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The Menton Theory of Engagement and Boredom

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Abstract

In this paper we describe a theory of boredom and engagement based on the menton theory of mental resources. According to this theory, boredom is a feeling resulting from a surplus of mental resources (mentons) given a relatively unchallenging task environment. Mentons are a functional mental energy resource that is unevenly distributed in a cognitive system. The theory is supported by its explanation of dual-task interference, automatization, art appreciation, and attention deficit disorder effects.

Keywords: boredom, cognitive architecture, philosophy, attention.

1. Introduction

Boredom is a kind of dissatisfaction. When we feel it we are unfulfilled, uninterested, or our minds are restless. In this paper, we will describe a cognitive theory of boredom, arguing that boredom is caused by an excess of mental resources that have no tasks to address. This means that boredom, essentially, is dissatisfaction with how challenging an environment is.

A key to understanding boredom is to reflect on what kinds of situations make us bored. First, we get bored when we have “nothing to do.” When we are waiting in line, or stuck somewhere without a book, we have some negative affect we describe as boredom.

Second, one can get bored of *something*, or even someone. We get bored with a song if we hear it too many times, bored of a conversation when it drags on too long, bored with a film that has a predictable or incomprehensibly convoluted plot, or when watching a children's television show that is too simple.

First we will discuss other theories of mental resources in order to put our theory in context. Next we will present our theory, as well as motivate it by showing that it provides a unified explanation of the effects observed in several studies on boredom. Then we will show how our theory is consistent with accounts of automatization and the experience of boredom particularly as it relates to the enjoyment of art, which is a particularly complex sort of boredom. Last we will discuss directions for future work, including experiments that would support our theory (at this point, our theory is motivated because it appears to provide a unified explanation of many effects that have been previously observed, but not by a specific empirical study).

1.1 The Nature of Multi-Task Interference

In our everyday lives, it is clear that certain tasks can take up varying amounts of our attention—for example, tapping your foot and having a conversation each require a certain amount of attention. Some tasks, when performed simultaneously, seem to fit together without difficulty, but others create interference with significant results—for example, if one is reading a book, a large dual task interference can be seen in trying to carry engage in conversation at the same time, while less interference would be seen in tapping your foot while reading a book. Similarly, our attention can be occupied to varying degrees—walking alone down a street, you might be aware of the sounds and sights around you, but if you were talking with someone else you might not be aware of these other features of the environment. Depending on your engagement with the conversation, your awareness of the ambient sounds can grow and shrink.

There are various theories that try to explain the nature of multi-task interference, which we discuss below. The final theory we discuss, menton theory, will be the theory we will try to use to explain boredom.

1.2 Central Bottleneck Theory

The central bottleneck theory of attention holds that tasks must be processed by a central executive, and as a result multitasking with zero interference is impossible (Pashler & Johnston, 1998). However, it has been suggested that a central bottleneck might be compatible with a certain amount of parallel processing, which makes it difficult to determine whether dual task interference is a result of a central bottleneck or the limited availability of attentional resources. The central bottleneck's existence is experimentally supported by observations that slightly changing the stimulus onsets in a dual-task experiment will result in greater or lesser interference, as the central processing for one task overlaps to a greater or lesser degree with the other task. The central bottleneck theory has been criticized in its failure to provide anatomical evidence of a central processing unit. Furthermore, it fails to clearly distinguish which tasks must be processed by the central executive and which can be locally processed. For a general review of the various flavors of central bottleneck theories, see Pashler and Johnston (1998).

1.3 Central Capacity Theories

Capacity theories of attention describe attention as a *single* resource that can be divided among several tasks— as the resource is divided more thinly, performance decreases on all simultaneously performed tasks. In Kahneman's model (1973), the amount of available attention is determined by the individual's physiological arousal.

Some have argued that Kahneman's model, and any model of attention where attention is singular resource, is flawed because these models cannot explain the results of certain experiments involving dual task interference. For example, it is harder to monitor two auditory messages than to monitor one auditory message and one visual message (Treisman & Davies, 1973). The singular resource model cannot account for that result because it predicts that the number and difficulty but not nature of the tasks will determine the amount of interference.

Sanders (1997) notes that subsequent research showed that in other instances of dual-task interference, singular resource models failed to predict dual task interference correctly for the same basic reason: not taking into account that some tasks might requires different *kinds* of processing (Navon & Gopher, 1979; Heuer, 1985).

1.4 Multiple-Resource Theory (MRT)

One solution to the problem introduced by single resource theories is to posit the existence of multiple resources. MRT is a four-dimensional model of attention with separate attentional resources for stages, sensory modalities, codes, and channels of visual information (Wickens, 2002, see also Navon & Gopher, 1979; Norman & Bobrow, 1976 for similar theories). Stages refer to different pools of resources being used for different stages of a process, such as the attention used to receive the input, the attention used for processing the data in working memory, and the attention used to express the output in some way. Sensory modalities refer to the sense with which the input was received, such as taste, audition or vision. Codes refer to the different attentional resources that might be used to symbolize different types of information in the mind. Channels of visual information refers to the attention used for foveal or peripheral vision. In MRT, the exact relationship between the priority of the resources and their allocation is still unclear, and it has been criticized for providing insufficient empirical evidence of the theory in action (Wickens, 2002).

2. Menton Theory

According to our theory, which we call "menton theory," a person has a single physiological resource that is consumed by actions the person does.[1] The central executive allocates this resource according to importance, urgency, cost, etc., just as a manager might budget money to various committees and projects in a large organization. For example, if a person is walking and carrying on a conversation, the central executive allocates mentons to the tasks of walking, listening, formulating responses, and talking. Each task is allocated an amount of this resource to work with. The effectiveness of the execution of the actions depends on the budget of mentons allocated to the tasks by the central executive.

We believe that mentons have physiological instantiations in brains. They might be, for example, oxygen, glucose, available neurotransmitters, or some combination thereof, but we do not yet know enough about brain function to hypothesize how this resource is instantiated at a biological level. Thus we describe it as a functional substance.

Like central capacity theories, menton theory holds that there is a single resource used for task execution. How it differs from others is that it suggests that each brain area has an amount of mentons to use and that the areas do not share or replenish mentons quickly enough to remove multi-task interference. To make an analogy, a country has a certain amount of food within its borders. However, the consumption of that food is local. There might be more food in some areas and less in others. Food can be transported between cities, but this does not happen instantaneously. So at any given time one city might be starving while another might have a surplus. Likewise, mentons flow around the brain, but this takes time.

A brain area's mentons are restored at a more or less constant rate. This is similar to the stages dimension of attention from MRT, but is more specific in its description of the brain's attentional resources. Menton theory also parts from MRT in treating the coding dimension as

[1] The term "menton" is intended to sound like an elementary particle, such as "proton" or "electron." It is the basic unit of mental energy. The theory is not developed enough to actually *count* mentons, so in this paper we will refer to the quantity of mentons as a continuous substance, as opposed to a collection of countable objects. However, because we hypothesize that mentons are a physiological resource, we remain committed to the idea that they could, in time, be identified independently of observations of task difficulty or boredom. For example, fMRI observations which report greater activation in one brain region *might* be a guide to showing where more mentons are being used.

irrelevant to resource distribution. In menton theory, the single factor that is relevant for a task is the brain areas that it involves, and the degree to which the mentons in those brain areas are already in use. It is a multiple resource theory in the sense that each brain area can use its mentons independently of other brain areas, but like a single resource theory in that we see no reason to suggest that there might be more than one kind of menton.

When an action becomes particularly taxing, it requires more mental resources to continue. For example, while listening to music, one can wash dishes, but find it difficult to read philosophy. This is because reading philosophy requires so many mentons that there is not enough left over for listening to music. Our preferences and goals influence which tasks receive the most mentons. For example, if one is washing dishes while listening to talk radio, one might find oneself pausing the dishwashing while something particularly interesting or difficult to understand is broadcast on the radio.

It seems likely that there is a minimum number of mentons required to be able to perform a task at all, but that people can focus more on a particular task if they decide to. The dishwashing task can be starved of mentons, and performance might decrease gradually, until it reaches the point where it cannot continue at all, at which point the dishwashing stops until it receives more resources.

Rather than positing the existence of multiple resources, menton theory holds that there is only one resource that is unequally distributed throughout the brain. Often cognitive scientists will refer to this resource as attention. Perhaps that is exactly what it is. However, it might be that there are mental resources other than attention resources (e.g., willpower). It also seems strange, for example, to describe being bored with a conversation partner as a problem of attention. But we will explain this kind of boredom with menton theory.

The hypothesis of the menton theory of boredom is that boredom occurs when there is a *surplus* of unused mentons. The feeling of boredom is your mind pushing you to find new challenges.

There is some preliminary evidence for this. In the psychology community it is generally believed that we perform best when focusing on only one task. However an experiment that found that students listening to a boring lecture recalled more facts from the lecture when they were allowed to doodle (Andrade, 2010). Why might this be? It turns out that without doodling, the participants' minds completely disengaged with the lecture, daydreaming about something else entirely, remembering nothing from the lecture. Andrade suggests several possible explanations for this, including that doodling reduces arousal, keeping it at an optimal level (2010).

While we agree with Andrade that doodling keeps people from daydreaming, the menton theory offers a different explanation for this result: that during a boring lecture, a student has an excess of mentons that are sitting idle, unallocated. The central executive of the bored student looks for something to apply the surplus to. Doodling would use fewer mentons than daydreaming. Together with listening to the boring lecture, the *combination* occupies enough of the mental resources to keep boredom at bay.

The students who were not permitted to doodle ended up thinking about something else. Daydreaming requires many more resources than doodling, however, and since the daydream was, presumably, more interesting, the students' central executives starved the "listen to the lecture" task to provide more mentons for the daydreaming task.

We will flesh out this explanation with an example. Suppose students have 10,000 mentons available every few seconds (these numbers are arbitrary). The lecture is slow and the students have heard a lot of it before, so comprehending the lecture only requires 6,000 mentons (every few seconds). The students have 4,000 unallocated, excess mentons. Subjectively, the students experience this state as boredom. The student who has a pen and paper might doodle. Doodling requires 3,000 mentons. The combination of listening and doodling sums to 9,000 mentons used, with only 1,000 left over. This could be a boredom mild enough to tolerate. The central executive might not be thrilled with the situation, but it does not try hard to occupy the few excess mentons.

The student without pen and paper, however, will also start trying to find something else to do to occupy the excess mentons. Daydreaming is always available, but requires 7,000 mentons. Now the central executive has two competing processes. The mind cannot handle both, because the required sum (13,000 mentons) is in excess of what the mind has available. Because the daydreaming is more fun, the executive starves the listening process to feed the daydreaming process. The listening process now only has 3,000 mentons with which to operate. This is not enough to understand anything in the lecture, so the task is tabled and uses no mentons. The student is completely disengaged, and the imagination task has access to as many mentons as it needs.

We are aware that this example does not take advantage of the different pools of mentons in different brain areas. *Overall* menton use is important for an overall feeling of engagement or boredom. Note, too, that doodling likely uses a different brain area than lecture comprehension (motor and visual areas vs. language and frontal areas) where daydreaming, like other kinds of imagination, will use the one of the same brain areas as the lecture comprehension task (the frontal areas).

Although Andrade hypothesizes that "this continual but small central executive load detracted minimally from the primary auditory task yet was sufficient to prevent the greater impairment to performance that would have occurred if central executive resources were free for daydreaming," he does not relate it to boredom, which is the reason the participants are tempted to daydream in the first place.

Similarly, some kinds of background noise have been shown to *improve* performance for people with Attention-Deficit Hyperactivity Disorder (ADHD), a disorder that is sometimes described as being chronically understimulated (Söderlund, Sikström, & Smart, 2007)[2]. It could be that part of having ADHD means having *increased* attentional capacity—or, as our theory would put it, more mentons.

Another experiment showed that people who chewed gum while working through challenging mental tasks showed higher alertness than those who weren't chewing gum. The authors speculated that chewing gum might increase blood flow or metabolism (Scholey et al., 2009). The menton theory explains this result differently— the gum chewing helps the students keep focus by occupying the small number of excess mentons left over by the primary mental task.

Anecdotal experience of the authors suggests that computer programmers working on a challenging project often listen to music, but only music of a certain kind. They report that if they listen to no music, they are bored, and are tempted to start doing other things. If they listen to music that they like too much, they ignore the programming and just enjoy the music. There seems to be a sweet spot— certain kinds of music, mostly instrumental, are entertaining enough to keep programmers from being bored, but not so interesting as to be distracting.

Thoughtful reviewers of this paper asked about meditation, which is an activity that people seek out but is often described as boring. Boredom is not the point of meditation; it is a side

[2] Paul Orfalea, founder of Kinko's, describes his ADHD affliction as "attention surplus disorder" (Pinker, 2008).

effect. People might seek situations that do not stimulate them, but their goal is not to be bored. Nevertheless, it poses a challenge to a simple theory of automatic allocation of mentons because people can force themselves to engage in highly boring activities if they ultimately think it's worth doing. High-level intentions can overcome an automatic menton allocation to force one to do a boring task, be it meditation or a tedious job.

It is important to note that menton theory is not *merely compatible* with the findings of Andrade (2010), Söderlund et al. (2007), and Scholey et al. (2009). While the three studies we have discussed have each provided their own explanations of the phenomena they observed, menton theory provides a single explanation for all of them. Doodling, gum chewing, and non-engaging music all serve the purpose of occupying excess mentons to allow the primary task to continue without boredom. Thus, menton theory's explanatory power is superior to the other three theories in question, which is a reason to think that menton theory is worth further investigation.

The above studies and scenarios describe situations where tasks are not challenging enough. However, people can also be bored when tasks are too challenging. According to menton theory, when a task is too difficult, no processes can effectively be brought to bear on the task. The minimum amount of mentons required to do the task cannot be met[3]. Because no mental actions are happening, the result is the same as when a task is not challenging enough: a surplus of mentons, and boredom. In education, it has been found that students get bored when they are too challenged, or not challenged enough (Small, Dodge, & Jiang, 1996). The makers of the computer game *Halo* 3 made extensive use of Microsoft's user testing laboratories to tailor the game so that it was maximally enjoyable—they described the process as making the game not too easy nor too hard at every point, resulting in continuously engaging gameplay (Thompson, 2007).

There is a sweet spot in between ease and difficulty. In aesthetics, it means there is a sweet spot between what is familiar, and easy to process, and what is incongruous, and difficult to process.

3. The Sweet Spot between Familiarity and Incongruity

We will now relate this theory of boredom to explain how people get bored with works of art, or genres of art. There are many factors involved with what we find compelling in a work of art, but one of them has to do with the sweet spot between familiarity and incongruity. Stimuli in this sweet spot are complex enough to rouse our curiosity, but understandable enough to give us hope of understanding (Munsinger & Kessen, 1964). This section has less to do with how our theory relates to resources being allocated throughout brain areas, and more to do with the ideas presented about boredom. Much in this section is compatible with other resource-based attention theories.

People are interested in things they can understand. Familiar things require less cognitive processing, which makes those things appear visually clearer (Whittlesea, Jacoby, & Girard, 1990), more pleasant (Reber, Schwarz & Winkielman, 2004; Whittlesea, 1993; Zajonc 1968), more recent (Whittlesea, 1993), less risky (Song & Schwarz, 2009), and more attractive (Winkielman, Halberstadt, Fazendeiro, & Catty, 2006). According to menton theory, tasks that require less cognitive processing require fewer mentons per unit time.

However, if stimuli are too familiar we bore of them. There needs to be a bit of challenge in the stimuli to keep us interested. Our natural curiosity draws us to things we *do not* understand.

[3] The central executive has access to estimates of how much energy is required to maintain a task, much like a committee might have a budgetary request for their supervisors.

This is the basis of the "preferential looking paradigm" in developmental psychology, in which children will look longer at scenes that violate their understanding of the world (Baillargeon & DeVos, 1991).

Smets (1973) conducted an experimental study of the aesthetics of abstract shapes, and found that people preferred pictures that were neither too simple nor too complex. A plain white screen is boring because it is too simple, and a television displaying white noise has too much—it is boring not because there is not enough information, but that so much information renders it incomprehensible. For counterevidence to this sweet spot idea, see Phillips, Norman, and Beers (2010).

Art scholars might be able to spend hours happily looking at a painting, but for the layperson, the typical response to looking at a painting for more than a few minutes is boredom. Though a painting might be captivating at first, after a while the painting feels understood, and the mind grows restless. Mentons are recruited to find patterns and comprehend the painting, but after they have done their job, classifications are made, representations are stored, and the mind now with excess mentons, starts yearning for something new.

The art scholar, on the other hand, can read more into the painting, and thereby continue to learn from it. Museum curators describe masterpieces as "bottomless," meaning that the paintings never stop revealing things to them (Csikszentmihalyi & Robinson, 1990). Menton theory explains this result in the following way: experts have more mental processes to apply to a work of art, and thus take longer to have a menton surplus. An expert can reflect on the color choices, composition, symbolism, historical context, what was going on with the painter at that point in his or her life, and other things of which novices are often unaware. With more things to consider, more mentons can be used to find more patterns.

People can grow bored of other art media, as when they hear the same song or watch the same dance performance over and over again. According to menton theory, *because* the work no longer surprises us, it takes minimal effort to appreciate and understand it upon subsequent exposures. This decrease in required effort leads to the menton surplus.

Likewise, people can grow bored of entire styles or genres of art (e.g., techno music, opera, horror movies) over longer time scales. The menton theory explanation for this phenomenon is that we have grown too familiar with the very motifs that make a style what it is.

If one likes rock music, one is a bit like the art scholar mentioned above, and can listen to it for a longer period of time than can someone new to the genre. Unfamiliar genres in music often "all sound the same," perhaps for the same reasons as the outgroup homogeneity bias (Quattrone & Jones, 1980), which is the bias in thinking that members of one's own groups are more heterogeneous than those of others. It could be that our greater sensitivity to the nuances of familiar genres, like those of our groups, allow us read more into them, and remain interested for longer. We bore of unfamiliar genres faster.

Although this theory is mainly concerned with boredom because tasks are too easy, it is also true that boredom can occur when tasks are too difficult. If we are listening to a story that is spoken too slowly, we will be bored because it is too easy to understand. However, if it is spoken too quickly to comprehend, there will also be boredom. According to menton theory, this is because the actions the mind can take to understand a story are ineffective at certain speaking speeds. As a result, they cannot be performed at all. This frees mentons, resulting in excess, which causes the experience of boredom. Thus, on either side of the sweet spot, there are excess mentons and boredom.

4. Automatization

It is well known that actions that are often repeated become easier to execute, and require fewer mental resources. This process is known as automatization, and it is the reason why new drivers can scarcely keep track of what they are doing, but experienced drivers can carry on complex conversations while driving. Automatization, in menton theory, means that practice makes those processes more efficient, requiring fewer mentons.

If we look at the comprehension of a stimulus as a cognitive process, we can infer that repeated comprehension of similar stimuli will result in an automatization of the comprehension process required for that stimulus, or class of stimuli. In the ACT-R theory of cognition, new processes are "compiled" for specific situations (Anderson & Lebiere, 1998). These compiled processes are more efficient and less broadly applicable than the more general processes from which they are created.

For example, one might have a general process for addition, and might apply it when adding 14 and 30. However, when asked repeatedly, the mind might create a compiled version of addition specifically for these numbers. The sum is retrieved, rather than derived.

When we are trying to understand a narrative, or how a person behaves, or the structure of a visual stimulus, we are using comprehension processes that become more efficient with practice. If there is less cognitive processing involved, the idea is more easily processed by the mind. This means the processes require fewer mentons, which means that one will be more likely, over the course of practice, to leave excess mentons available. This is the menton explanation for why we grow bored of a stimulus.

This section is not to show that menton theory is *superior* to other attention theories in terms of how it fits with what is known about automatization, but merely that it is compatible.

5. Discussion

This paper has two contributions. First, it describes a mental resource allocation theory that is based on brain area rather than function. This theory is still in its infancy. Second, it uses resource theories of attention to account for boredom.

Scholarly research on boredom tends to explore under what conditions one will be bored, and individual differences in proneness to boredom. The Boredom Proneness Scale (Farmer & Sundberg, 1986) measures individual differences in how easily one is bored. In general, boredom is thought to involve attention. Csikszentmihalyi (1997) claims that boredom occurs when one is engaged in a task for which one has more than enough skill. Menton theory would predict that individuals with more attentional resources would be more easily bored. Thus, on menton theory, skill might be one of many reasons that one has too many mentons allocated to a task, resulting in boredom.

Ours is not the first theory to equate mental resources with physiological entities. Kahneman's model of capacity (1973) specifically dealt with attention as a resource, and speculated that it was physiological. Kahneman speculated that arousal influences the amount of resource that was available, moment to moment. Although he did not specifically relate his theory to boredom, it shares qualities with the menton theory in general. However, our theory is distinct from Kahneman's because we are proposing that different brain areas draw from different menton pools, so that two tasks drawing from the same brain areas will draw on the same pool of mentons, and have more interference.

Note that the menton theory of boredom could still be even if there is no true multitasking. Some researchers (e.g., Anderson & Lebiere, 1998) theorize that what appears to be multitasking is actually rapid task switching. If this turns out to be true, the menton theory could still be accurate, with the following adjustment: that even though mentons are only allocated to one task at a time, *over a period of time* mentons are allocated to multiple tasks, which get switched out according to the same rules (urgency, importance, etc.). In either case, boredom involves too much resource and not enough challenge.

An unaddressed problem is the ultimate reason for boredom: why do people even have the capacity to feel boredom? What function does it serve? We speculate that boredom is an evolutionary adaptation that encourages people to learn more from their environment, and continually learn new skills. Perhaps those who got bored out-survived and out-reproduced those who were complacent in their learning. Those who had to fight boredom ended up knowing more about their environment and having more skills than those who were satisfied with simple tasks. Looked at in this light, perhaps boredom, the negative feeling of having excess mentons, is one of the ultimate explanations of human progress.[4]

If we are right that boredom has played this role in the past, but more importantly, that boredom *currently* plays this role in the cognitive lives of humans, many psychologists ought to rethink the motivations behind their research on boredom. Several researchers treat boredom as an entirely negative aspect of peoples' cognitive lives by investigating its correlation with depression and a lack of self-actualization and, sometimes, arguing that their results are useful because in contributing to our understanding of boredom they will play a part in future research which will determine how to reduce boredom (Farmer & Sundberg, 1986; McLeod & Vodanovich, 1991). But on our account, boredom plays a positive role in peoples’ lives by encouraging them to apply themselves to more challenging and interesting tasks.

We recommend that scholars currently treating boredom and boredom proneness as problematic redirect their attention to investigating reasons external to the cognitive mechanisms behind boredom that cause it to become problematic. Speculatively, boredom is the symptom caused by factors in peoples’ lives that prevent them from taking the actions that boredom naturally leads them to take. We do not mean to claim that *sometimes* an individual might be boredom prone to an unhealthy level, but we *do* mean to undermine the common assumption that being boredom-prone is necessarily a bad thing: boredom makes people do interesting and creative things.

6. Applications for Artificial Cognitive Systems

Computer operating systems (OS) keep track of available resources (sometimes called “clock cycles”) and allocate them to the many tasks requested of them. In the UNIX OS, and its variants, users can specify a job as having a certain priority level using the affectionate term “nice” in the command line.

Most artificial intelligence (AI) programs are single-task entities, with robots standing as notable exceptions. One of the main goals of the Cognitive Systems approach is to replicate human-level competencies with computer programs, and one thing that people are quite good at is doing more than one thing at a time with limited resources (for example, seeing, talking, and walking).

Even if the programmer is not intending to model a human cognitive system with his or her artificial cognitive system, any system endeavoring to replicate human *behaviour* must be

[4] We attribute boredom to animals (e.g., a dog in a cage all day), but regardless of whether they have it, they lack the other cognitive abilities to make progress like humans.

prepared to deal with parallel processes. For the foreseeable future, the computational resources of such a system will be limited, requiring the need for resource allocation.

When personal computers were released with graphics processors that operated independently from the main CPU, it allowed simultaneous processing of graphical and other processes—an analogue to multiple menton pools in humans.

As we define mentons as a functional resource, it is possible to speak of mentons in a computer program as well. Though they are implemented in biological systems with some kind of physiological resource, in computers they might be implemented at clock cycles, and represented symbolically to some central executive function.

As computers grow more powerful, they have more mentons to allocate. Desktop computers do not currently have the processing power of human brains, but might by 2041 (Kurzweil, 2005). According to Moore's Law, the mentons available to a desktop computer at that time will exceed that of humans.

With more mentons there are more opportunities for opportunistic and exploratory inquiry. While the idea that we should build computer programs to be bored sounds strange, it makes more sense to make the curious. When there are excess mentons, future programs should look for things to think about, such as planning for the future, making sense of past experiences, etc. As such, the menton theory of boredom and engagement could provide fruitful ideas for future cognitive systems.

7. Conclusion and Future Work

This paper presents a theory of boredom based on a mental resource theory. Although previous work has suggested that boredom occurs when a person's skill exceeds the need of the current task, and other work has suggested that the mind works through spending physiological resources, the menton theory for the first time uses one to explain the other. In essence, the menton theory of boredom holds that mental resources (measured in "mentons," the unit of mental energy) sometimes exceed the needs of the current task environment. The resulting experience, which we describe as boredom, is relieved by occupying the available mentons in another way. This can happen through multi-tasking, or by switching to a more challenging main task.

We have discussed what we perceive as problems with other theories of attention, but the main point of this paper is not to establish menton theory as a superior attention theory: for this paper, the menton theory is more about the interesting fact that it is an explanation for a variety of experiences we describe as boring.

Although we have shown how menton theory is compatible with current evidence, future empirical research can test the theory's specific predictions.

Although we do not know what physical form mentons take, the theory holds that mentons are *some* kind of physiological entity. Blood flows through the brain, carrying oxygen and glucose, and neurotransmitters are refreshed locally. As such, different parts of the brain would have access to differing amounts of mentons. For example, if the frontal lobes are particularly busy with a task, there should be more dual-task interference if the second task also taxes the frontal lobes. Similarly, there should be *less* dual-task interference if the second task taxes primarily the rear of the brain, because it is drawing from a different menton pool. Kahneman's Central Capacity Theory (1973), in predicting a singular resource that is a function of arousal, has failed in some experiments that have shown that different kinds of multitasking result in differing amounts of interference (Sanders, 1997). This suggests, as menton theory holds, that mental resources are not all coming from one singular "pool." Wickens (2002) addresses this concern. In his Multiple Resource Theory, dual-task interference occurs when two tasks are similar in *kind* (e.g., verbal and verbal, as opposed to verbal and visual). Menton theory predicts differences based on brain area rather than task kind. We conclude with a description of an experiment that could be run to test these competing hypotheses.

The proposed experiment involves measuring the amount of dual-task interference when we manipulate the nature of the component tasks. MRT predicts that naming things will draw on a single resource—the linguistic resource. However, it turns out that naming animals shows relatively more brain activation in the medial occipital lobe, and naming tools shows relatively more brain activation in the left premotor cortex (Martin et al., 1996). Menton theory predicts that interference is the result of competition for resources in the same brain areas, rather than because the tasks have the same function, as MRT suggests. So MRT predicts that the interference will be the same for dual tasks involving animal-animal as animal-tool. In contrast we predict that the animal-tool dual naming task will have *less* interference, because they tax different parts of the brain.

Likewise, other tasks that tax left premotor cortex, such as sound localization (Frackowiak et al., 2004), should have high interference with naming tools, even though they are, according to MRT, functionally different.

This would be a suggested empirical test of menton theory in general. However, the claim about boredom, specifically, should be tested as well. One prediction that could be tested is that people will willingly engage in multiple tasks if one of the tasks is not sufficiently challenging, but will cease doing the less important task when the primary task increases in difficulty. An experiment could test this. Participants would play a game, such as Tetris, while repeating aloud numbers they hear. At the beginning, the number will have single digits (e.g., 8), and over time will increase (84, 249, 23490). The menton theory predicts that players will 1) happily play while the task is easy, because they are bored, and 2) will pause their game of Tetris when the task grows difficult, and 3) resume it when it gets easy again.

With hope studies like these will determine if interference is better described by same-function or same-brain area conflicts.

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