Supporting Metacognitive Decision-making in Product Design

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Introduction

Metacognition, often described as “thinking about thinking”, draws upon executive functions in the brain. These functions are made up of high-level cognitive skills that depend on three systems: working memory, mental flexibility, and self-control (Harvard, 2020). Researchers have struggled to agree on how best to define the complex skill of metacognition (Livingston, 2003). More recent studies have proposed that metacognition involves the monitoring and control of thought (Martinez, 2006). This idea builds upon the findings of John Flavell (1979), the founding scholar of metacognition, who presented that humans control thinking processes through the strategies of organizing, monitoring, and adapting. In decision making, metacognition supports the monitoring and revision of actions as humans navigate uncertainty (Qiu et al., 2018).

The following paper will examine how product designers can leverage users’ metacognitive skills to support good decision making and improve human performance. In addition, this paper will consider how designers can mitigate the effects of metacognitive limitations that take away from the primary decision-making task. After a review of metacognition in decision making, we will demonstrate how product design can impact metacognitive performance through an evaluation of a retail website: 1-800 Flowers.

Metacognition

Flavell (1979) suggests that humans use both metacognitive knowledge and metacognitive experience to inform the selection of metacognitive and cognitive strategies. Metacognitive experiences “refer to a person's awareness and feelings elicited in a problem-solving situation” (Schneider, 2015). These experiences can occur at any point in the cognitive process and can vary in duration (Flavell, 1979). Flavell (1979) claims that metacognition is more likely to occur in situations where careful thinking is demanded. These situations may happen at work, in school, or in unfamiliar circumstances where humans must establish “establish new goals or revise or abandon old ones” (Flavell, 1979). Meanwhile, metacognitive knowledge includes “knowledge about cognition in general, as well as awareness of and knowledge about one's own cognition” (Pintrich, 2002).

Metacognitive Regulation

Self-regulating processes allow humans to make continuous adjustments to their course of action and examine their thought process (Brown, 1987, p. 88-89). These metacognitive actions can occur in response to feedback, such as when an error occurs, or even in the absence of feedback (Brown, 1987, p. 89). In other words, metacognitive regulation includes two main functions: cognitive monitoring and cognitive control (Fernandez-Duque et al., 2000). Cognitive monitoring, a top-down process, includes actions such as error detection and source monitoring in memory retrieval (Fernandez-Duque et al., 2000). Cognitive control, on the other hand, is a bottom-up process where actions such as conflict resolution, error correction, and resource allocation take place (Fernandez-Duque et al., 2000). Some processes combine both top-down and bottom-up procedures. For example, error monitoring is a metacognitive process that allows humans to detect errors and correct the following action as soon as possible (Yeung & Summerfield, 2012). Researchers have found that error monitoring has a significant impact on future behavior—showing participants, after making an error, reacted much slower in subsequent trials to prevent further errors (Rabbitt, 1966; Bogacz et al., 2010). In addition, several external factors impact the human ability to self-regulate, such as motivation, environmental context, stress, adversity, and support (Murray et al., 2015). In product design, designers must consider these factors, along with an apparent speed-accuracy trade-off during task performance to ensure an interface supports regulation.

Metacognitive Strategies and Skills

Humans possess several metacognitive strategies that support skills such as decision making, problem-solving, reading comprehension, self-assessing, and evaluating progress (Teal Center, 2019). These strategies help humans take control of thinking processes and include practices such as monitoring, planning, and evaluating (Ku et al., 2010). Humans learn to select strategies and allocate resources depending on the learning goal (TEAL Center, 2019). For example, when reading, humans may shift from skimming, scanning, or searching to reflective reading, depending on the level of comprehension desired (Ngoc, 2015). A reader hoping to gather the general idea of a paper may choose to skim content, allowing them to accomplish the task goal without allocating unnecessary resources. Depending on the task, users may have varying levels of expertise or proficiency. Researchers have found that experts possess a higher degree of metacognitive skill (Sternberg, 1998). Thus, designers should consider users' level of expertise when designing complex interfaces.

The Metacognitive Process of Decision Making

Decision making, a crucial metacognitive skill, allows humans to select a course of action among different alternatives. Several decision-making models work to explain how humans undergo this complex process. A dominant theory was proposed by Kahneman and Tversky, two psychologists who proposed the prospect theory of decision making.

System 1 and System 2

Kahneman and Tversky's prospect theory adopts the terms proposed by Keith et al. (2000) who claim there are two systems in the mind: System 1 and System 2. System 1 involves an automatic, rapid operation that requires little or no effort. This system is responsible for 98 percent of thinking, allowing humans to expend less effort processing the environment (Kahneman, 2017). From an evolutionary perspective, using System 1 for the majority of processing allowed early humans to respond quickly to potential threats in the environment. On the other hand, System 2 slowly and consciously directs attention towards mental activities that require careful thinking. Impressions humans gain from System 1 impact "explicit beliefs and deliberate choices of System 2" (Kahneman, 2017, p.21). In System 2, Kahneman (2017) suggests that if humans are ill-prepared or distracted, performance will decline.

Prospect theory builds upon Bernoulli's utility theory, another dominant decision-making model that assumes individuals will choose the outcome that will provide maximum utility, or benefit, given the probability of outcomes (Kahneman, 1979). However, prospect theory suggests humans are not quite as rational in decision making. Instead, Kahneman and Tversky (1979) propose that humans may choose to not maximize utility due to "decision weights" that do not correspond to probability. In other words, prospect theory acknowledges that humans have different preferences that influence how they make decisions (Kahneman, 1979). These preferences can have a greater effect on decision making when there is a constraint on time (Young et al., 2012). System 1 helps to explain key aspects of prospect theory. For example, Kahneman (2017) explains how human perception of whether an outcome is a gain or loss depends on our reference point (or past experience).

Strategies for Decision Making

In making decisions, humans suffer from limited working memory capacity, as well as being emotional, near-term oriented, and often distracted (Cowan, 2010; Erwin, 2019). Thus, humans use metacognitive strategies to become better problem solvers and decision makers despite these limitations. Kahneman refers to these strategies as heuristics, also known as mental shortcuts, that help humans perform while keeping cognitive load to a minimum (Kahneman, 2017). However, these heuristics are imperfect and can often lead to bias. For example, the availability heuristic, explains how people tend to favor certain concepts based on the ease with which they come to mind (Kahneman, 2017). One implication of the availability heuristic is that "people tend to assess the relative importance of issues by the ease with which they are retrieved from memory" (Kahneman, 2017, p. 8). Another strategy, the representativeness heuristic, claims humans judge whether information belongs to a group depending on how much it resembles other objects in that group (Kahneman, 2017).

Moreover, when information is misinterpreted, humans form inaccurate conclusions that can be detrimental to human decision making (Murata et al., 2015). There are several biases that humans use unconsciously to inform decisions. Anchoring bias explains how humans tend to

favor information that was first consumed when evaluating something. Meaning, first impressions often impact subsequent judgments. Attentional bias suggests that when humans focus more on certain information, they may disregard other information. Similarly, confirmation bias describes how humans tend to avoid information that conflicts with their beliefs. However, Johnson et al. (2013) claim that biases can also improve decision making. The authors found that these mental shortcuts can benefit humans in error management, allowing for a “bias toward making the least costly error over time” (Johnson et al., 2013).

Individual Differences

Human differences in working memory capacity, expertise, and emotion also have a large effect on decision making (Barrett et al., 2004; Hutton and Klein, 1999; Schwarz, 2000; Swanson & Siegel, 2011). In terms of expertise, Hutton and Klein (1999) describe how “the expert decision maker is able to focus on meaningful, relevant information, and generate plausible goals and expectancies about the situation” to inform decision making. However, the authors note that in novel situations, even experts will have to expend more effort following knowledge-based decision-making strategies (Hutton and Klein, 1999). Beyond expertise, researchers have also found that emotion can also significantly impact decision making (Schwarz, 2000; Lerner et al., 2015). Lerner et al. (2015) determined emotion has the potential to improve or degrade decision making depending on cognitive and motivational mechanisms. Furthermore, people with learning disabilities have a more difficult time making decisions due to working memory deficits (Swanson & Siegel, 2011). To ensure universal accessibility, designers must account for these differences.

Product Review

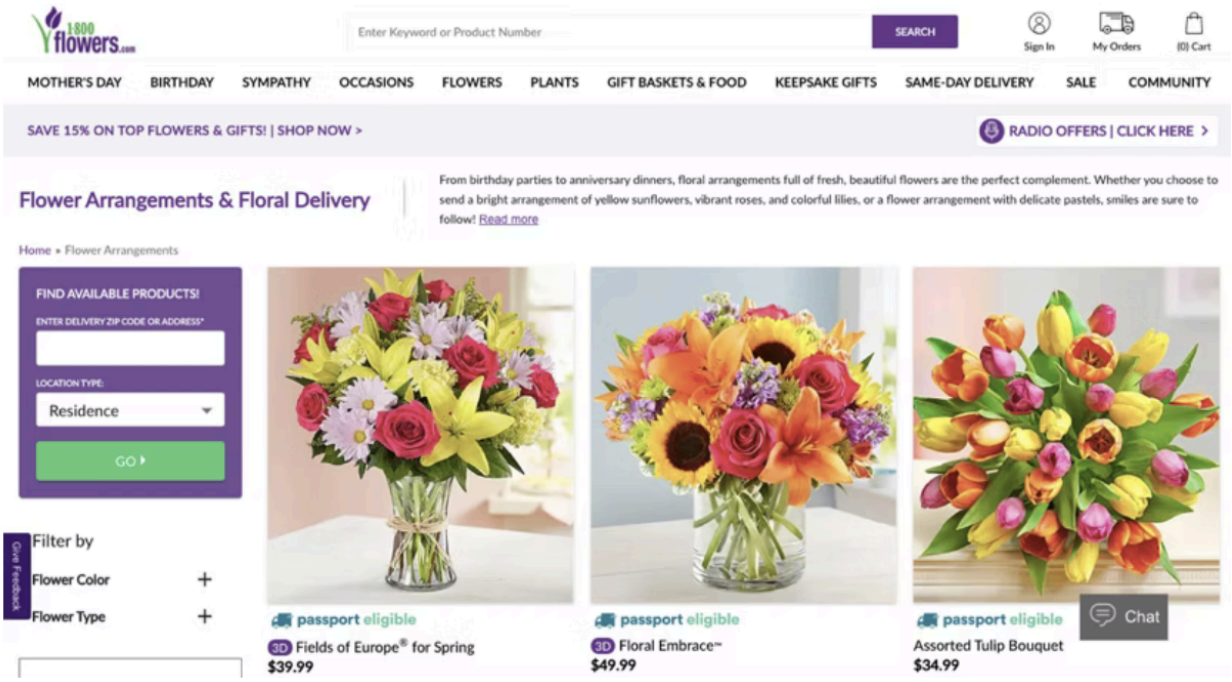
Considering humans’ metacognitive processes and limitations, designers can create systems that will impose less cognitive load on users and increase the chances of good decision making. We will demonstrate this case by examining the 1-800 Flowers website. As a fresh floral retailer, 1-800 Flowers offers a wide selection of floral arrangements and gifts with same-day delivery. The goal of 1-800 Flowers is to help people celebrate special occasions and connect with important people in their lives (1-800 Flowers, 2021). People often choose 1-800 Flowers due to the rushed delivery options and convenience. As a result, the online platform must support efficient decision making, especially since these purchase decisions are largely driven by emotion.

Choice Overload

Starting from the Floral Arrangements and Floral Delivery page, users looking to browse products are immediately presented with a myriad of arrangement options (See Figure 1). Around 150 options are presented on one page in the fixed three-column layout. Researchers

have found that being presented with too many options can have adverse effects on motivation and satisfaction in decision making (Bollen et al., 2010; Chernev et al., 2015). Chernev et al. (2015) found that choice-set complexity and preference uncertainty have a significant impact on choice overload. The authors noted that users who are unfamiliar with the product category (having lower expertise) are more likely to defer choices when shown many options (Chernev, 2015). Therefore, when users are unsure of the recipient's floral preferences or lack knowledge related to floral arrangements, choice overload may cripple decision making. To improve this page, the website could leverage progressive disclosure to avoid overwhelming the users. Instead of having products automatically appear on-scroll, users could be given the option to "View More" after a smaller set of options are shown. Alternatively, the website could use separate, numbered pages to break up information.

Figure 1
1-800 Flower Arrangements and Floral Delivery Page



Note. From 1-800 Flowers [Photograph], by 1-800 Flowers 2021.

Inadequate Filtering

The filtering system employed on the Floral Arrangements and Floral Delivery page allows users to narrow products by flower color and flower type. The flower type filter may confuse users who have limited floral expertise (See Figure 2). Besides, several arrangements include more than one type of flower. Thus, a user may be unsure if filtering by a certain flower type will show arrangements of only that flower type or any arrangement that includes that flower type.

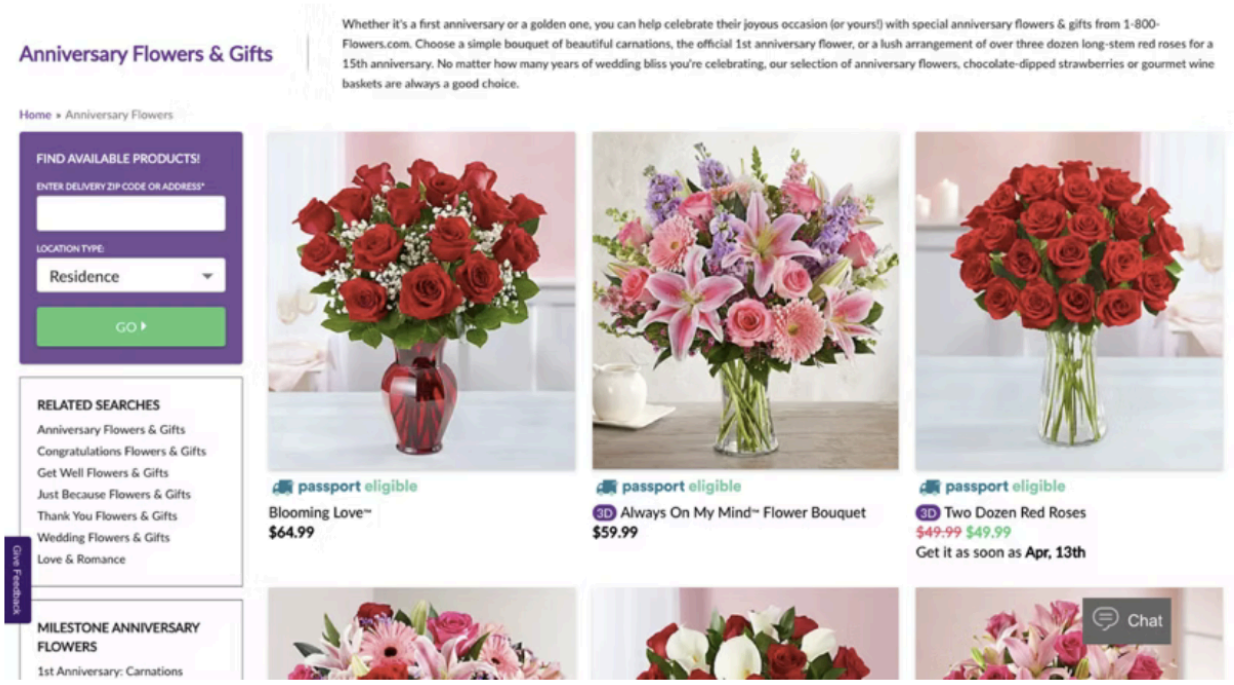
Moreover, the lack of additional filters limits the ability to which users can narrow down the results to a reasonable set of options. This is even more problematic on occasion-specific pages where no filter options are included (See Figure 3). Including filters such as price range, ratings, and occasion would help users find the best option more efficiently. Similarly, a “Sort” drop-down option would benefit users looking to see certain products first, such as lower-priced options, best sellers, or highly rated products. These recommendations are supported by the elimination-by-aspects heuristic, helping to reduce cognitive load by lowering the number of comparisons needed to be made (Tversky, 1972). Furthermore, other tools such as interactive decision aids have been found to help consumers make better decisions with significantly less effort (Häubl & Trifts, 2000).

Figure 2
1-800 Flowers Left-hand Filter



Note. From 1-800 Flowers [Photograph], by 1-800 Flowers, 2021.

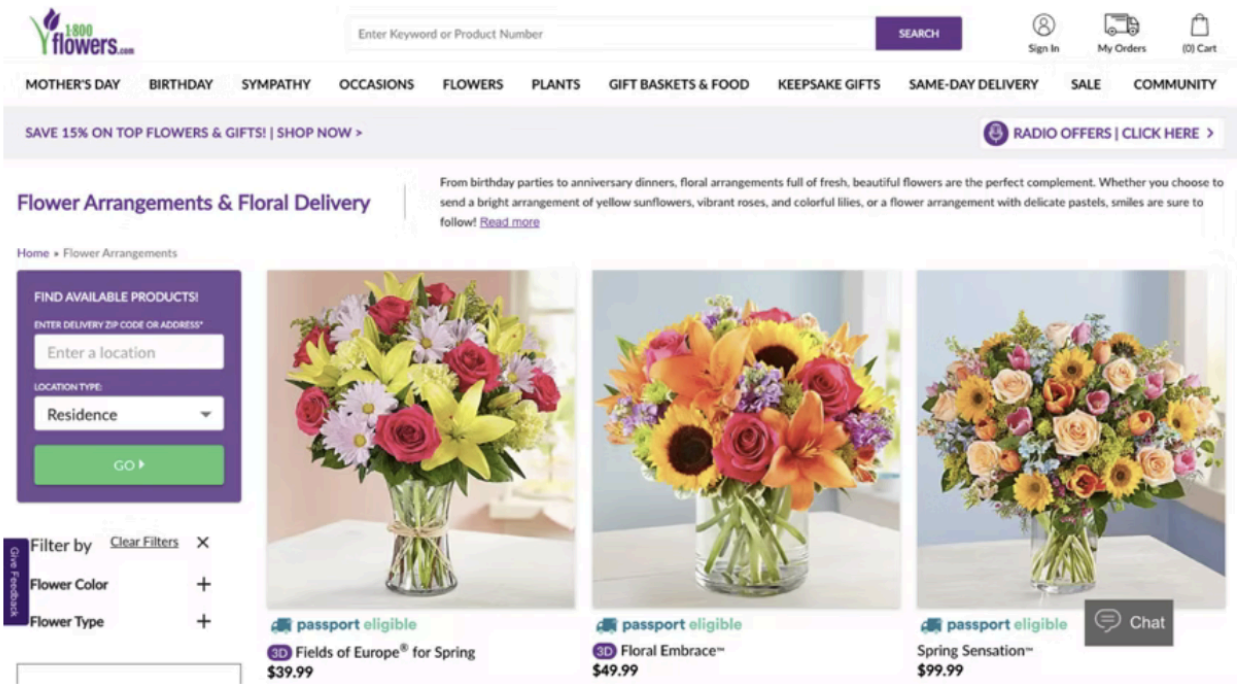
Figure 3
1-800 Flowers Anniversary Flowers & Gifts Page



Note. From 1-800 Flowers [Photograph], by 1-800 Flowers, 2021.

The filtering system on the Flower Arrangements and Floral Delivery page also lacks visibility and feedback. Once a user selects a chosen color and flower type, these selected filters are not highlighted anywhere on the page. Instead, the “Clear Filters” text merely indicates at least one filter has been applied, with no indication of what that filter may be (See Figure 4). Knowing users already have limited working memory capacity, the design would benefit from clearly communicating what filters have been applied. For example, the selected filters could be displayed at the top of the page above the three arrangements shown in Figure 4. In doing so, users could more easily adjust filters in response to changing product results.

Figure 4
Filter Selected - 1-800 Flower Arrangements and Floral Delivery Page



Note. From 1-800 Flowers [Photograph], by 1-800 Flowers, 2021.

Hidden Reviews

On the product pages, average product reviews are not shown under each listed item—a convention widely used by online retailers (See Figure 1, 3, or 4). Researchers have found that people are strongly influenced by others when making purchase decisions (Kim and Srivastava, 2007). In a study looking at social influence in e-commerce decision making, Kim and Srivastava (2007) describe how “high quality reviews written by previous consumers can have a direct, positive effect on potential consumers’ decision making”. Moreover, reviews help to convey credibility and trust to the user. This is especially important in the context of buying perishable floral arrangements where quality and consistency are a major concern for buyers. Hence, 1-800 Flowers would benefit from displaying average product reviews under listed products.

Conclusion

Designers can leverage humans’ metacognitive strengths through performance support. In decision making, humans benefit from design elements that limit the demand for working

memory and minimize the use of unhelpful biases. Performance support becomes even more critical as the consequences for making a bad decision increase. For example, a poorly designed patient-monitoring system risks causing doctors or nurses to make a fatal judgment while caring for a patient. However, performance support is not limited to complex products used by experts. Through a review of the 1-800 Flowers website, we have demonstrated how small improvements in information architecture may help increase user satisfaction while decreasing decision fatigue. Furthermore, in publicly-facing systems, designers have a responsibility to ensure universal accessibility. Meaning, performance support systems must also consider those with cognitive disabilities.

References

Barrett, L. F., Tugade, M. M., & Engle, R. W. (2004). Individual differences in working memory capacity and dual-process theories of the mind. Psychological bulletin, 130(4), 553–573. https://doi.org/10.1037/0033-2909.130.4.553

Bollen, D., Knijnenburg, B. P., Willemsen, M. C., & Graus, M. (2010, September). Understanding choice overload in recommender systems. In Proceedings of the fourth ACM conference on Recommender systems (pp. 63-70).

Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert& R. H. Kluwe (Eds.), Metacognition, motivation, and understanding (pp. 65-116). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Chernev, A., Böckenholt, U., & Goodman, J. (2015). Choice overload: A conceptual review and meta-analysis. Journal of Consumer Psychology, 25(2), 333-358.

Cowan N. (2010). The Magical Mystery Four: How is Working Memory Capacity Limited, and Why?. Current directions in psychological science, 19(1), 51–57. https://doi.org/10.1177/0963721409359277

Erwin, M. (2019, September 11). 6 reasons we make bad decisions, and what to do about them. Retrieved April 12, 2021, from https://hbr.org/2019/08/6-reasons-we-make-bad-decisions-and-what-to-do-about-them

Fernandez-Duque, D., Baird, J. A., & Posner, M. I. (2000). Executive attention and metacognitive regulation. Consciousness and cognition, 9(2), 288-307.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. American psychologist, 34(10), 906.

Harvard University: Center on the Developing Child. (2020, March 24). Executive function & self-regulation. Retrieved April 12, 2021, from https://developingchild.harvard.edu/science/key-concepts/executive-function/

Häubl, G., & Trifts, V. (2000). Consumer decision making in online shopping environments: The effects of interactive decision aids. Marketing science, 19(1), 4-21.

Hutton, R. J., & Klein, G. (1999). Expert decision making. Systems Engineering: The Journal of The International Council on Systems Engineering, 2(1), 32-45.

Johnson, D. D., Blumstein, D. T., Fowler, J. H., & Haselton, M. G. (2013). The evolution of error: Error management, cognitive constraints, and adaptive decision-making biases. Trends in ecology & evolution, 28(8), 474-481.

Kim, Y. A., & Srivastava, J. (2007, August). Impact of social influence in e-commerce decision making. In Proceedings of the ninth international conference on Electronic commerce (pp. 293-302).

Kahneman, D. (2017). Thinking, fast and slow.

Ku, K. Y., L., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. Metacognition and Learning, 5(3), 251-267. http://dx.doi.org/10.1007/s11409-010-9060-6

Lerner, J. S., Li, Y., Valdesolo, P., & Kassam, K. S. (2015). Emotion and decision making. Annual review of psychology, 66.

Livingston, J. A. (2003). Metacognition: An Overview.

Martinez, M. E. (2006). What is metacognition?. Phi delta kappan, 87(9), 696-699.

Murata, A., Nakamura, T., & Karwowski, W. (2015). Influence of cognitive biases in distorting decision making and leading to critical unfavorable incidents. Safety, 1(1), 44-58.

Murray, D. W., Rosanbalm, K., Christopoulos, C., & Hamoudi, A. (2015). Self-regulation and toxic stress: Foundations for understanding self-regulation from an applied developmental perspective. OPRE Report, 21.

Ngoc, N. T. M. (2015). The essential roles of Skimming and Scanning Techniques in teaching reading comprehension. Retrieved on July, 4, 2017.

Pintrich, P. R. (2002). The role of metacognitive knowledge in learning, teaching, and assessing. Theory into practice, 41(4), 219-225.

Qiu, L., Su, J., Ni, Y., Bai, Y., Zhang, X., Li, X., & Wan, X. (2018). The neural system of metacognition accompanying decision-making in the prefrontal cortex. PLoS biology, 16(4), e2004037.

Rabbitt, P. M. (1966). Errors and error correction in choice-response tasks. Journal of experimental psychology, 71(2), 264.

Schneider, W. (2015). Metacognitive development: Educational implications.

Schwarz, N. (2000). Emotion, cognition, and decision making. Cognition & Emotion, 14(4), 433-440.

Sternberg, R. J. (1998). Metacognition, abilities, and developing expertise: What makes an expert student?. Instructional science, 26(1), 127-140.

Swanson, H. L., & Siegel, L. (2011). Learning disabilities as a working memory deficit. Experimental Psychology, 49(1), 5-28.

TEAL Center. (2019, April 08). TEAL center fact Sheet No. 4: Metacognitive processes. Retrieved April 12, 2021, from https://lincs.ed.gov/state-resources/federal-initiatives/teal/guide/metacognitive#:~:text=Examples%20of%20metacognitive%20activities%20include,completion%20of%20a%20task%2C%20and

Tversky, A. (1972). Elimination by aspects: A theory of choice. Psychological review, 79(4), 281.

Yeung, N., & Summerfield, C. (2012). Metacognition in human decision-making: confidence and error monitoring. Philosophical Transactions of the Royal Society B: Biological Sciences, 367(1594), 1310-1321.

Young, D. L., Goodie, A. S., Hall, D. B., & Wu, E. (2012). Decision making under time pressure, modeled in a prospect theory framework. Organizational behavior and human decision processes, 118(2), 179–188. https://doi.org/10.1016/j.obhdp.2012.03.00

1-800 Flowers: Fresh Flowers online: 1-800-flowers.com. (2021). Retrieved April 12, 2021, from https://www.1800flowers.com/