Episode 32: From the Bottom to the Top and Back Again

Show Notes
When processing information, humans use both the information coming through our senses and previously stored knowledge. This is referred to as bottom-up versus top-down processing. This podcast explores how this occurs when we play games.

Game References
Paranormal Detective

Research References
Cattell, J. M. (1886). The time it takes to see and name objects. *Mind*, *41*, 63–65.

McCelland, J. & Rumelhart, D. (1981). An interactive activation model of context effects in letter perception: part 1. An account of basic findings. *Psychological Review 88*(5), 375–407.

Dogs that look like fried chicken:
https://i.pinimg.com/736x/87/41/65/87416554d02921c91d3116c77c6cf8b7--hilarious-stuff-funny-jokes.jpg

Blind Spot Demo
http://people.whitman.edu/~herbrawt/classes/110/blindspotdemo.pdf

Transcript
Hello! This is Episode 32 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, and it's been a while since my last podcast. I apologize for the hiatus, but the pandemic has thrown us all for a loop, hasn't it. Hopefully we are beginning to see the light at the end of the tunnel. To be honest, I didn't play many games this past year. I had the time and I was locked down with my family, but we ended up not playing very much. It's only been recently that we have started again. I know that was some people's experiences, whereas others played a lot of games. At any rate, I hope you are safe and healthy, and I'm ready to talk about what playing games can tell us about how we think.

One of the games I did play was one called Paranormal Detectives by designers Szymon Maliński, Adrian Orzechowski, Marcin Łączyński. In the game, one player plays a ghost that was killed via some means, and the other players, the paranormal detectives, have to guess who, how and why this player was killed. The ghost of course can't simply say how and why they were killed but can only communicate through a variety of different, somewhat indirect means, like using pipe cleaners to make a picture, mouthing words, or drawing on another player's back. By using these limited pieces of data and filling in the gaps of knowledge, the players can deduce the why and how of the ghost's demise.

A lot of games have this set up, of what players know for sure to be true and then some information that needs to be filled in on the basis of that. Obviously most mystery and deductive games, have this, but probably most games have this dichotomy between known data and

information guessed at based on prior conceptions. This distinction is the one I would like to talk about in this episode, and it is a very basic, foundational idea within cognitive psychology. It usually appears in Chapter 1 or maybe Chapter 2 of a cognitive psych textbook, and is a major distinction between how we process information. Cognitive psychologists will often talk about the difference between bottom-up and top-down processing. Bottom-up processing, or what I prefer to call data-based processing, is how information comes into our cognitive system, through our senses. Let's consider vision. Light waves bounce off an object and enter our eye. Those light waves hit the back of our eye, where the rods and cones are. The rods and cones transduce the energy in the light wave into energy that our neurons can understand, and that energy, that message, goes from the rods and cones, to the optic nerve, to the thalamus, and then on to the occipital lobe, the main cortical area for vision. At each of those locations, there's processing and organization of the signal that happens, so that vision can do what it needs to do, namely identify the lines and edges in the visual stream that denote object boundaries in order to do object recognition.

That process as just described would be called "bottom-up," because it's all about the data following that pathway from first being picked up from the environment by the receptor cells, the rods and cones, and then finally being transmitted to cortex, through the optic nerve and thalamus. That seems straightforward, but it's not the only way we make heads and tails out of what we are seeing. Sometimes that signal is incomplete, and we need to fill in some missing details. That requires using previously stored knowledge, and whenever we do that, that's top-down processing, or what I will sometimes call either knowledge-based processing or conceptually-based processing. From a more neurological point-of-view, this involves parts of the cortex sending signals to parts of the processing chain that has occurred earlier. For instance, in addition to the bottom-up connections that go from the thalamus to the occipital lobe, there are also connections that go the other way, from the top-down, from cortex to thalamus. These connections help to clean up and provide context to help direct the processing in the thalamus. Indeed, if you look at the absolute number of connections in this particular example, between the thalamus and occipital lobe, there are substantially more connections from cortex to thalamus than going the other way, bottom-up.

When I say the information is incomplete coming from the retina, I can give you a very clear example of that. Close your left eye. Looking with your right eye, you can see the world around you I hope pretty clearly and without issue. You don't see a tiny hole in your vision, do you, maybe about 15 degrees to the right of your center point of vision? If we relied solely on bottom-up processing, you would have such a hole in your vision, because that is where your blind spot is. Due to the quirky way our rods and cones communicate and are arranged with our optic nerve, there is a break in the rods and cones to allow the optic nerve to exit the eye. For the right eye, that exit location is about 15 degrees to the right of the center point. Because there are no rods or cones at that point, that means there is no data coming in that would image whatever is at that location in your visual field. But yet you still perceive an unbroken visual image, because there is a filling-in mechanism that happens later on in visual processing, or in other words some top-down processing, that fills in the missing information. If you google "blind spot demonstration" you can find lots of demos to illustrate that indeed, if you arrange things just right, there is a small hole in your vision. I'll link to one of those demos in the show notes. But, in most everyday situations you do not notice it, because of good old top-down processing.

I'll also link to a picture that I use in my class to demonstrate data driven v. knowledge-driven processing. In class, I will only show it to them for a brief period of time, as quick as I can advance the slide. I then ask what they see. The picture is actually of brown furry dogs in a kennel, with a wire grate in the floor. But, some students, perhaps the hungrier ones, will see it as fried chicken. Because the image is slightly ambiguous, and I just flashed the image, not enough for them to get all the data so to speak, they have to do some top-down processing to fill in the missing pieces, and some, perhaps the ones who didn't have breakfast, will perceive chicken and not dogs.

I have a lot of visual examples I could share, but those obviously don't work well in a podcast. I do have at least one that will work well as an auditory example of bottom-up v. top-down processing. This comes from a demo from the textbook by Bruce Goldstein that I use in my Sensation and Perception class. The book used to come with a CD-ROM that had many examples for each chapter with it. This demo comes from the second chapter on hearing, one that talks about different auditory heuristics that we use to figure out what we are listening to. For example, when two people are singing a duet, we can hear the two distinct voices, even though the soundwaves coming from their mouths are totally overlapping by the time they reach our ears. We can distinguish them due to similarity of frequency and similarity of timbre.

Another heuristic that we use is called good continuation. We do this in the visual realm as well, that is, we assume a line tends to continue in the direction it was going, so we will mentally link line segments together if parts of them are obscured, and it turns out we do the same thing auditorily as well. The following tone is like a slide whistle, with an oscillating frequency. Notice that there are noticeable gaps in the sound as it plays.

<sound 1>

Did you hear the gaps? There is total silence in those parts. Or in other words, no data.

Now then, I'm going to play another sound, the same slide whistle noise. But, this time white noise, a bit of static, has been inserted into the gaps. And that's all it is, just static. Here's the sound.

<sound 2>

Many people perceive that the slide whistle noise plays above the static. If you heard that, then you are doing top-down, conceptually driven processing. You are connecting the auditory dots over the white noise. Because that white noise is simply that, it's just static. The slide whistle sound is not there, but with the static, it gives our ear and auditory cortex a reason to connect those auditory gaps and perceive something that's not in the data.

I'll give you another, similar example to listen to. This sound is a steady frequency, but with gaps of silence inserted:

<sound 3>

Now, like before, the same sound, but with static inserted into the gaps.

<sound 4>

Perhaps if the first demo didn't quite work for you, this one did, Again, many people hear the steady sound of the tone above the static, but like before, the static is just static. That tone noise you hopefully perceived simply is not there, but rather your auditory cortex doing top-down processing.

It's this kind of auditory processing that allows us to listen to a static-y radio station or carry on a conversation in a crowded and noisy room. We don't get all the data in those situations, but we get enough to fill in the gaps, either through good continuation or other means, enough to seemingly perceive or at least understand what's being said. This is also partially why some people prefer analog vinyl records over digital sound files when listening to music. Your cortex might have to do a bit more top-down processing with the analog signal, which partly explains the warmer sound that some report when listening to a physical record.

Before talking about how this applies to game playing, I'll give you an experimental finding that shows bottom-up and top-down processing in play. It's a finding from a little while ago, the word superiority effect. It's also an early win for neural networks as an explanation for cognitive phenomenon. It has been known for quite some time, a researcher named James Cattell in 1886 actually first noticed this, that people are quicker to recognize letters in the context of a word than they are to recognize that same letter either by itself or in the context of a non-word. That is, if I gave you the task to recognize the third letter of "W-O-R-D" you would say "R" faster than if I either gave you an "R" by itself or the task was to recognize the third letter of even something like "W-U-R-K," a pronounceable non-word. In 1981 Jay McClelland and David Rumelhart, big names in neural networks back then, created a neural network architecture they referred to as the interactive activation model that basically had top-down and bottom-up processing happening, in a way not too dissimilar to how the human visual system works, at least at a macro-level. The word superiority effect exists because as the data is coming from the thalamus, helping us to recognize the individual letter features, that's the bottom-up activation, there is also activation coming in from higher levels of the visual and cognitive system, the parts that tap into our knowledge about possible words, and this top-down activation is also causing the individual letters to become more and more active, and so the condition where the "R" is in the context of a an actual word, "W-O-R-K," the letters will receive the most activation first, because it is getting activation both from the bottom and the top, and so the "R" will reach threshold quicker and you'll recognize it more rapidly.

This distinction between bottom-up and top-down processing occurs often when talking about our senses. I touch on it in many discussions in my Sensation and Perception class. But, more broadly, it occurs for most of our cognitive processing. Which, as I said at the beginning, includes all the games we like to play. Let's consider Paranormal Detectives again, because I think this data driven v. knowledge driven distinction comes into play at a couple of different levels in that game. Each turn, a detective asks a question of the ghost, and the ghost answers using one of various different means. Each of these means themselves is some mixture of data-

driven and top-down processing. In one method of communication, the ghost can mouth a word. This is very much like I was talking about with Sensation and Perception. The detectives see the mouth moving, that's the data. But, that can be very ambiguous. Did they just say "mall" or "ball?" "Knife" or "nerve?" Maybe you can figure it out based on the other clues you received in earlier rounds; that would be using top-down processing. Another technique the ghost can use is to draw on the detective's back. Again, the data can be very ambiguous, and you'll have to use previous clues and guesswork to figure it out. All the techniques have that characteristic, a mixture of bottom-up and top-down processing.

And then, once you think you have figured out that clue, you can then use that data along with the other clues to figure out the broader crime or incident surrounding the ghost's death. This gives a slightly broader meaning to top-down and bottom-up processing, outside of just sensation and perception. As an aside, if you haven't had a chance to play Paranormal Detectives, I highly recommend it especially if you like other deductive games, particularly Mysterium.

Of course, I think about this distinction in other games as well, such as even trick-taking card games. In these games you need to observe what other people play in order to figure out what else might still be in their hands. That ace of diamonds they just played, that piece of data I just observed, did they just play that high card to take the trick because they have more high cards, or are they now out? Using that data can help you fill in some of the gaps needed in order to better play your cards.

This too, though, leads to the broader meaning of top-down and bottom-up processing. I've seen these phrases used in a number of contexts outside of cognitive science, everyplace from management to investing to even occupational therapy. In these areas, I think a similarity can be drawn from the distinction between strategy and tactics. Tactics are the moment-by-moment decisions made on the ground, which starts more at the bottom, using more micro-level pieces of data to make your choices, whereas your strategy is your overall set of goals you want to accomplish, which requires much more of a top-down, macro-level view and knowledge of the world. Put in those terms, that distinction can be made across a whole host of games, in particular any wargame, area control game, or miniatures tabletop game out there. How much of your game-play is driven by the turn-by-turn dictates of your current position, versus how much of it comes from a higher-level set of goals you set out at the beginning of the game, or even your goals as they evolve based on what's happening during the game. Again, good play, just like cognition, isn't all one or the other, but it's a combination of the two. When doing some searching for this podcast, I came upon this Sun Tzu quote form the Art of War, "Strategy without tactics is the slowest route to victory. Tactics without strategy is the noise before defeat." You need both, just like you need data driven versus knowledge driven processing. I stress to my students that sensation and perception in particular, or cognition in general, isn't all one of the other, but it is a mixture of both bottom up and top down processing.

That brings us to the close of this episode on different methods of processing. 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 Twitter, @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.