Episode 02: Now You See It, Now You Still Do: The Use of Visual Imagery in Memory

Show Notes

Visual memory has a different character than verbal memory. This episode examines the nature of our visual memory, and how it is used in such games as Tetris, Carcassonne, and any game that has a map that your character must navigate.

Game References

Assassins Creed, Asteroids, Breakout, Carcassonne, DixIt, Horizon Zero Dawn, Pandemic, Patchwork, Risk, Super Mario Brothers, Tetris, Tsuro, Watch Dogs 2

Research References

Shepard, R.N., & Metzler, J. (1971) Mental rotation of three-dimensional objects. *Science*, *171*, 701-703.

Kosslyn, S. M., Ball, T. M., & Reiser, B. J. (1978). Visual images preserve metric spatial information: Evidence from studies of image scanning. *Journal of Experimental Psychology: Human Perception and Performance, 4*, 47-60.

Pylyshyn, Z.W. (2002). Mental Imagery: In search of a theory. *Behavioral and Brain Sciences*, *25*, 157–182.

Clive Wearing video

Transcript

Hello! Welcome to episode two of Cognitive Gamer. I am Steve Blessing, and I hope you have played some fun games since the last podcast. In that first podcast we talked about how words and other verbal material are stored in long term memory.

I'm going to continue that theme in this podcast and stay on memory. Don't worry, I'll talk about other topics in later podcasts, but memory is a big one! In a typical cognitive psychology text, about a quarter of the book is specific to memory, so it's an important topic! When I teach intro to psychology, I often start with the memory chapter, even though that's not the first chapter in the book, usually it's like chapter 6 or 7. I start there because it gets us to an interesting topic quickly, but also because it's ***that*** important. I show the students a short clip of a man named Clive Wearing. At the age of 47, Mr. Wearing suffered from encephalitis, a disease that attacked his central nervous system and destroyed part of the brain responsible for recording new memories, the hippocampus. He simply cannot form new memories; he cannot carry on a conversation, because within 10-20 seconds, he will have forgotten what you just told him. Living without a memory, like Clive, is a very sad state of existence, and just goes to underscore memories' importance.

Last time we talked mostly about verbal memories, those memories that really come into play during games like Codenames and Scattergories. In this episode I would like to talk about how we store and represent more visual information, like what we might use when we play a video game like Tetris and need to mentally rotate that piece to figure out where it might fit, or how best to play the piece we just drew in Carcassonne or Tsuro.

This is a dichotomy that we see across all levels of memory, between how we store and represent more verbal information, and how we store and represent more visual information. This is the way our brain is wired, with part of it dedicated for verbal information, and part more dedicated to visual information. Differences can be seen with how that information is brought in initially through our senses, how it's stored in our shorter term memory, and ultimately how it's stored for longer periods of time. In later episodes we'll talk about those shorter periods of time, referred to as sensory memory and working memory. But for now, I'll like to talk more about longer term stores and representations.

Probably for most of you, this seems kind of obvious. When you are storing and retrieving verbal information, like a shopping list or words for Codenames, it seems like you are doing something different than when you are trying to store and retrieve a picture or rotate shapes in Tetris or Patchwork. In short, the shopping list seems like words, whereas the image you can see in your mind's eye seems like a picture. As we'll see, psychologists actually debated this point: do we really have two different ways to store information? Or, can we account for the findings by having only one way in which our memory systems store information. Having only one way to do it would be more simple, more parsimonious in scientist speak, so it has its advantages. But, if the data show that we need two, like it seems to be, then we need two, and a slightly more complicated system. We'll see in a number of later episodes how our intuitions about how our minds work can be wrong, but this is one case where our intuition is correct. We have verbal ways of remembering information, and we have visual ways of storing information.

For now though, let's talk about this more visual way of storing information. Earlier I used the phrase, "your mind's eye," and that's really what this memory is about, being to store, recall, and act on that visual information in a way that's consistent with how your actual vision works, but one that's an entirely mental construct. Having this more pictorial representation for your memory system proves to be very powerful. You have probably heard of the expression, "A picture is worth a thousand words." I do a simple demo of that in class, where I show my students a simple picture of my two kids, and ask them to describe it. They start with just a very simple description, like "a boy and a girl sitting together" but after I get the ball rolling by talking about color, about position, about what's going on in the background, they see that indeed, one can say a lot about a very simple picture. In short, pictures are a very compact representation for information that has a strong visual component.

You can also do operations on pictures that you just cannot do on verbal representations. Here's another short demo I do in my class. I want you to imagine a capital letter D. Now, I want you to rotate that D so that it is laying on its flat part, its spine if you will. Now, take a capital letter J and move it so that it is just below the D, touching the midpoint of the flat part. What do you see? Did you say umbrella? If you did, that's the beauty of the mind's eye. It allows you to do those visualizations and rotations as if you could manipulate the actual shapes. How do you think that might help in playing games?

Visualizing using your mind's eye also helps you to solve problems and come up with explanations, both in real life and in games. For example, imagine trying to pack the trunk of your car for a long vacation without being able to visualize how you might solve that problem first. You would have to move and try lots of positions of luggage until you get one that works. But, by using your mind's eye and visualizing the moves first, you can pack the trunk of your car with minimal effort. Well, hopefully. As with most cognitive skills, there are individual differences. That is, some people are just better able to do it than others. Some of being better comes as natural skill, and some comes with practice. That also true of playing games, too, like classic arcade games like Breakout and Asteroids, both of which have a strong visual component. But, expertise is a topic for a different time, so we'll talk about that later.

Some scientific theories were discovered with the help of mental imagery. Abraham Ortelius and others, back in the 16th century noticed how the continents could be rotated and moved in order to fit together. This led to continental drift theory. The chemist August Kekule in the 19th century claimed he had a vision of a snake seizing its own tail, and this vision allowed him to figure out the structure of benzene. Mental imagery is a powerful way to represent the information we need to process. These operations of inspection, rotation, transformation, and zooming are difficult to imagine using a more verbal-based representation. One can easily see how these representations come into use when playing a variety of different types of games. Obviously about any video game has a strong visual component to it, as we consider the best path between one location and another, or need to think about how to rotate or transform one shape into another, either in a 2D or a 3D environment. Many board games also have a visual component. I'm sure many of you have played Risk or Pandemic, and can easily call to mind the paths and connections between the items on those boards, without the board being physically present. Keep those sorts of things in mind as we talk about the science behind how we store items with a strong visual component.

Let us now start to consider the evidence and capabilities behind these visual representations. I'm going to talk about 2 classic experiments done in the 1970s to illustrate these points.

One of the most famous experiments, done in 1971 by two researchers named Roger Shepard and Jacqueline Metlzer, involved people playing Tetris. Well, okay, not Tetris. It was 1971 after all and Tetris hadn't been invented yet. But, if you look at the task the participants did, it sure looked like it involved the pieces used in Tetris. The participants were given pictures of two Tetris-like shapes side-by-side. They weren't quite the usual Tetris shapes, though, because they were drawn to look three dimensional. The shapes were composed of about 10 cubes, arranged in various orientations to each other. The task the participant had to do was to indicate if the two shapes before them were the same shape or different shapes. In most of the trials, to make that determination, the participant had to mentally rotate one of the shapes in order to see if they could line it up with the other shape. Sometimes the shapes could be lined up, and sometimes they couldn't. All Shepard and Metzler did was to measure how long it took the participants to make that determination, to say yes or no to whether the shapes were the same. Their main finding was also pretty simple, but important enough that it merited publishing in the influential journal Science. Not surprisingly if the two shapes started off in the same orientation, participant's judgement time was quickest. If the one shape had to be rotated a lot in order to get a match, then it took noticeably longer. The really neat finding is that this increase in judgement time was linear with regards to how much the shape had to be rotated. The graphs that Shepard and Metzler provided, and that has been reproduced in a large number of studies, is that as the amount of mental rotation increased from 0 to 180 degrees, one sees a nice linear increase in the judgement time, just like one would see if one had to physically rotate the objects. But, the participants weren't physically rotating the objects, they were mentally rotating them. This was an early study which considered that there must be a different representation used between verbal stuff and visual stuff. If we used a more verbal representation for these shapes, then one wouldn't expect that linear increase between amount of rotation and judgement. With a more verbal representation, one would probably expect a more linear judgement time.

The other classic experiment from the 1970s that I would like to share with you was done by Stephen Kosslyn, Thomas Ball, and Brian Reiser in 1978. In one part of their experiment, participants were shown a simple line drawing of an island. Think about all the maps you've seen in various video games. On the island used in the experiment were several landmarks, such as a beach, a hut, a swamp, and a tree. The participants had to memorize this map. Kosslyn and his colleagues made sure it had been memorized by waiting until the participants could draw the map from memory. Once the participants could do that, then the next phase of the experiment started. In this phase, the participants were verbally given one location on the map. Another location was then given. This location may or may not be on the map. If it was not on the map, participants pressed one of two buttons. If the second location was on the map, then they had to imagine a dot moving between the first location to the second location and then press the other button. The researchers presented the data for these second type of trials, where the participants imagined a dot moving between locations. Much like with Shephard and Metlzer's study there was an almost perfect linear increase between the distance of the two map locations and the reaction time to press the second button. That is, the longer the distance on the map, the longer the reaction time, again suggesting that participants were using a mental representation very similar to that of a physical representation.

These experiments, along with many others done during the same time frame suggested that the way in which we store visual information is different than verbal information. As I mentioned earlier, this was not a cut-and-dried case though for scientists. Some still argued for a more parsimonious view that accounted for the findings without resorting to another type of storage. Leading the charge was a cognitive scientist with the interesting name of Zenon

Pylyshyn. He argued that our sense of having an imaginal representation for doing these processes was epiphenomonal, meaning they were just a by-product of how the mental procedure was actually done, which he argued was through a more verbal-based, propositional network. Data collected in the last twenty or so years that involves the use of brain scans support having two different representations. In short, these data show that when people imagine something, they by and large use the same brain structures for mental images as they do for physical images. One sees a lot of activation in the part of the brain called the occipital lobe when someone looks at something. However, one also sees a lot of activation in that area when someone uses their mind's eye as well. So, it looks like we use the same machinery when we mentally imagine something as when we physically look at something.

As I've said, we use these visual representations a lot when we play games. Once you see the stimuli that Shepard and Metzler used, you will always think about their study when you play Tetris. To proficiently play the game, you don't want to physically rotate your tetromino around anymore than you have to, and you want to figure out where to place it as quickly as possible. Both of those goals require the use of mental rotation and transformation. That is also true of figuring out what piece would be best in the boardgame Patchwork, or how best to lay that tile in Carcassonne. In all of these games we rely on visual representations.

I also think about these sorts of concepts when I play video games that have a map or other type of spatial environment associated with them. Many games have an in-world map, or at least a 2D or 3D environment that needs to be navigated, like Horizon Zero Dawn, Assassins Creed, or Super Mario World. How I remember these spaces and represent them in my mind will use the very visual type of representations that we've talked about here. As I figure out how to navigate my character from one location to the next, I am using my mind's eye and these visual representations, and the part of the brain that I'm relying on is the same part of my brain that helps me to physically see something as well.

This calls to mind one last demo I'll share with you, one that shows that there are at least some differences between our mental representations and physical representations. I don't want to leave you with the impression that visual mental representations are identical to physical images; just similar. Let's start off with this question: which city is farther west, Reno, Nevada, or Los Angeles, California? Don't use a map! Which one do you think it is? If you have a sense of US geography, you probably said Los Angeles, California. But, that turns out to be wrong. Reno is in the very western part of Nevada, and the way California hooks around it to the south, Los Angeles turns out to be farther east than Reno. That surprises a lot of people. If that one didn't work for you, which city do you think is farther south, Montreal, Canada or Seattle, Washington? It's Montreal, actually. The point is, that in our mental visual representations, we often make simplifications. We'll put right angles where there shouldn't be. We'll have things be parallel when they really aren't. That makes them easier to remember, and might even help in navigating, but will lead to errors like what you see here. There are have been some interesting studies of cab drivers and their mental representations of the cities they navigate, and they exhibit these sorts of errors as well. A lot of studies have been done on London cab drivers, given the extensive knowledge they have to commit to memory in order to navigate around that city. Perhaps on a later podcast I'll talk more about that work. For now, I'll just close that I thought a lot about these kinds of things as I was playing through Watch Dogs 2, an open-world game set in a pretty realistic San Francicso. I had a pretty good mental map of San Francisco before playing, having spent a fair amount of time there. That helped me out while playing the game, being able to get around the city. However, they of course took short cuts in making the map, as not every part of city was represented and liberties were taken with the in-game map. I'm sure my mental representation of San Francisco has now been tragically altered by having played Watch Dogs 2. It would be interesting to do a study!

In a future episode I'll talk about how the representations that we've talked about in these first two episodes co-exist, as obviously they must. I'm thinking about games like DixIt, which of course have a strong visual component, but then that gets distilled down to a verbal clue that is given to the other players, who then must translate that to the pictures on their cards. This use of both representations are at the heart of most memory techniques, so whenever a player needs to remember a lot of information, pairing a visual representation with the verbal representation can be very powerful. That's how many card counters do their thing. But again, that will be a topic for a later episode.

Okay, that wraps up another episode of the Cognitive Gamer podcast. I hope you have enjoyed it and learned something about how your mind processes visual information and how that works out whenever we play games. In the next podcast I'm going to talk about attention, and how that affects our ability to play first person shooters and other games that require our full attention in order to play them. Between now and then, if you have any questions or comments, please email me at steve@cognitivegamer.com. I would love to hear from you, and if you have a question, I may answer it in a later podcast. Also, be sure to like my facebook page, Cognitive Gamer, and to visit the website cognitivegamer.com. Until next time, remember to think about what you play, and have fun doing it.