Does Multitasking Interfere with Learning?

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Introduction

Multitasking is generally assumed to increase our productivity. But, does it? During the past decade an increasing amount of research has examined various aspects of multitasking, including the differences between sequential and simultaneous processing, divided attention, continuous partial attention, and task switching (Abate, C., 2008; Applebaum, S. and Marchonni, A., 2008; Ben-Shakhar, G. and Sheffer, L., 2001; Delbridge, K., 2001; Dux, P., Tombu, M., Harrison, S., Rogers, B., Tong, F. and Marois, R., 2009; Konig, C., Buhner, M., Murling, F., 2005; Loose, R., Kaufmann, C., Auer, D., Lange, K., 2003; Naveh-Benjamin, M, Craik, F. I. M., Perretta, J. G., Tonev, S. T., 2000; Stone, L., 2007). There continues to be a variety of approaches taken when researching multitasking, some describing its advantages while others claiming it has a negative impact on nearly all that we do.

A review of the literature helps in sorting through what sometimes appears to be occasional conflicting findings. This article addresses the differences between sequential and simultaneous processing, the impact of divided attention on encoding, task completion, retention, and information retrieval, all of which are necessary in order to acquire knowledge. Depth of processing is an important variable in this discussion because our brains respond differently to simplistic vs complex information and tasks. As noted by Applebaum and Marchonni (2008), "Multitasking behavior needs to be understood in the context of its manifestation as a variable that is at least partially dependent on the existence of relatively 'cheap' information" (p. 1313). Conceptual information, or "expensive" information, requires a considerably deeper level of processing. Doing several things quickly is certainly not the same as learning them well.

What is known - A review of the literature

Multitasking behaviors need to be understood in the context of their purpose and goals. For example, if one's job involves primarily using a computer to enter data and also to respond to work related emails, both of these activities can certainly be effectively completed by the end of each work day. However, since it would be difficult if not impossible to *simultaneously* perform these tasks, called dual tasking, the typical employee might enter data, then respond to several emails, return to data input, perhaps even make a phone call, return to email, etc. In other words, *sequential* processing, or task switching, is occurring whereby one is actually successively switching among tasks but not performing two at exactly the same time. Whenever we attempt to perform two tasks at the same time, then simultaneous processing is taking place. However, most often it is sequential processing that engages our time. Delbridge

(2001) referred to the switching among sequential tasks as "attention switching" because to effectively switch tasks requires a change of focus and attention. Changing attention does allow one to switch between tasks, but different neurology, and different parts of the brain, are involved in the actual execution of the tasks.

Delbridge (2001) demonstrated that task and attention switching during *sequential* processing can result in effectively accomplishing multiple goals in the same general time period, depending on the type of activity. However, it was noted that when attempting to do just two tasks *simultaneously*, performance on one task is generally detrimental to the performance on the second task. It was found that a switching of neurologic gears requires a change of attention, and that focusing on just one goal resulted in fewer errors and less time. Practice does tend to improve the cost of task switching in terms of increasing its speed (Delbridge, 2001; Dux, et al, 2009). We can learn to do more switching, more quickly, but that does not translate into the efficient encoding and learning of new information.

Allport and Wylie (2000) used the term "reaction time switching costs" to describe the "shifting of gears" that occurs when one changes tasks. They, too, noted that different parts of the brain are needed when there is a change in task, which requires additional time, and the time used results in a decrement in performance. We need to consider what happens when we attempt to perform two tasks *simultaneously* and also how much *sequential* processing can occur before it interferes with encoding and task performance.

In their research on encoding, Naveh-Benjamin et al (2000) recorded "marked differences between encoding and retrieval activities involved in processing information created via multitasking" (p. 610). They found that the encoding processes require more attention than retrieval processes and are therefore more vulnerable to the effects of competing demands associated with multitasking. In order to most effectively encode, we need to focus our attention on a single task. When attempting to engage in just two tasks simultaneously, partial engagement in one task will interfere with focus, and therefore encoding, of the second.

Rubinstein et al (2001) also found that multitasking takes more time and results in more errors than single task performance. The switching time costs become more problematic when they conflict with the environmental demands for productivity. Hembrooke and Gay (2003) found a performance decrement under divided attention conditions related to the limited capacity model of attention. They noted that there is a "fixed amount of cognitive resources upon which we can draw" (pg. 5). Konig et al (2005) found that when we try to engage in simultaneous processing, the tasks necessarily interfere with one another. This interference is a matter of resource allocation. We have a neurologically limited capacity for cognitive processing.

Meaningful information is stored in memory more easily than information that is not meaningful, but it requires a deeper level of sustained attention to process. Sequential and simultaneous processing both interfere with our ability to sustain focus and attention. It is the level of processing during an activity that is most significant to our ability to store information. The more cognitively difficult a task, the greater attention it requires. Sustained thought is no doubt impaired when one's attention is partial or fractured. Stone (2007) coined the term "continuous partial attention" and distinguished it from multitasking. She wrote that multitasking is driven by a desire to be more productive whereas "continuous partial attention" means, literally, to pay partial attention – continuously. It has less to do with being productive or efficient and more to do with being neurologically stimulated by multiple activities.

Any variables that distract us will interfere with our ability to effectively encode information. When we think with the intent to learn, we need to be aware of the depth of our thinking and whether we are maintaining it. Choosing between two tasks, one of which requires active thinking, is predictably problematic in maintaining sustained and uninterrupted thought. In turn, interrupted thought interferes with encoding and retention.

Our Brain and Information Processing

Much has been written about the brain's plasticity; that is, the structural changes that occur via our learning and our individual experiences. The biochemical and neurological changes result in a memory traces, called engrams. Although the entire brain is believed to be involved in processing and storing our memories, research shows that the hippocampus is involved in processing declarative memories that include such things as data, events, and knowledge based experiences. These memories can certainly be created via reading, study, and thinking. In addition to factual information, personal experiences are a type of declarative memory that are also processed via the hippocampus. When information is processed in the hippocampus, we can recall and apply it later in places different from where it was learned. The hippocampus regulates working memory, which is active when new learning takes place, as well as when past memories are retrieved from long term memory. It also plays a prominent role in "consolidating learning and converting information from working memory to long term memory" (Sousa, 2006, pg. 19) Zull (2002) described this process as resulting in the integration of new information which creates new synapses and neural connections. As a result, it is believed that new neurons are acquired throughout our lives in this region of the brain.

A different part of the brain, the striatum, is used to process habitual tasks associated with procedural memory, or the "how to" part of memory, which includes both cognitive and motor tasks. These memories are created by repeating activities over and over until they become automatic. However, memories in the striatum are closely tied to the situation in which they were actually learned. This makes future transfer, generalization, and application of the information or skill more challenging, as compared with what is processed via the hippocampus. Because of this, information that is processed via the striatum is not as readily applicable to learning as that which is processed via the hippocampus, where working memory is actively combined with information from long term memory.

Sousa (2006) noted that from the study of brain scans it can be determined that different parts of the brain are also involved in various aspects of problem solving activities. As the task becomes more difficult, more of the brain is activated. The brain is in a constant state of reorganization, which helps to facilitate more complex, higher order thinking and problem solving. Higher order thinking requires an increased amount of sustained thought and attention.

The Impact of Focused Attention

Rubinstein et al (2001) found that task priorities and environmental cues are assessed via our supervisory attentional system which helps us to determine which cues will be responded to. Hembrooke and Gay (2003) found that both our conscious and unconscious cognitive mechanisms and resources determine what we select for encoding and further processing. "Sustained distraction" is what causes problems. If information is important or interesting to us, we pay attention to it longer than when we determine it to be unimportant or uninteresting. As we focus and sustain our attention, the information is transferred into working memory where the hippocampus will begin to integrate it with information that is already stored in long term memory. When our attention is fractured or interrupted, the process of integration is also disrupted.

Information to be encoded needs to be attended to. This is why trying to multitask is particularly problematic as the parallel distracting task interferes with encoding the input. This in turn limits what is further processed and stored. Attention to details significantly aids memory. It takes concentration and cognitive engagement to associate what is being learned with what is already stored. Concentration and focus cannot be sustained when interrupted by environmental distractions. As with all activities associated with parallel processing, effective encoding is impacted by the difficulty of the task. The more complex the task and the more attention that is required, then the greater the negative impact of distractions.

It is known that the brain seems to be attracted to uniqueness and novelty in our environment. We also know that constantly scanning the environment for stimulation, novelty, and interesting details is easier than trying to maintain focused attention. When we switch between and among tasks, the anterior prefrontal cortex is activated, which appears to be the control center for changing our attention consistent with a change in tasks. Interestingly, the prefrontal cortex continues to develop through early adulthood, improving our ability to maintain attention for longer periods of time while decreasing the impulsivity characteristic of youth.

It is generally recognized that some people are simply better at focusing and maintaining attention than others. Given that some individuals are going to struggle with maintaining focused attention, it can be anticipated that they will look for stimulation, whether or not it is an irrelevant distraction. These individuals might excel at multitasking. Richtel (2010) described persons with "fractured thinking" as ones who struggle to maintain focus whether or not multitasking is occurring. Even though we have a dedicated part of the brain to help us prioritize and focus, the more primitive parts of our brain direct us to pay attention to incoming visual and auditory stimulation.

Our focus and our attention have a limited capacity. Even though we can pay partial attention to more than one thing at a time, the number of things depends on how much thought is needed to process the information. As noted by Ormrod, J. (2011), "Attention's limited capacity means that we must be quite selective about the information we focus on, and we must ignore (and so lose) a lot of the information we receive "(p. 55). Shallow processing of information might be accomplished during multitasking, but shallow processing more readily fades from memory. Deep processing, as needed during thought, reflection, problem solving, and learning, is less likely to fade or be lost because it requires more sustained activity in more parts of the brain.

What have we recently learned?

Constant use of technology disrupts or interferes with our ability to sustain attention, which is the foundation of thought. Attention and reflection are both needed not only to learn but to understand the world in which we live. The purpose of teaching is to change the brain of the learner via adding synapses and making neuronal connections between what is already stored in memory and the new information being learned. The first challenge is to engage students so that they maintain focus and intentionally connect new information with what they already know. To be stored, information needs to rehearsed and practiced. Add to this an opportunity to think creatively at a more complex level in a way that is meaningful to them. It is only when we pay deep attention to information that we can associate it with what we already know and make it personally meaningful.

Do we want to just be able to do more, faster, or do we want to teach students to think independently, to think deeply, to make connections and associations, and to apply what they know? What happens in a classroom needs to be connected with their world. The more meaningful information is, the more likely it will be stored and retrieved, but this process still requires the desire and effort to learn.

An active and engaged mind is one that is used for reading, thinking, listening, writing, doing, and speaking. Compare this with the neurologic activity that occurs when we sit in front of our computers, read e-books, listen to music, and switch among various digital tasks. Are we thinking? Are we learning? To become critical thinkers, students need to move beyond surface knowledge and acquire the skills needed to analyze, synthesize, and evaluate information. We cannot do that, neurologically speaking, if we have tied up our attentional and working memory capacity with superficial facts, environmental distractions, or purposeless activities that are often characteristic of multitasking. What we *can* effectively multitask are activities that we have practiced to the point that they are automatic and take little or no conscious thought.

As stated by Abate (2008):

> *"I eventually conclude that multitasking, as we ordinarily understand it, is both impractical and counterproductive to successful learning and scholastic education. (p. 7)….Whatever the case, the implicit acceptance of multitasking as a viable and productive strategy cannot, and should not, be encouraged in the academic environment – at least not if we hope to maintain the level of educational efficacy of generations past (p. 12). To further encourage this practice – discredited by significant neurophysiological testing – is to invite academic implosion" (p. 13).*

Conclusion

We remember what we pay the most attention to. Given that, we have a great deal of control over what we *select* to pay attention to. Perhaps that, alone, is the key to effective multitasking; ie, ignore, turn off, or put away those things that distract us and which we find difficult to ignore. Focus when it matters, sustain thought, work efficiently, and then reward ourselves with the multiple modes of digital stimulation that we find so appealing.

Back to the original question: Does multitasking interfere with learning? It all depends on the difficulty of a task, its meaningfulness, and our ability to maintain attention. Thinking and learning require focus and sustained attention. The more interruptions that occur during this process, the greater the negative impact on encoding and storage of information. We know what is required for deep and effective learning. We also know that multitasking is not compatible with it. Focus when it matters most. Multitask when it does not conflict with learning or the need to accurately process and recall meaningful information.

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