Episode 07 : That Blows Chunks: Increasing Working Memory

Show Notes

One constraint that everyone has is working memory capacity. Or in other words, how many things you can remember at any one point in time. While there are individual differences in this, another aspect turns out to be more important: chunking.

Game References

Chess, Guitar Hero, Konami Code, Scrabble

Research References

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Miller, George A. (1956). The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychological Review*, *63*, 81-97.

Transcript

Hello! This is Episode 7 of the Cognitive Gamer podcast. I am your host, Steve Blessing. This episode returns us back to memory. We'll be looking at one important aspect of memory that goes by the descriptive phrase of chunking! After I describe what it is, I believe you'll agree that this is a great name for the phenomenon.

Let me start by asking you to remember this sequence of words: Up, Up, Down, Down, Left, Right, Left, Right, B, A. Now, I read that fast, and I'm not going to repeat it. But, some number of you could repeat back the 10 words I just said no problem. The others of you would be like, if I asked you what you remember, "ummm, something about up and down, right, left, and an A?" If you remember what I said, say it with me: Up, Up, Down, Down, Left, Right, Left, Right, B, A. That's what is referred to as the Konami Code, and if you grew up playing Nintendo games in the late 80's, you are probably familiar with it. In some games produced by Konami a player could enter the code on the gamepad to get some in-game benefits, like free lives or power ups. It has since showed up in many different contexts, including the 2012 film Wreck-It Ralph and the Bank of Canada even had it as an Easter egg on their website.

The Konami Code has 10 items to it, Up, Up, Down, Down, Left, Right, Left, Right, B, A. Telephone numbers also have 10 items in them. Let me give you a made up number and see if you can remember it: 893-712-6554. In case you are wondering, I double-checked that the area code I used is not one currently in use in the United States. It's only been a few seconds, but can you repeat back those 10 numbers? Maybe some of you? Most would probably find this at least slightly challenging, even those of you would still could repeat back the first list of 10 items that

I gave you, Up, Up, Down, Down, Left, Right, Left, Right, B, A. The Konami code does have some patterns and repeated items within it that I didn't put into the phone number, but that doesn't fully explain why some of you found the first 10 items so easy to remember, but most of you did not probably remember the made up phone number. The reason one set of items is easier to remember is due to chunking.

If you ever had Psychology 101 in college, you probably remember what's given as the capacity for working memory, or short term memory. Textbooks often give students the statistic of 7 plus or minus 2 as the size of short term memory. This comes from a paper written by the famous cognitive psychologist George Miller, back in 1956. The paper had the title, "The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information" and describes a large number of studies that all seem to point to this number, seven or so, as being the capacity of our short term memory. What's the unit being used here though? Is it letters? Words? Numbers? No, Miller himself used the word "chunk," which means a meaningful unit of information. So, short term memory can hold 7 plus or minus 2 chunks of information.

For many of you, the Konami code is a chunk of information. It's not 10 separate items, but rather a single entity that you can unpack. The phone number I gave, though, was not a chunk. It was more like 10 separate chunks, particularly since I didn't use an actual area code. That makes it hard to remember. If I had started it 813, then my Tampa friends would at least have had that as a chunk.

One quick note before moving on, and this is something I could maybe make a whole episode on. I've used both the terms working memory and short term memory. In many contexts they maybe could be interchanged, but I generally use the phrase working memory, as that's the preferred form nowadays. But historically, it has been called short term memory. But, that implies something that's more static and less active than how our shorter-term memory actually behaves. So, in most places, I'll be using the phrase working memory.

For many games, both board games and video games, it's advantageous to keep in your immediate memory many things at once. That allows you to compare and contrast various moves you could make, what the current position of the board may be, and where in the environment you need to concern yourself. If you are limited in what you can keep in your working memory, then your play will be limited. So, using chunking to your advantage can really help your play of many different kinds of games.

I'll give you an example that I use in class about using chunking to your advantage. Here's another straight-up memory test, a sequence of 12 letters: TVIB MCB SUS SR. Let me wait here a couple of seconds. Okay, right about now, let's see if you remember all 12 letters? Maybe at least some? 12 is a lot bigger than the upper bound that Miller put on working memory. Let me give you those letters again, but change my pauses: TV IBM CBS USSR. Those are the same 12 letters in the same sequence, but I just paused differently. If you recognize the acronyms, you probably now have little trouble remembering the 12 letters, because you're not remembering 12 chunks anymore, but are remembering 4 chunks, those 4 acronyms of TV, IBM, CBS, and USSR. Of course, TVIB or MCB from the original list might be a familiar acronym to you, in which case you might not have had too much trouble with the way I read it the first time.

Miller's initial estimate was that what you can hold in your immediate memory is 7 or so chunks. If anything, that's an overestimate. It's probably only more like 4 chunks of information. It's precious little. Just ask my wife when she has me go to the store. I know if it's over 3 items, I should be writing it down! Seriously, though, a lot of research points to the capacity of working memory as more like 4 items of information. Of course, there are individual differences with working memory, and some people are blessed with higher capacities than others. But on average, about 4 chunks of information can be stored.

Let me tell you about one of my more favorite studies to illustrate this point. And, to make it even better for this podcast, the researchers used a board game to collect their data! William Chase and Herbert Simon used chess in a study of memory they did back in 1973. By the way, this is the same Herbert Simon who I talked about a couple of episodes ago with satisficing. Chase and Simon had different people of different chess experience participate in their study. I'll just talk about the chess experts and how they performed versus the chess beginners. Chess is an interesting game to study for a number of reasons, but here it is nice because there is an objective way to measure how good a player is, in terms of their chess ranking. So, the chess masters in their study had won enough games to achieve master status in official chess rankings. The beginner had just started out, and had no official ranking.

They did a number of observations that all had the same flavor. The general setup had the participants observe a chess board that had a certain number of pieces on it. They looked at the board for only 5 seconds and then it was removed from view. After that time, they had a blank board in front of them that they would then reproduce the position of the pieces. Chase and Simon collected a lot of data with this basic setup, but let me share with you a basic finding that illustrates this notion of chunks.

One of the initial types of boards that the participants attempted to reproduce were middle game positions, where the board had 24-26 pieces on it. One of the clever things that Chase and Simon did was to have two different types of quote unquote middle board positions. One type were actual middle games, that could be reached through actual play of the game. Another type of board position was random, where they just took the 25 or so pieces and plopped them on the board, in a way that could not be reached by the actual play of the game. So, you have chess masters and chess beginners, and you have real middle game positions and random board positions.

Let's consider how well the beginners did first. They averaged less than 4 pieces on both types of boards, real and random. So, relating that back to George Miller, it does look like that 7 as the average working memory size might be a bit much. But, how did the chess masters do? On the real board positions, they did great, averaging about 16 correct placements out of the 25 or so. But, on the random board positions, they did the same as the beginners, getting less than 4 pieces right.

This experiment illustrates two things quite nicely. First, it makes a point about expertise. That will be the focus of a future podcast, looking at experts versus novices at a task, but here we see that chess experts aren't experts at chess because they have a phenomenal memory. They performed the same as the beginners on the random boards. This tells us something important about nature versus nurture and how it relates to differences we see in how experts perform at a task. They are probably more made than born. But, we'll talk about that on a later podcast.

For our purposes here, the second thing this experiment illustrates is the power of chunking. The chess masters seemingly overcome working memory constraints on the real board positions. They correctly placed 16 pieces, which is way more than the 7 or perhaps 9 that George Miller's estimate gives. Remember, as pointed out first, experts don't have all around better memories than novices. They perform the same on the random boards. But, on the real board positions, the pieces aren't individual elements to the expert player, but rather the chess master can group maybe 4 or 5 pieces into a single chunk. Perhaps 3 or 4 pieces are arranged in a very indicative attack pattern or these 3 or 4 pieces are a typical way to defend. Once a player sees 3 or 4 patterns, or chunks, like that, 16 or so pieces can easily be remembered, because they are not 16 separate pieces, but 4 or 5 chunks, which can fit into the working memory of an expert. As part of their experiment, Chase and Simon also timed the pauses in how the chess pieces were being placed, and indeed, you could see these chunks in this timing data, in that 3 or 4 pieces would be placed down in rapid succession, a long pause, and then 3 or 4 more pieces quickly placed.

So, one way to remember more items at one time is to gain more familiarity with what it is you want to remember. Chess experts are able to remember true board positions better because they have spent many, many hours playing and studying chess. If you are able to remember the Konami code, Up, Up, Down, Down, Left, Right, Left, Right, B, A, without any mental effort you have probably spent some amount of time using it, such that it is now one chunk of information for you.

Many games I imagine benefit from this chunking mechanism. Chess, as we've seen, but then games that have the same features as chess as well, with the obvious ones of checkers, go, and probably backgammon. But the games don't have to be abstract, and chunking would enter into modern games as well. I know people who play word games like Scrabble and Boggle look for patterns within the letters, and that is facilitated by chunking. Like many people, I was caught up in the plastic guitar craze of Rock Band and Guitar Hero a number of years ago, and there is definitely chunking in music as a general skill outside of games, but also within those sorts of games as well. Certain sequences of notes are pleasing to the ear and allow for transitions between one phrase of music to the next, so those sequences of notes become chunks.

I would like to end this podcast with a short discussion of how these chunks come to be. At a very high level the answer is experience with the domain, but let me tell you about another interesting study done by William Chase this time with his colleague Anders Ericsson. This study examined how experience within a domain changes both working memory and long term memory, all to allow the individual to increase memory size. The task they chose wasn't an interesting game, but rather a pretty dull digit span task. A digit span task is the most basic memory test, where you give a person a list of random numbers, and see if they can repeat them back. The longest the list of numbers they can successfully repeat back, that's the participant's digit span. Not surprisingly, given George Miller's finding, most people have a digit span someplace between 7 and 8. Now then, Chase and Ericsson had a small number of participants practice, and practice, and practice their digit spans. They made a bit of a game out of it. If the participant successfully repeated back all the numbers from the current list, the next list size was increased by one. If they messed up the list, the next list was decreased by one. The simple goal then was to see how high someone could get their digit span. The participant who stuck with it longest is known as SF in the literature. He played about 250 hours of this tortuous game over the span of about 2 years, so about 2 hours or so a week. I hope he was well compensated. He started out at the average digit span, 7. Nothing unusual at all about SF's memory at the outset of the experiment. At the end of 250 hours of practice, what do you think his digit span was? 10? 15? 20 or 25 even? At the end of the experiment, SF tested as having a digit span of 81 digits. At the very least, he had a good bar bet he could pull out to maybe get some free drinks.

Chase and Ericsson did some great work looking at how exactly SF accomplished this. They found changes in both working memory and long term memory that allowed SF to do this feat. For our present discussion, chunking was a big part of it. SF was an avid runner, and what he did was to associate the numbers coming in with running times, using that as a way to naturally chunk the digits. So, if the sequence was 3 4 3 2, he might chunk that as 3 minutes, 43.2 seconds, a near world record mile time. That is obviously particular to SF, but he would also sometimes use dates, like 1 1 6 3, as November 1963, the month President Kennedy was assassinated. In short, he would use something that was already familiar to him, like running times and dates, to interpret the new information, ultimately allowing him to chunk that information into larger and more useful units. This is a simple form of analogy, a topic we will talk about in a later podcast. For now, let me just say that analogy is a very common process that we do a lot. How many times have you described a game you are about to show or teach someone as being like this other game they are already familiar with? Oh, Kingdomino, it's like dominoes meets Carcassonne. Ah, Everybody's Gone to the Rapture is like Gone Home. It's a useful shorthand that allows people to begin interpreting the new game through the lens of the old game, which in part allows you to chunk the experience into bigger, more memorable pieces.

In case you are interested, I also mentioned that Chase and Ericsson found changes in their participant's long term memory as well. If you do the math, I said that SF topped out at a digit span of 81 numbers. Each chunk he would encode had 4 or 5 digits in it. That still makes for like 20 or so chunks, way above working memory capacity. Chase and Ericsson found that experts can also store more chunks than novices, not by keeping them in working memory, but by quickly storing them into long term memory, through what they called retrieval structures. These are structures in long term memory that allow the quick storage of very specific pieces of information, like digits in SF's case. Experts within any task have these retrieval structures that allow them to store specific information, like the status and location of opponents in DOTA or Overwatch, or the state of the board in Scythe or Risk.

I hope that you now appreciate the power of chunking and that the next time you play a game, you might think about the chunks you use to store information as you play the game. Next time we will look at a topic that got me into cognitive psychology, problem solving. 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. Until next time, remember to think about what you play, and have fun doing it.