Episode 36: Memory Behaving Baddeley

Show Notes
It's time to dive in and finally have an in-depth discussion of working memory!

Game References
Carcassonne, River Valley Glassworks, Tetris, That's Not a Hat, Wandering Towers, Wilmot's Warehouse

Research References
Baddeley, A. (1992). Working memory. *Science, 255*(5044), 556-559.

Baddeley, A. D., & Hitch, G. (1974). Working memory. *Psychology of learning and motivation, 8*, 47-89.

https://brainscale.net/app/brain-training/corsi-block-tapping/training

Transcript
Hello! This is Episode 36 of the Cognitive Gamer podcast. I am your host, Dr. Stephen Blessing, professor of cognitive psychology at the University of Tampa. I use games to both explain and explore concepts in psychology. Back in Episode 11 I provided an overview of our memory system. Given how important our memory is to us, it's not surprising that it involves several subsystems and many different parts of our brains assist in its functioning. In that episode I quickly sketched the three main components of memory, sensory memory, working memory, and long term memory. It's that middle component, working memory, that I want to examine more closely in this episode.

Working memory is what we are currently consciously aware of. It's our shorter term store. Older textbooks may refer to it as short term memory, but I and most other cognitive psychologists today will use working memory, to indicate its more active nature. To keep items active in this memory takes a bit of work, and to make sure those items get transferred to a longer term store also takes a bit of effort. So, let's use "working memory" instead of just short term memory to describe it.

All games use various aspects of working memory to at least some degree. There are some games that depend on it, like That's Not a Hat by Kaspar Lapp and a new game called Wilmott's Warehouse designed by Ricky Hagget, Richard Hogg, and David King. Both of these games are really essentially tests of memory, but are enjoyable games and experiences in their own right. In both, you need to keep track of some number of items as they get moved and positioned around the table. They form an interesting pair, in that playing That's Not a Hat might convince you that you have a terrible memory, but going through Wilmot's Warehouse will seemingly overcome any working memory constraints. And of course, one of the games that I talked about last time, Wandering Towers, centers on your ability to keep track of where all your wizards are as they get hidden by the towers.

In this episode I want to talk about a particular theory of working memory, one first proposed many years ago and that has several decades of research surrounding it. The main researcher to associate here is Alan Baddeley. I was curious as to if he was still alive, and so of course just now googled him. At the time of this podcast, he is 90 years old, and listed as a Professor Emeritus at the University of York, where he has been since 2003. In 1999 he was named as a Commander of the British Empire for contributions to the study of memory, which another google indicates that this is just below the ranking that would have allowed him the use of the title Sir. Needless to say, though, he's incredibly well known and regarded in academic circles.

His theory of working memory has been revised over the years, and I'm actually going to go back and just talk about a simpler version that just has three main parts to it. These parts are the central executive, the phonological loop, and the visuospatial sketchpad. Later versions add something called the episodic buffer, but let's just keep it at the initial three for our discussion today. We will talk about each of these in turn.

First up, the central executive. It's aptly named, I feel, because it sounds like the piece that runs the show, and indeed, that's what it does. My wife and I learned a new game last night, River Valley Glassworks, designed by Adam Hill, Ben Pinchback, and Matt Riddle, with adorable art by Andrew Bosley, and published by AllPlay games. As we were going through the rules, our central executive was making sure we were getting everything down. It was getting input from our sensory memory as we looked at the rules, the board, and the components. It was retrieving information from long term memory as needed in order for us to understand the words we were reading and the objects we were seeing. To help it do its job, it has two other systems to help it out, the phonological loop and visuospatial sketchpad. We will spend much more time on those two later, but suffice it to say they help with the verbal and visual aspect of memory, respectively. As we were reading the rules and matching up the images in the rulebook with the components on the board, the central executive was using those two systems to help it out.

Of course, the central executive has a lot to do while actually playing the game as well. As new information comes in, the central executive needs to decide what to do with it—toss it aside or keep it in active, conscious memory. And if to keep it, what previous information in consciousness may need to be overwritten so that the new information has a place to be stored. In this capacity, it's really helping out with our selective attention—what do we keep our attention on, and when is it time to shift? River Valley Glassworks isn't too complicated of a game, but given that it was our first time, we didn't quite know where to spend most of our attention—on the pieces of glass as it makes its way down the river, the lake at the end, or on our own player board with the columns and rows of glass that are building up? As we played a couple of more games that evening, we got the hang of it better, with our central executive being more efficient about what information it was attending to and how that information flowed in and out of our conscious awareness. Obviously the central executive is really at the heart of whatever game you may be playing, handling your attention and what's in your shorter term store.

Let's now turn our attention to the two companion systems to the central executive, the phonological loop and the visuospatial sketchpad. Before looking at them separately, let me reiterate that this clearly illustrates a dichotomy that one sees running up and down memory, that between verbal information and visual information. The phonological loop handles more

auditory information, and the visuospatial sketchpad the more visual information. Playing these types of memory off one another turns out to be a very useful tool in remembering more information. If you have two systems, then using both to help you remember maximizes your resources. I'll devote an episode to mnemonic techniques at some future point. For now, though, let's talk about these two systems in turn.

First up, the phonological loop. The main metaphor I've always used for the phonological loop, one I got from Herbert Simon when I took a class from him and then TA'ed from him at Carnegie Mellon, was that the phonological loop can be thought of as 2 seconds worth of audiotape that you can record information onto. Whatever you can "say" to yourself, in terms of your inner voice, you can record onto this 2 second audiotape for later playback and retrieval. Of course, it needs to be actively maintained. If your attention gets diverted, then that audiotape will quickly degrade and you won't be able to retrieve any information off of it. This analogy indicates the very acoustical nature of the phonological loop. I've sometimes heard it referred to as the articulatory loop, which indicates its very acoustic nature. Again, think of laying down or recording two second tracks to that audiotape. That consideration gives rise to a number of experimental findings. I'll provide you with two of them.

First, imagine two word lists. List A has all one-syllable words on it: book, chair, game, and so on. List B has all multi-syllabic words on it: telephone, animal, computer, and others. All the words are common, everyday nouns. Which list would I be able to remember more words from? Most people probably get the right answer here and say List A, the list with the one-syllable words. It makes intuitive sense, and can also be easily explained by the phonological loop. You can simply say more one syllable words to yourself, either out loud or using your inner voice, in the same amount of time as you can multi-syllable words. In memory research, this is referred to as the word-length effect. It's easier to remember many shorter words than longer words.

Let's try another thought experiment. Again, you have two different lists. This time, List A has all rhyming words, like clear, dear, fear, cat, mat, pat and List B has words that sound distinct from one another, like man, lot, neck, glow, five. Now which list will be more easily remembered? A majority of students get this wrong when I ask in class—they think it will be the rhyming words, because you have a common thread to hang them all together. But, it's actually List B, the words that all sound dissimilar that will be easier to remember. Because of the acoustical nature of the phonological loop, it's too easy to get the rhyming words confused and begin to second guess yourself. From that example I gave you, was near on the list? What about rat? Maybe there were, but maybe there weren't. With the acoustically dissimilar list, you don't get confused and can more readily keep the items on the list separate. This is referred to as the phonological similarity effect, that it's hard to remember words that sound alike, because they get confused when you record them to your 2 seconds of audiotape.

What purpose does the phonological loop serve? Why do we have this two seconds of audiotape that we can record acoustical information onto? Perhaps the most basic answer is that it helps us to learn language. As we are figuring out what our caregivers are saying to us, having a mechanism that allows us to play back what they just said in our mind's ear, and to perhaps rehearse what we want to say is very useful as we are learning to speak a natural language. As such, the nature of this phonological loop probably also shapes our languages. For instance, think

of the basic number words in the language that you speak. In English, all the basic number words are one syllable except for seven. They are also pretty phonologically distinct. Other languages have similar features for their number words. Specifically with regards to games, the phonological loop will come into play as we listen to someone teach us a game, or as we teach a game to someone else. That rehearsal mechanism is crucial to learning instructions.

Let us now move on to the second helper system, the visuospatial sketchpad. This is our mind's eye, the virtual chalkboard we have that we can draw information onto so we can keep it straight. Note that the name has two parts to it, visuo and spatial, indicating there's really two things here, the visual aspect, that helps us to picture the objects, and then also spatial, which helps us to keep track of where things are. They are combined in the name here, but they are actually distinct systems, though obviously related. If you look at our visual system and what happens in cortex, after information is processed by the occipital lobe early in the visual process, there are two pathways that lead from there. One pathway goes to the temporal lobe and processes what it is we are seeing, the various objects and whatnot, and another pathway goes to the parietal lobe and processes where those objects are. That leads to interesting neurological disorders, where you might know there is a chair in your visual field, but you can't point to it, because you have a damaged parietal lobe. Or, if the damage is in the temporal lobe but not the parietal lobe, you may be able to point to where an object is, but not be able to identify what it is.

For fun, if you want to test your spatial memory, I'll include a link in the show notes to an online version of the Corsi block tapping task. It's a bit like the old Simon electronic game, but here there's a grid where blocks can appear, and for each round, you need to touch the blocks in the order they appear to you. If you are successful, you are rewarded with another round that increases the sequence by one. Again, this is a test of spatial memory. You can poke around on the site where this is at, BrainScale.net, for lots of other memory tasks as well.

Why have visuospatial memory, as distinct from the phonological loop? Why, to play Tetris of course! Well, to do that and any other task that requires keeping track of visual and spatial relationships. Like, packing the trunk of your car, or designing some new gadget, or making scientific discoveries like Benzene rings and the supercontinent Pangea. Look those last two up—Both August Kekulé for benzene and Abraham Ortelius for continental drift proposed their theories based on using their visuospatial sketchpads. And, outside of Tetris, your visuospatial sketchpad is used in a whole host of games, like first and third-person action shooter videogames where you navigate 3-D spaces, to tile laying games like Carcassonne—any game in which you have to imagine how to get from point A to point B or how to position this piece in relation to the other pieces on the board.

I am glad we finally got to talk about working memory! It's obviously a very important topic in general, and comes into focus quite strongly as we play any game. In a future episode I will need to talk about different mnemonic techniques we can use to bypass, in a manner of speaking, these constraints on our working memory. As always, I welcome any comments or questions you may have, so please email me, steve@cognitivegamer.com and also visit my website, cognitivegamer.com. Also, you can like me on Facebook, Cognitive Gamer, or follow me on X, @cognitive_gamer. And, if you like the podcast, please give a rating in whatever service you use to play podcasts. Just like most dice rolls, higher is better! This will make it easier for other

people to discover the podcast. Until next time, remember to think about what you play, and have fun doing it.