Episode 23: Game, Mental Set, Match

Show Notes

Game players often get stuck, either not seeing how to properly use an object in the game or perhaps persisting in an inefficient strategy. I discuss two such mental sets, functional fixedness and Einstellung.

Game References

Burgle Bros, Defender, Go, Hanabi, Hoizon Zero Dawn, Overwatch, Root, Tetris

Mutilated Checkerboard:
https://en.wikipedia.org/wiki/Mutilated_chessboard_problem

Defender:
http://www.folklore.org/StoryView.py?story=Make_a_Mess,_Clean_it_Up!.txt

Research References

Adamson, R. E. (1952). Functional fixedness as related to problem solving: A repetition of three experiments. *Journal of experimental psychology*, *44*(4), 288-291.

Bard, N. and colleagues (draft). The Hanabi Challenge: A New Frontier for AI Research. Download at: https://arxiv.org/pdf/1902.00506.pdf

Duncker, K., & Lees, L. S. (1945). On problem-solving. *Psychological monographs*, *58*(5).

Luchins, Abraham S. (1942). Mechanization in problem solving: The effect of Einstellung. *Psychological Monographs*. **54** (6): i–95.

Transcript

Hello! This is Episode 23 of the Cognitive Gamer podcast. I am your host, Steve Blessing, a professor of cognitive psychology at the University of Tampa. I use games to both explain and explore how we think. At the end of the last episode I mentioned two cognitive phenomena, functional fixedness and Einstellung. I thought we would take a closer look at both of these in today's podcast. Both can be referred to as a mental set, or an issue that arises when performing a task or solving a problem. Generally speaking, these mental sets cause you to not see or consider the full picture, thus causing you not to be as efficient at going about your life. Which, for us, includes playing games! As we go along, I'll give you lots of examples of how these two issues can sneak in as we play both video games and board games.

I’ve mentioned my love of puzzle games before, like the video games The Witness or the Talos Principle, or in tabletop games things like the Exit and Unlock series, along with other escape-room style experiences. Many times in these sorts of games you need to “think outside the box,” overcoming preconceptions about how the world should be looked at in order to perform actions you might not have initially considered. This is what functional fixedness is all about—being “fixed” in your thinking regarding the “functions” of various objects.

Many of you are probably familiar with the puzzle that many believe the phrase “thinking outside the box” originates from, but if you’re not, here it is. The puzzle starts with a 3 by 3 grid of dots. The challenge is to connect all nine dots using 4 straight lines. The big constraint though is that once you start drawing the first line, you cannot pick the pen up until the fourth straight line is drawn. If you haven’t done this one before, go ahead and take a few seconds to think about it. Or perhaps better, get a pencil and paper and try to do it. And, you do have the big hint that this puzzle started the phrase, “thinking outside the box.” Go ahead, give it a try.

If you didn’t already know the solution, were you able to figure it out? It’s not the easiest of puzzles, because it does require you to overcome a type of functional fixedness. Most people place an additional constraint on the problem that any line they draw must stay within the bounds of the grid. But, to solve the problem, you have to draw outside of the grid in order to connect all the dots with only the 4 lines. Why is this hard, and what does this tell us about playing other types of games, and more generally, about how humans think in day to day life?

In answering this question, I’d like to give you just a smidge of a history lesson in psychology. It turns out that psychologists have been grappling with how to answer that question ever since psychology began as a distinct field of study, back in the latter half of the nineteenth century. Some of the first psychologists, like Wilhelm Wundt and Edward Titchener, believed that the mind could be studied by investigating and breaking it down into its fundamental components, much like chemists had had success at breaking matter down into its atomic structure earlier in the nineteenth century. In terms of the mind, then, they held that the whole would equal the sum of its parts. Know the parts, and you have the whole. They would take the stance that if we know how we think about this part of puzzle, say in terms of memory, and we know how we think about this other part of the puzzle, perhaps decision making, we can put those two observations together and see how we think about the whole puzzle. We now call this historical school of psychological thought structuralism, concerned with the structure of the mind.

Not all early psycholoigsts were structuralists though; we also had the functionalists and the Gestalists. These scientists would say that in terms of studying the mind, how we think, you need to study the whole activity and not break it into parts. In other words, in terms of thinking, the whole is greater than the sum of the parts. If you tried to look at just the parts, you would be missing something. These psychologists then were not concerned as much with structure, but with function. They would take the stance that in order to see how we solve puzzles, you have to look at how we solve the puzzle all together, say both memory and decision making, not the individual parts.

Today’s psychologists don’t call ourselves structuralists, functionalists, or Gestaltists, but we still grapple with the question of do we need to study the whole behavior that we are interested in, in the context in which it is performed, or can we study bits and pieces of the behavior, perhaps outside of its original context, like in a lab. Or, again in other words, is the whole equal to or greater than the sum of its parts. Most psychologists will see advantages and disadvantages to both approaches. You can sense that tension in even a simple problem like the nine dots problem and the approach a structuralist might take to study it versus a Gestaltist.

To give a game example here, I think an asymmetric game like Root from the board game world or something like Overwatch from video games, with the different roles that you can take on during play. In order to figure out how those games work as a whole, could you just study the individual factions and roles separately and see how each works individually? Well, you have to have some of that knowledge, so that might not be a bad place to start. Or, you could study it by looking at how the factions and roles interact, and how they help or hinder each other during play. And again, that knowledge will be necessary as well, because in none of these games do just one faction or one type of character plays, but rather several different types all play at once, and depending on the roles, different sorts of play will emerge.

These different approaches, structuralism, functionalism, and Gestaltism, affected the types of cognitive phenomena the early psychologists studied. The structuralists were fond of perceptual experiences. The Gestaltists were also fond of such perceptual demos, perhaps primarily as a way to show up the structuralists, because their demos had the nature that the observer would see things not directly represented in the drawing, but that only emerged out of the way the individual pieces were arranged. A simple example of this is something the Gestalists called the phi phenomenon, which is basically how animation works. I imagine you've seen a flip book, and you know how Disney animators get Mickey Mouse to walk across the screen. If you present a properly sequenced series of still images, the observer will sense motion; Mickey Mouse walking across the screen. But, Mickey Mouse isn't really walking, that motion isn't in any of the individual parts, the static images. The motion only arises when the parts are arranged just so; or in other words, the whole is greater than the sum of the parts, because the parts here are just static images. Because of this, the Gestaltists were also very interested in problem solving behavior, and how the situation presents itself to the solver and the manner in which the problem solver attempts the solution.

I should explain a bit this word I've been using to describe this school of psychology, Gestaltism. Gestalt is a German word that doesn't have a great translation into English, but it's something like "shape" or "form." So if I'm talking about the Gestalt, I'm talking about the whole thing and how it's arranged, not the individual pieces. You can see how the name fits the movement, given their stance on the whole being greater than the sum of the parts. That also lead them to be interested in investigating what is termed insight problems, problems that you tend to have an "A-ha" moment while solving, in which the solution suddenly presents itself. The nine-dot problem is one such problem; you need to have that insight that you don't have to constrain yourself to drawing lines inside the grid in order to solve the problem. The whole shape, or Gestalt, is important, and you need to consider how the pieces relate to the whole in order to solve the problem. Another classic insight problem is the mutilated checkboard problem. It involves putting dominoes on a checkboard that has a couple of spaces taken out of it. I'll put a link to it in the show notes if you like these sorts of puzzles and want to give that one a go.

This examination of insight problems and what causes some people to solve them and others to not solve them lead Karl Duncker in the 1940s to investigate something he called functional fixedness. The common example used from that study is the candle problem, in which the problem solver needs to figure out how to make a wall sconce for a candle. The problem solver has a candle and a box of tacks, among other objects. The solution is to empty out the tack box, and then use the box lid as a platform to hold the candle, using one of the tacks to adhere the box to the wall. Most people though exhibit functional fixedness, and do not see the box as anything but something to hold tacks, they don't see it as a potential candle holder. That is, they are fixated on that one function of the box, and not on other uses of it. Overcoming functional fixedness can be hard, but I'm sure we've all used something other than a hammer to drive in a nail. Whenever you have used a shoe, a screwdriver, or a heavy book to put a nail into a wall, congratulations, you have overcome functional fixedness.

Overcoming functional fixedness is a key to success in getting through many puzzle games, like the Exit and Unlock games, or the maze video game The Witness. Being able to see an object in a different light is often what enables a solution. In an escape room style game I have played, you had to see the box insert as something besides a box insert in order to solve one particular puzzle. What allows someone to more easily overcome functional fixedness? Practice helps. As you see more examples of solution types, you can more easily overcome functional fixedness. In a follow-up study to Duncker's original work, Robert Adamson looked at something he termed utilization. If the candle problem is presented to participants with the tacks already in the box, pre-utilization to use his term, they were less likely to solve the problem than if the tacks were outside of the box at the start. That can explain why in playing games and solving puzzles, moving things around and looking at things from different angles can help, because you are more likely to find additional uses for the objects that are available to you. Typically puzzle designers will give you a bit of a hint as to what to look for, with a misspelling or a color or a symbol, but not always. It usually always pays to fiddle with the different objects available to you to figure out the solution, as this will get it out of its pre-utilization.

Game designers can also benefit from such "thinking outside the box." I'm not sure if he was the first to do this, but in his game Hanabi, game designer Antoine Bauza overcame functional fixedness to have players hold their cards facing away from themselves, not towards them. That means you don't know what you are holding, everyone else does, and the game becomes one about communication and figuring out what you have and what you should play based on what your fellow players tell you. As an aside, AI researchers including those at Google's DeepMind project have recently proprosed Hanabi as an AI challenge problem. I'll put a link to a draft to their paper in the shownotes. As another quick example, some designers have used dice not as a way to get a random number, but rather as counters. That's how Tim Fowers used a die to keep track of guard movement in Burgle Bros. It's a non-standard use for a die, but it's clever because it's easier to use than a chit for this purpose and they are easy to come by. I've heard a couple of designers now say it would be great if someone came up with a use of the cardboard that's left over after you have punched out the pieces of a game. Again, that would be overcoming functional fixedness, seeing that excess cardboard as something besides trash.

The other mental set I would talk about today is Einstellung, another German word without a great translation, but roughly meaning "setting" or "attitude." This happens when a problem solver fails to see or consider a simpler solution when one presents itself, but instead continues pursuing a less efficient strategy. I offhandedly mentioned Einstellung back in Episode 12 when I talked about the video game Horizon Zero Dawn. I was failing at a hunting challenge because I did not consider all my options as to how to hunt the mechanical dinosaurs. Instead, I was persisting with my tried and true, but less efficient, way of dealing with the beasts. Einstellung is another mental set, as it prohibits you from being as efficient as you can be at solving problems. And, like functional fixedness, comes into play quite a bit while playing games, like in my Horizon Zero Dawn example.

A Gestalt psychologist by the name of Abraham Luchins studied Einstellung initially, back in the 1940s, during the same time period as Karl Duncker was looking at functional fixedness. Luchins developed what he called the waterjugs task. Bruce Willis had to solve a waterjugs task to avert disaster in Die Hard III, about the only redeeming quality in that movie. In Luchins' task, he told his participants about three waterjugs. In the first problem Waterjug A could hold 21 units of water, Waterjug B could hold 127 unit of water, and Waterjug C could hold 3 units of water. An unlimited supply of water is available, so that jugs could be filled and dumped out when needed. The task was to figure out what sequence of filling up and pouring out could result in exactly 100 units of water. Remember 3 jugs, 21 units, 127 units, and 3 units. Think about it for a little bit, can you figure out the sequence? It's relatively straight-forward. Fill up the 127 units, then dump it out in to the 21 unit jug. That leaves 106 units of water. Then fillup Jug C, dump out C, then fill up C again, leaving 100 units of water in Jug B. That's problem 1. Problem 2 had different size jugs, but ultimately the same solution, fill up B, dump into A, then dump into C twice. Problem 3 was solved by the same pattern. So was problems 4-8, fill up B, dump into A, then dump into C twice. Problem 9 came around, and the jug sizes were 15, 39 and 3, and the goal amount was 18. The same solution works, fill up B, dump into A, then dump into C twice, but a shorter solution also works, fill up A, fill up C, dump both into B. But, most people didn't see the shorter solution, because they thought they had figured out how all these waterjug solutions worked, and so didn't see the simpler solution.

As my Horizon Zero Dawn example illustrates, this happens in game playing some number of times, and given how it works, more likely to happen to more experienced players, those that believe they know the most efficient path or solution. A dramatic example of this was when Google's Deepmind AlphaGo program played the world champion Go player in March 2016. On Move 37 of Game 2, AlphaGo made a move that apparently no human master would consider making. I'm not a Go player, so I can't explain it more deeply, but that's the way I have heard it described, as a move that a competent, human player would not make. But, AlphaGo made it, and it ultimately had the effect of taking the machine on to victory. The Go Master Lee Sodol and the commentators suffered from Einstellung; AlphaGo didn't.

We can probably all recount games we've played, video games and board games, where we've persisted in making the same types of moves, only perhaps to discover later that a more efficient or better path existed. I'll give two video game playing examples. The first is a simple, personal memory that sticks in my mind as I was learning Tetris. I had a very particular ground pattern I would look for when I had to put the pieces that look like an L. If I saw it, great, if not, I just did the best I could. As I was watching a friend play, I realized he had a different strategy for where to put those L’s. That’s a small, simple example, but had I not seen his strategy for playing L’s in certain configurations, I might have persisted in not being quite as efficient at playing.

A second video game example. I read a story about Burrell Smith, one of the people who designed the Macintosh. I’ll link to the story in the show notes. When not doing hardware design on the original Macintosh, Burrell often played on a Defender machine they had in the lounge. One day he hit upon the strategy to shoot all the humans first thing. That’s contrary to what you’re supposed to do, and results in a firestorm of enemy alien activity you have to deal with. However, that forced Burrell to figure out how to clean up the mess, which resulted in him being a better player and earning much higher scores. He overcame Einstellung, the tendency to repeat the patterns that have worked okay before, and tried a new strategy that ultimately proved more effective.

Think about the times you’ve either not seen a certain use for an item, functional fixedness, or persisted in a non-optimal strategy, Einstellung. Both of these mental sets happen in game playing frequently, and also in real life. This is why it’s useful to think outside of the box, challenge your assumptions, so that you might be able to see more efficient ways of accomplishing your goals, both in games and out in the world.

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.

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