Working memory, cognitive load, emotion – reviewing Craigslist

Samantha Lee

Human Factors in Information Design, Bentley University

HF700-HB1: Foundation in Human Factors

Dr. Bill Gribbons

December 18, 2023

Humans perceive the world through their senses and these sensory systems have evolved over time (Buchsbaum, B. R., & D'Esposito, M., 2008). So much information is constantly thrown at humans in their environment and sensory systems have evolved to determine which inputs should be stored in long term memory for later use, kept for a short amount of time, or disregarded (Buchsbaum, B. R., & D'Esposito, M., 2008). If long term memory is central to human cognition, working memory is the here and now processing of information (Pass. F., et al., 2010). These determinations are made by the working memory system which stores and processes information temporarily with components including the central executive, the visuospatial sketch pad, and the phonological loop (Baddeley, A., 1992). The working memory system has limitations in capacity and duration as it takes in an unlimited amount of sensory information and then determines what is stored in the vast long-term memory (Paas, F., et al., 2010). The working memory system cannot process everything and with this there is something called cognitive load, which "is increased when unnecessary demands are imposed on the cognitive system" (Sweller, J., et al., 2019, p. 262). Additionally, anxiety is present in the working memory system and can lower control over attention as well as lead someone to place more focus on perceived threats; yet is can also sometimes lead to someone utilizing strategies to overcome these limitations (Eysenck, M. W., et al., 2007). This review of craigslist.org will involve discussion around working memory limitations, cognitive load, and anxiety.

Working Memory

Working memory is limited in its capacity (Buchsbaum, B. R., & D'Esposito, M., 2008). It is extremely important to learning, planning, and reasoning (Carruthers, P. (2013). The working memory model consists of multiple different subsystems, or components (Baddeley, A. D., & Hitch, G. J., 1994). The central executive controls attention at the top level, and then the visuospatial sketch pad deals with spatial and visual information and the phonological loop rehearses audio and speech information (Baddeley, A., 1992). The visuospatial sketchpad is responsible for "object and spatial information" (Buchsbaum, B. R., & D'Esposito, M., 2008, p. 241). Furthermore, it "refers to our ability temporarily to hold visual and spatial information, such as the location of a parked car, or the route from home to a grocery store" (Baars, B. J., & Gage, N. M., 2010, p. 35).

The phonological loop has something called buffer storage which is temporary storage, different from memory storage for later use, allowing for multiple streams of information at once (Baddeley, A. D., & Hitch, G. J., 2019). It is important to cognitive processing functions and occurs at the retina and pattern processing levels and in temporary visual memory (Baddeley, A. D., & Hitch, G. J., 2019). The rehearsal within the phonological loop system's limitations includes a study finding that "serial retention of sequences of five unrelated words declined from

around 90% with monosyllables to around 50% with words of five syllables" and that "memory span was approximately equivalent to the number of words that could be articulated within 2 sec" (Baddeley, A. D., & Hitch, G. J., 2019, p. 94). Chunking involves making many smaller pieces of information into larger groups of familiar information to aid in surpassing usual constraints in working memory (Thalmann, M., et al., 2019).

Interference in Working Memory

Both the phonological loop and visuospatial sketchpad are vulnerable to interruption and interference (Buchsbaum, B. R., & D'Esposito, M., 2008). Interference, including distraction and interruption, messes with one's ability to hold information within working memory and this gets worse with age (Clapp, W. C., & Gazzaley, A., 2012). Interruption is not always external, internal intrusive thoughts are also present in working memory as a distraction (Brewin, C. R., & Smart, L., 2005). Not only is interruption detrimental to temporary memory storage but a study found that fatigue can make the effects even worse (Chen, Y., Fang, W., Guo, B., & Bao, H., 2021). Small things may be detrimental to working memory processing; similarity between objects can confuse someone and damage performance (Jackson, M. C., et al., 2015). Additionally, when there are competing tasks in working memory, the outcome is non-optimal memory storage (Lewis-Peacock, J. A., & Norman, K. A., 2014). Too much information to process leads to the topic of cognitive load.

Cognitive Load

There are different types of loads including intrinsic, extraneous, and germane (Paas, F., et al., 2010). Intrinsic load marks the level of difficulty there is in the new concepts to be learned, germane load marks the resources needed to apply to the learning of the new concepts, and extraneous load is the load that accounts for the surplus of steps or requirements making tasks more difficult (Paas, F., et al., 2010). In other words, intrinsic load deals with "the nature of the material", extraneous load "reduces working memory capacity" due to "poorly designed instructional materials" and germane load "occurs when free working memory capacity is used for deeper construction and automation of schemata" (Bannert, M., 2002, p. 139). The overall price of high cognitive load is decreased processing (Sweller, J., et al., 2019). There is also the modality effect when an audio and visual display combined is easier to understand than visuals only, yet problems may occur with this if there is too much audio information to be processed at one time (Leahy, W., & Sweller, J., 2011). To ultimately aid processing it is important to cut out information that is not needed and ensure the right and sufficient number of resources are called on (Sweller, J., et al., 2019). It is important to note that working memory is subject to cognitive overload since it is new information, but long-term memory is not subject to limitations in the

same way, so to help the learning process, making connections to information that is already known is extremely helpful (Paas, F., et al., 2010).

Problems with cognitive load theory have been voiced. These problems include that the theory is almost impossible to falsify, that the types of loads cover all possible bases, there is a lack of ways to measure cognitive load, and a lack of clarity (De Jong, T., 2010). Ton de Jong has admitted the contributions of cognitive load theory but has also made recommendations to continue by figuring out some pieces of it including "which instructional treatments lead to which cognitive processes (and how)" and "how best to measure effects on working memory load in a theory-related manner" (De Jong, T., 2010, p. 126-127). However, there are types of measurement for workload that NASA has used including the "NASA Task Load Index (NASA – TLX) and the Workload Profile (WP)" yet mental workload "is still a vague concept, with different definitions and no universal measure" (Rizzo, L. M., & Longo, L., 2017, p. 126).

Emotion and working memory

Trait Anxiety and State Anxiety

Spielberger had early discussions on types of anxiety in the 1960s; trait anxiety was discussed and is an experience someone has constantly, and state anxiety is triggered by a particular circumstance (Spielberger, C. D., 1966). It included a "predisposition" in trait anxiety and "transitory emotion" in state anxiety with "physiological arousal and consciously perceived feelings of apprehension, dread, and tension" (Endler, N. S., & Kocovski, N. L., 2001). It has been compared to "the distinction between potential and kinetic energy" (Endler, N. S., & Kocovski, N. L., 2001). In one study it was found that "trait anxiety impairs central executive functioning on a nonverbal task" but does not disrupt the phonological loop and visuospatial sketchpad (Eysenck, M., Payne, S., & Derakshan, N., 2005, p. 1214). One study found that there is reason to believe that working memory capacity determines the effects of anxiety on "cognitive test performance" (Owens, M., et al.,2014, p. 92). In the study, trait anxiety was found to have no correlation to test performance "for those adolescents with average WMC scores ($\beta = .13$, $p > .10$)" and was "negatively related to test performance in adolescents with low WMC ($\beta = -.35$, $p < .05$)" and was "positively related to test performance in those with high WMC ($\beta = .49$, $p < .01$)" (Owens, M., et al.,2014, p. 92). This means that working memory capacity determines anxiety effects on performance.

Anxiety continued plus Motivation

Even so, anxiety can be detrimental to concentration as a major distraction, and there are findings to suggest that anxiety takes up more resources specifically under low load task engagement (Vytal, K., Cornwell, B., Arkin, N., & Grillon, C., 2012). Yet, when there is a high load and anxiety around performance, individuals will work harder and findings show that more

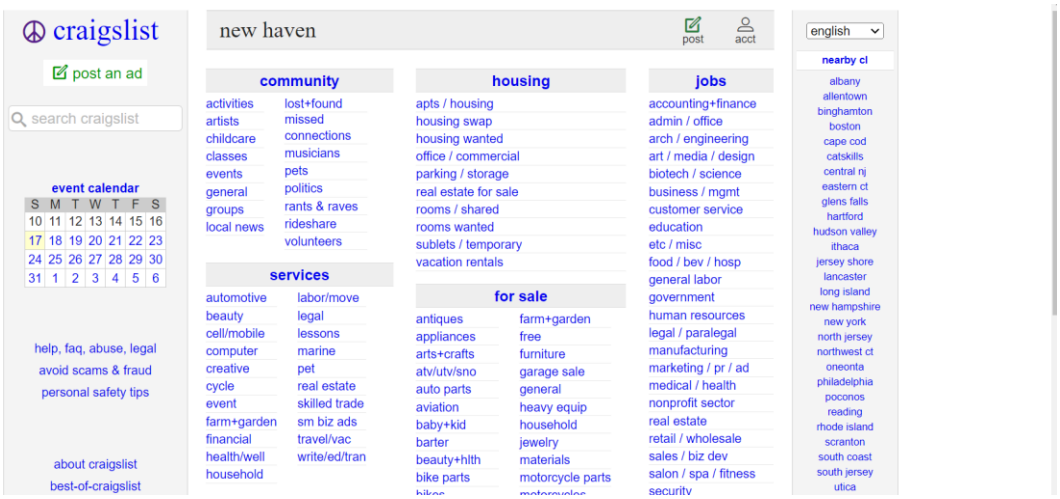
mistakes and less efficiency can occur in these circumstances (Hepsomali, P., et al., 2019). This leads to motivation. Motivation can "enhance working memory (WM) capacity" (Sanada, M., et al., 2013, p. 864). Relating to metacognition, self-efficacy can help "predict motivation and performance" (Schunk, D. H., 1995, p. 112). Motivation plays an important role in learning as it "drives learners in reaching learning goals" (Borah, M., 2021, p. 550). One study found evidence to suggest that the motivation aspect of "emotional state is more effective" on working memory than the "valence dimension" particularly regarding reaction times and efficiency (Yüvrük, E., et al., 2020, p. 1). Motivation is helpful to the learner, anxiety is usually detrimental.

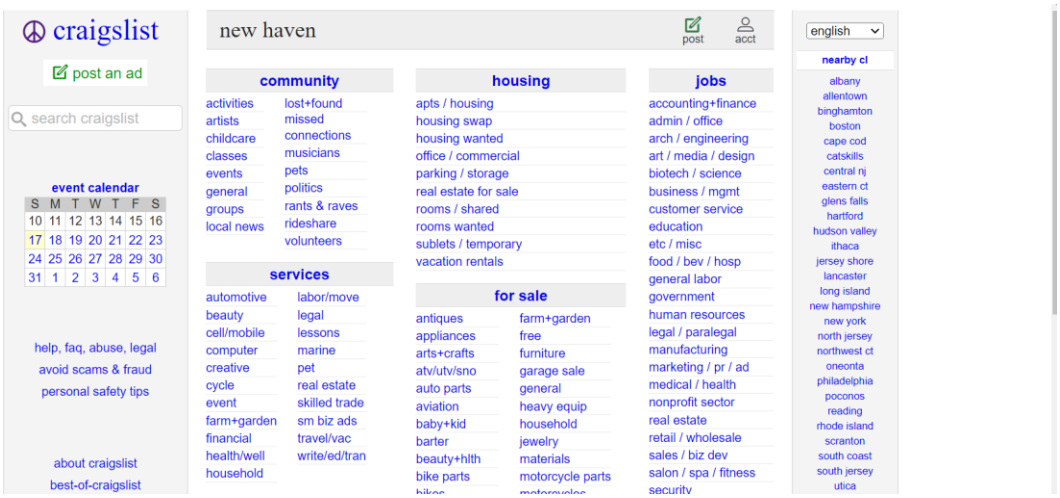
Case of craigslist.org

User

Many people use craigslist.org for a vast number of reasons, since it is an advertising site with dedicated sections labeled: "community", "housing", "jobs", "services", "for sale", and "discussion forums". Craigslist users may be searching to purchase antiques or look for upcoming events in their area, homes, legal advisors, and more. User goals include browsing, purchasing, finding services, etc. The use environment is at home online but could lead to in-person meet ups if you are purchasing an item or meeting with a service provider. For the sake of this review, the user will look at the "help,faq,abuse,legal" section to understand the site better, and then consult a craigslist discussion forum in an attempt to find out what is wrong with their apple device.

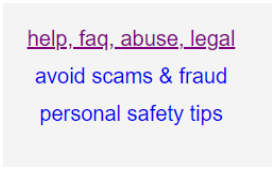
Homepage

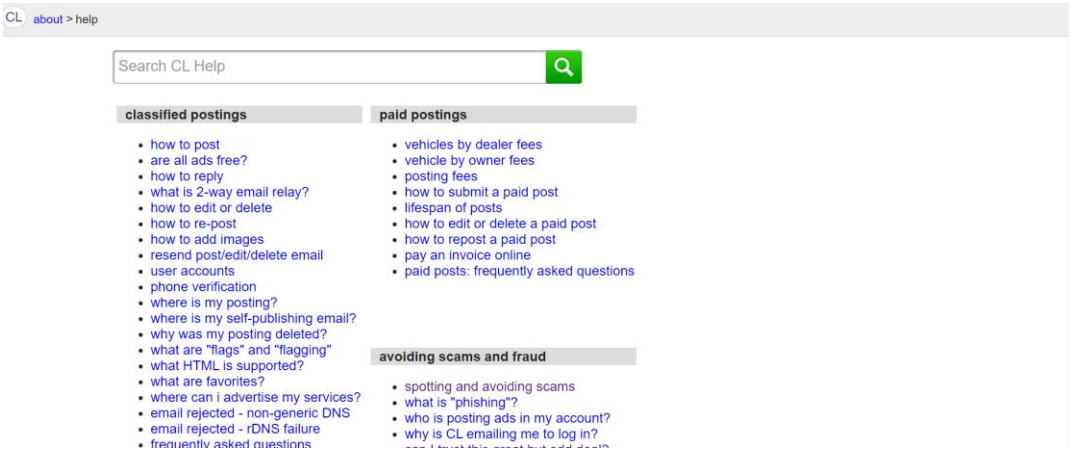




On the homepage, there is already so much information. If the user is browsing the site, here they will see a page of tons of links that are all the same color blue, same font, same font size, and all lowercase letters under categories that also have the exact same color with all lowercase letters. It is difficult to differentiate categories and subcategories here. Additionally, the central executive system controls attention, yet here the user must attend to almost the entire screen to find their goal location due to the limited differentiation of categories. This similarity makes it difficult for the user to locate their desired section placing an unnecessary extraneous load, causing anxiety for the user. A recommendation would to be to add images that people are already familiar with (from long-term memory) and different colors dedicated to each section.

“help, faq, abuse, legal”

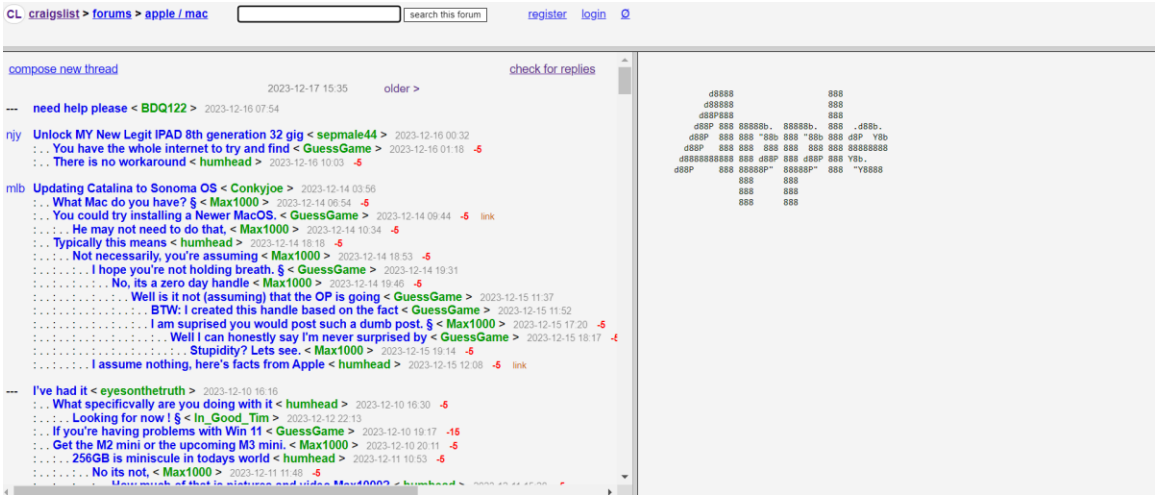




The items on the left column are differentiated by each line. Yet this may be confusing to someone since again, there is no way to differentiate the sections besides that they are on one line

and if you place your mouse over the section, it will turn purple and underlined. “help, faq, abuse, legal” holds very serious words in the title, yet it looks just like the rest of the page in terms of font and could be lost to the user. Once the user clicks into the page there is a mishmash of information from posting fees to spotting and avoiding scams (which there is also an entire section dedicated to). This is too much for the user to process at once. It is difficult for a user to note, even temporarily in buffer storage, the placement of each item on their visuospatial sketch pad to refer to at later use. There is no chunking to help process the information besides the category titles that still have long lists of links below. A recommendation would be to chunk the information into more categories that are differentiated and familiar to the user, as mentioned earlier, to make it easy for the user to locate and process each section of information.

Discussion Forums – “forums” > “apple / mac”



Lastly, when a user goes to “forums” and clicks on “apple / mac” to try to find helpful information on figuring out what is wrong with their device, the interface is complicated and unclear. On this page the left window has a list of links to past posts of issues and solutions people have had with their devices and the right window is where each link’s information will pull up. The plethora of links, arrows, dates in light gray, and usernames in green are overwhelming. It would be helpful to have some sort of icon and larger search bar to help the user navigate the page. Here, the material is already hard for the user to understand since they are consulting a forum to learn more about how to use the device (intrinsic load) and now they must use their cognitive resources (germane load) to find which problem posted may help with their own problem (or they can post about their problem directly). This is cognitive overload as it creates anxiety. Also, clicking on links with unneeded information is an interruption to the process of fixing the user’s own problem. Again, “compose a new thread” is in the left corner of the screen but still similar to most of the rest of the font on the screen in shape and color, making it difficult to find and process. Changing the color or having some outline shape to differentiate

this option would be helpful. Perhaps adding AI for the user to ask a question and locate any related information in the forum and pull it up would also be helpful to the user.

Conclusion

As mentioned, humans' working memory system has limited capacity. Prioritizing information and cutting out extraneous information is crucial in order for efficient information processing. Otherwise, high cognitive load interferes with the process of completing a task or learning something new. The craigslist site places such a high cognitive load on users that are new to the site, and even on those who are not. Everything on the site looks the same more or less; patterns are limited. There is a surplus of information under such different sets of categories. The site makes it difficult for the user to understand where to find information. This is especially true in a case where the user is consulting an online forum as the result of them having an issue with a device and already in an anxious state. Craigslist should consider updating their site to offer users more affordances and clear instruction for a limited load.

References

Baars, B. J., & Gage, N. M. (2010). *Cognition, brain, and consciousness: Introduction to cognitive neuroscience*. Academic Press.

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

Baddeley, A. D., & Hitch, G. J. (1994). Developments in the concept of working memory. *Neuropsychology*, *8*(4), 485.

Baddeley, A. D., & Hitch, G. J. (2019). The phonological loop as a buffer store: An update. *Cortex*, *112*, 91-106.

Bannert, M. (2002). Managing cognitive load—recent trends in cognitive load theory. *Learning and instruction*, *12*(1), 139-146.

Borah, M. (2021). Motivation in learning. *Journal of Critical Reviews*, *8*(2), 550-552.

Brewin, C. R., & Smart, L. (2005). Working memory capacity and suppression of intrusive thoughts. *Journal of behavior therapy and experimental psychiatry*, *36*(1), 61-68.

Buchsbaum, B. R., & D'Esposito, M. (2008). 3.13-Short-term and working memory systems. *Learning and memory: A comprehensive reference*, 237-260.

Carruthers, P. (2013). Evolution of working memory. *Proceedings of the National Academy of Sciences*, *110*(supplement_2), 10371-10378.

Chen, Y., Fang, W., Guo, B., & Bao, H. (2021). Fatigue-related effects in the process of task interruption on working memory. *Frontiers in Human Neuroscience*, *15*, 703422.

Clapp, W. C., & Gazzaley, A. (2012). Distinct mechanisms for the impact of distraction and interruption on working memory in aging. *Neurobiology of aging*, *33*(1), 134-148.

De Jong, T. (2010). Cognitive load theory, educational research, and instructional design: Some food for thought. *Instructional science*, *38*(2), 105-134.

Endler, N. S., & Kocovski, N. L. (2001). State and trait anxiety revisited. *Journal of anxiety disorders*, *15*(3), 231-245.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion*, *7*(2), 336.

Eysenck, M., Payne, S., & Derakshan, N. (2005). Trait anxiety, visuospatial processing, and working memory. *Cognition & Emotion*, *19*(8), 1214-1228.

Hepsomali, P., Hadwin, J. A., Liversedge, S. P., Degno, F., & Garner, M. (2019). The impact of cognitive load on processing efficiency and performance effectiveness in anxiety: evidence from event-related potentials and pupillary responses. *Experimental brain research*, *237*, 897-909.

Jackson, M. C., Linden, D. E., Roberts, M. V., Kriegeskorte, N., & Haenschel, C. (2015). Similarity, not complexity, determines visual working memory performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(6), 1884.

Leahy, W., & Sweller, J. (2011). Cognitive load theory, modality of presentation and the transient information effect. *Applied cognitive psychology*, *25*(6), 943-951.

Lewis-Peacock, J. A., & Norman, K. A. (2014). Competition between items in working memory leads to forgetting. *Nature Communications*, *5*(1), 5768.

Owens, M., Stevenson, J., Hadwin, J. A., & Norgate, R. (2014). When does anxiety help or hinder cognitive test performance? The role of working memory capacity. *British Journal of Psychology*, *105*(1), 92-101.

Paas, F., Van Gog, T., & Sweller, J. (2010). Cognitive load theory: New conceptualizations, specifications, and integrated research perspectives. *Educational psychology review*, *22*, 115-121.

Rizzo, L. M., & Longo, L. (2017). Representing and inferring mental workload via defeasible reasoning: a comparison with the NASA Task Load Index and the Workload Profile. *1st Workshop on Advances In Argumentation In Artificial Intelligence,* 126-140.

Sanada, M., Ikeda, K., Kimura, K., & Hasegawa, T. (2013). Motivation enhances visual working memory capacity through the modulation of central cognitive processes. *Psychophysiology*, *50*(9), 864-871.

Schunk, D. H. (1995). Self-efficacy, motivation, and performance. *Journal of applied sport psychology*, *7*(2), 112-137.

Spielberger, C. D. (1966). Theory and research on anxiety. *Anxiety and behavior*, *1*(3), 413-428.

Sweller, J., van Merriënboer, J. J., & Paas, F. (2019). Cognitive architecture and instructional design: 20 years later. *Educational psychology review*, *31*, 261-292.

Thalmann, M., Souza, A. S., & Oberauer, K. (2019). How does chunking help working memory? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *45*(1), 37.

Vytal, K., Cornwell, B., Arkin, N., & Grillon, C. (2012). Describing the interplay between anxiety and cognition: from impaired performance under low cognitive load to reduced anxiety under high load. *Psychophysiology*, *49*(6), 842-852.

Yüvrük, E., Kapucu, A., & Amado, S. (2020). The effects of emotion on working memory: Valence versus motivation. *Acta Psychologica*, *202*, 102983.