering the impact of interruptions on skilled performance, 2 assertions appear self-evident: (1) interruptions increase error rates; and (2) people can acquire skill expertise to allow multitasking, under specific conditions, to reduce the impact of interruptions. In this issue of the journal, Gottlieb et al[1] presented some evidence that addresses these assertions. They demonstrated that listening to a podcast while driving on a familiar route impacts neither learning nor the retention of knowledge compared with undistracted listening. The theoretical rationale to support multitasking posited by the authors has implications for emergency medicine learners and teachers who use podcasts. However, what are the larger implications of interruptions on emergency medicine clinical practice?

To an external observer, the emergency department (ED) may represent a chaotic environment with repeated and frequent interruptions. Chisholm et al[2] observed that over a single 180-minute period, physicians were interrupted an average of 30.9 times, and they experienced a break-in-task 20.7 times. They concluded that "[w]hile some interruptions are important and necessary, an 'interrupt-driven' practice is prone to distraction and, thus, potentially to error." Similar results have been reported elsewhere.[3,4] Many authors have commented on the potential for error under these circumstances. In a commentary, Croskerry[5] eloquently described the ED as an environment where "decision making is often naked and raw with its flaws highly visible. Nowhere in medicine is rationality more bounded by relatively poor access to information and with limited time to process it, all within a milieu renowned for its error-producing conditions."

Although the abovementioned studies documented frequent interruptions and hypothesized that these interruptions lead to errors, none actually studied the impact of interruptions on errors. Perhaps surprisingly, direct experimental studies of the effect of interruptions have yielded somewhat different results. Monteiro et al[6] presented a series of 20 virtual general medicine cases assigned to residents and physicians in a variety of specialties under a fast and a slow condition. Half of the cases, at random, were interrupted by either an audio message in the form "Dr. X, page 14795, Dr. X," requiring the input of the paged number into the virtual environment, or a multiple choice general medical question unrelated to the virtual case. Neither type of interruption had any impact on the diagnostic accuracy of the residents or physicians, but an interruption added to the overall response time. In a nonmedical setting, graduate students who were required to instantly message while reading a passage took longer but did not perform worse in a recall test.[7]

Of course, such empirical research does not prove that interruptions have no effect on clinical reasoning and that multiple tasks cannot interfere with each other. Rather, it may suggest that for multitasking to occur, certain boundary conditions must be present. A moment's reflection brings to mind many circumstances in which we are capable of performing multiple tasks simultaneously; most of us can walk and chew gum at the same time (although the second author may be an exception). Moreover, we all have the experience of driving a car while carrying on with a conversation (as long as the traffic is relatively light and the route is familiar). Thus, the purpose of this commentary is to explore circumstances in which multitasking can arise and, conversely, those in which, when faced with multiple tasks, people are more likely to adopt a task switching strategy. We also examine the consequences of task switching. To begin, we review a theoretical model describing how information is stored and retrieved from memory.

A MODAL MODEL OF MEMORY

Based on the empirical research of Atkinson and Shiffrin,[8] Baddeley and Hitch,[9] and others, a model for human information processing is shown in the Figure. Although critiqued for being oversimplified, this model offers a clear, foundational explanation of memory.[10]

There are 3 critical modes: the sensory register that identifies information in the environment, short-term (working) memory, and long-term (associative) memory. The operation of the sensors, encompassing issues such as perception and attention, is for another day. However, in terms of understanding multitasking, it is critical to know more about short-term and long-term memory.

The working memory involves effortful, intentional mental processes; any conscious thinking is a characteristic of the working memory. It includes a supervisory central executive system and 2 subordinate systems: a visuospatial sketchpad and a phonologic loop. A critical element of the working memory is its limited capacity. The cognitive load theory articulates the finite capacity of working memory, including the classification of information that is relevant or distracting to thinking.[11] Miller's[12] classic article, "The Magic Number Seven Plus or Minus Two," says it all; people can remember and recall about 7, plus or minus 2, elements. Of course, the scope and scale of what constitutes an element is dependent on expertise. For example, an attending emergency physician possesses a complex schema to represent a primary trauma survey as a single element, whereas a novice emergency medicine learner represents each of the elements of a primary survey as a unique element. This can lead to an overwhelming cognitive load for a novice clinician. The separate subsystems for visual and aural information also allow a slight advantage of processing more information through 2 separate sensory registers rather than a single register.[13] Nonetheless, a cognitive load and the finite capacity of working memory place constraints on the conscious processing of multiple tasks.

The associative or long-term memory is what is generally considered when discussing the ability to remember. Although the size of typical human memory is impressive (estimated at more than 2.5 million terabytes of memory), the efficient access to information is more impressive, given the relatively slow speed of neuronal processes.[14] The explanation for this efficiency is contained in the description "associative." Every retrieval proceeds via massive parallel processing, with signals propagating across multiple nodes. It is this massive diffusion and parallelism that enable a human to compete with a supercomputer. With increasing expertise, cues for retrieval and association between related information in associative memory improve. This allows improved retrieval of necessary information and decreased demands on working memory.[15]

One consequence of associative memory is that associations can arise from any similarity, regardless of analytic relevance. As a result, if 2 tasks are introduced concurrently and they contain similar features, there is a greater chance of interference and a resulting error.[16,17]

MEMORY, DUAL PROCESSING THEORY, AND EXPERTISE

Both working and associative memory are fundamental to the dual process theories of reasoning. The dual processing theory has been extensively discussed in the emergency medicine literature.[18,19] The 2 systems work in concert to support clinical reasoning, with only the most artificial and constrained research environments

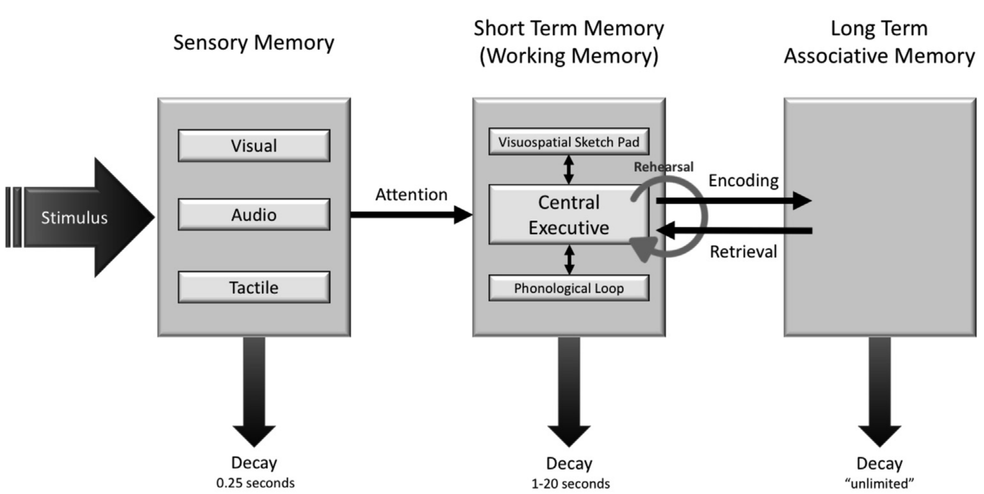

Figure. The modal model of memory.

demonstrating the function of a single system in isolation. System 1 is characterized as rapid, unconscious, automatic, and associative. System 2 is characterized as slow, conscious, effortful, and capacity-limited. According to Evans and Stanovich,[20] the defining contrasts between the 2 systems are that system 1 is autonomous and does not require working memory, whereas system 2 requires working memory and involves explicit hypothesis testing.

Expertise does not primarily relate to improved system 2 functioning. Thinking longer or harder does not necessarily lead to better clinical reasoning. Rather, a feature of expertise is enhanced system 1 functioning, wherein more associations and more complex associations are derived from a more extensive past experience.[18] Thus, the acquisition of expertise amounts to, in part, improved automatization of skilled activities. Experts unconsciously adopt pattern recognition approaches (ie, automated identification of a larger system based on the presence of key component parts), freeing up cognitive resources required of analytic strategies to solve tasks. In contrast to a novice, an expert can bear a larger cognitive load.

IMPLICATIONS FOR MULTITASKING AND TASK SWITCHING

Perhaps the most fundamental implication of the psychology of thinking in the present situation is the distinction between task switching and multitasking. To a casual observer, they may appear the same. In task switching, the cognitive transfer back and forth between tasks may lead to the loss of fidelity of information relevant to each separate task. Depending on the degree and extent of task switching, this loss of information may impair clinical reasoning. This does not automatically induce errors, although it will generally slow down the process.[6,7] Multitasking can arise to the extent that there is sufficient allocation of working memory to accomplish both tasks in parallel. Typically, this occurs when one task is automated, thus avoiding working memory. However, when the complexity or unfamiliarity of a task increases, it becomes necessary to allocate resources to working memory, leading to task switching. Task switching becomes more prone to error when the tasks are more closely related (eg, interpreting the result of a venous blood gas analysis rather than an ECG while supervising the resuscitation of a patient with septic shock) because the process of association can lead to interpretations based on similarity between the tasks, regardless of analytic relevance.[16,17]

Returning to the 2 experimental studies, both the investigators set up conditions in which the concurrent tasks would not impair performance. In the study by Gottlieb et al,[1] residents were driving on familiar routes; so, it would have been unlikely to encounter cognitively demanding issues with navigation. Even if they did, the podcast was transmitted aurally, whereas driving cues were primarily visual. This might be predicted to have reduced interference. In the study by Monteiro et al,[6] task switching was deliberately introduced by the investigator. Yet, the tasks were conceptually different from virtual patient presentation—a pager number or a basic anatomy question unrelated to the relevant diagnosis. Such a difference in tasks prevents associative interference, wherein information is recalled based on similarities between the tasks but is not relevant to the reasoning process at hand. Moreover, the interrupting task required very little conscious effort to complete because the solutions were basic. As Monteiro et al[6] demonstrated, task switching in these instances results in an increased time for completion but no decline in performance. In general, for multiple tasks to affect performance (not just by slowing down processing), they must be conceptually similar.

IMPLICATIONS FOR EMERGENCY MEDICINE CLINICAL AND EDUCATIONAL PRACTICES

1. Avoid interrupting a clinician during a complex task. There may be insufficient working memory to attend to a second task. In the process of task switching, the fidelity of information is lost between the tasks. Implementing this recommendation can be challenging. We suggest adopting a modified practice from the human factors literature—the procedural timeout. During complex tasks, a task-switching timeout should be implemented, wherein members of the ED team are informed not to interrupt the clinician until the completion of the task. For example, the podium or documentation nurse should signal to the ED team that only communication relevant to the airway management of the patient with sepsis is permitted until the task is complete. The team can regroup at the completion of airway management, task switch as necessary, and then commence with the next required complex task.
2. The threshold to define a complex task increases with experience, where pattern recognition, established through practice, allows for increasing automaticity. Practically, a clinician should signal to the ED team that they anticipate a task to be complex and that a task-switching timeout should be implemented. Common complex ED tasks requiring the implementation of a task-switching timeout should

be preidentified. It should be assumed that many tasks completed by a novice clinician are complex, and a task-switching timeout should be adopted until the clinician can demonstrate automaticity and efficiency in completing the task.

3. Multitasking is a consequence of the acquisition of clinical expertise in a specific domain, which permits the automaticity of a specific task. There are no general multitasking skills; like other aspects of clinical reasoning, the skills arise with context.[21] For example, practicing task switching in a simulated environment will not inoculate a novice clinician from errors associated with multiple tasks. Multitasking is not a general skill to be acquired. Rather, practice and experience with a specific task allow automaticity and, hence, multitasking when faced with this specific task. Instructional designs, such as interleaved (eg, a common presenting complaint with different, appropriately represented diagnoses) simulated cases, that efficiently organize the acquisition of experience may be beneficial, but evidence is lacking.[22] Novice emergency medicine trainees should be protected from task switching.
4. Teaching that employs both aural and visual stimuli can help access different independent subsystems of working memory, optimizing cognitive load.[23]
5. There is no evidence that the current generation of students is any more adept at multitasking than older generations. Brains do not evolve in a generation.[24]

Emergency medicine is a unique clinical context wherein interruptions are too frequently normalized and the potential for error is often underconsidered. Drawing on cognitive psychology, emergency medicine can adopt teaching and clinical practices that permit the acquisition of experience to allow multitasking while ensuring that the risk of task switching does not lead to patient harm.

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