Selective Attention and Feedback Performance: Does Feedback Actually Help?

Rebecca E. Leuenberger

Ripon College

Abstract

This study mainly focused on the load theory of selective attention proposed by Lavie, Hirst, and de Frockert (2004), which identified that high perceptual loads and high cognitive loads yield higher detections of irrelevant stimuli in selective attention tasks. A directional flanker task was used to study changing cognitive loads while maintaining two fixed levels of perceptual load. Two experiments were completed in this study; Experiment 1 revealed significance in the effects of the flanker task, specifically the congruent and neutral trials exhibiting significantly faster reaction times than the incongruent trials. Experiment 2 revealed significance in the effects of the flanker task and changing cognitive loads, demonstrated by feedback. Based on these findings, this study concluded that both perceptual load and cognitive load influence reaction times.

Keywords: selective attention, perceptual load, flanker

Selective Attention and Feedback Performance: Does Feedback Actually Help?

Attention

Attention is a phenomenon that underlies every activity performed by a human (Kirby & Das, 1990). Whether it is washing the dishes, driving a car, writing an essay, flying a spaceship, or administering a vaccine, attention drives these activities. Attention, therefore, is a very complex and multifaceted phenomenon that involves many different systems, different processes, and is divided into different types.

To begin understanding the depth of complexity of attention, it is necessary to understand the mechanics of attention. Petersen and Posner (1990, 2012) defined that attention has three key networks: the alerting network, the orienting network, and the executive network. Petersen and Posner (1990, 2012) defined the alerting network as the arousal system that attracts an individual's attention to a task. The alerting network is the "when" of attention because it allows the individual to focus on one stimulus despite other displayed stimuli.

The orienting network, by comparison, is the system that prioritizes sensory input by discriminating locations, this network can be thought of as the "where" of attention (Petersen & Posner, 1990, 2012). The orienting network is meant to direct the individual towards the stimulus and fixate on it. If an individual is working on a task in which they are asked to color a picture of a specific cartoon character out of a group of characters, they have used their alerting network to ignore that other characters (displayed stimuli) and their orienting network to find the specific (target) cartoon character from the group. Already, the complexity of attention is shown because even in a task as simple as coloring an image is navigated by two different networks.

The last network described by Petersen and Posner (1990, 2012) is the executive network. The executive network is responsible for maintaining any task parameters or instructions given. Continuing with the example of coloring a cartoon character, suppose that the individual is asked to only color with a purple colored pencil and hum their favorite song. Alongside the alerting and orienting networks, the executive network is keeping the individual aware that they need to select a purple colored pencil to use while simultaneously humming their favorite tune. Here again it is quite extraordinary how many systems are involved for performing a simple task.

Attention is further propagated by four essential and independent processes: working memory, competitive selection, top-down sensitivity control, and salience filtering (Knudsen, 2007). Working memory, according to Knudsen (2007), is the short process that occurs while the brain is evaluating any given information and compares it to any relevant information. For example, an individual is given an object they have never seen before; this object may be rectangular with spikes emitting from each edge. The individual's working memory is recording and processing this novel object and is providing a base framework about the object for future decision making and planning of behavior in response to the object (Knudsen, 2007). Working memory is important because it is an information storage reservoir, and this storage is important for performing on cognitive tasks such as language comprehension and reasoning (Baddeley, 1992). Perhaps the novel object is dangerous; the individual's working memory would be responsible for providing the first initial understanding that the object is dangerous.

Competitive selection, then, is the competition of information on the basis of relevance and importance (Knudsen, 2007). Suppose that the novel object is colored purple, competitive selection would determine that, in the moment, the color of the object is unimportant because of the spikes emitting from each side. The individual may sense the color briefly but their attention is better served at the level of sensing danger. Competitive selection occurs within working memory as there must a distinct discrimination of relevancy (Knudsen, 2007). While competitive selection determines what information is most relevant, top-down sensitivity determines the proper behavioral response to a stimulus (Knudsen, 2007).

Top-down sensitivity control serves the purpose of processing information in the brain to then elicit a behavioral response (Knudsen, 2007). This control would be responsible for processing the danger the novel object poses and would then be responsible for the individual moving away from the object. This control is important in attention because it continues to process information from the working memory and is able to integrate any previous knowledge that may be relevant (Knudsen, 2007).

The last process Knudsen (2007) discussed is the process of salience filtering. Salience filtering is similar to competitive selection on the basis that information is filtered by level of importance. Salience stimuli occur at infrequent times such as a sudden loud noise. If the noise is unimportant, however, it is filtered out. Conversely, if the noise *is* important, it will be passed onto higher processing networks. Many other explanations of attention come to the same conclusion: importance wins (Braun, 1994; Parkhurst, Law, & Niebur, 2002; Yantis & Jondes, 1984).

In addition to these networks and processes, attention is divided into different types. Crawford, Brown, and Moon (1993) explained that there are four different types of attention: selective attention, divided attention, sustained attention, and executive attention. Crawford et al. (1993) first explained that divided attention is devoting attention between two tasks. Next, these researchers explained that sustained attention is the ability to maintain attention without distraction. Finally, Crawford et al. (1993) explained that executive attention is the primary command which interprets and processes stimuli.

Selective attention, which is the focus of the present study, is the ability to single out a particular stimulus among other stimuli (Huang-Pollock, Carr, & Nigg, 2002). These researchers discussed that selective attention is necessary because the world and all of its activities provide too much perceptual information and overload limited capacity systems. The overloading perceptual stimuli must be eliminated, which is the primary function of selection attention. As previously discussed, working memory is a quick and discriminatory system that has a limited capacity, and in order for working memory to function correctly and efficiently there must be a process that eliminates irrelevant information (Knudsen, 2007). Further, Treisman (1969) defined attention as selecting and ignoring perceptual stimuli in order to select the proper behavioral response. Selective attention is what allows an individual to focus on their book in a crowded area or to spot a particular figure in a crowd. It is clear that attention is enormously complicated and requires the harmony of many different networks and systems, and testing attention is subsequently difficult.

Much like how attention is divided into different types, attention testing is also divided into types that correspond to the different types of attention (Crawford et al., 1993). Due to the focus of this study, a look into the testing of attention is limited to selective attention. One way to test selective attention is the Eriksen Flanker Task (Eriksen & Eriksen, 1974). This task is designed to present a target stimulus with irrelevant stimuli (known as flankers) alongside the target stimulus. The goal of the task is to correctly identify the target stimulus among the irrelevant flankers.

Eriksen and Eriksen (1974) developed their task using letters. Participants were instructed to identify a target letter (such as the letter Q) even though the letter may be presented with others (such as the letter F). Throughout the task, there were three different conditions of flankers presented: a congruent flanker, an incongruent flanker, and a neutral condition. In the congruent condition, the irrelevant flankers are exactly the same as the target flanker. In the incongruent condition, the irrelevant flankers are other types of stimuli, such as different letters or different perceptual features. In both the congruent and incongruent conditions, there were three irrelevant flankers that appeared on both sides of the target. In the neutral condition, only the target stimulus is presented (Eriksen & Eriksen, 1974).

On the basis of selective attention, Eriksen and Eriksen (1974) demonstrated that when additional stimuli (the flankers) are presented, response time of the participants is slowed. The researchers presented that reaction time significantly increases in incongruent conditions; the additional flankers and their incongruency to the target increased the reaction time. These results are explained on the principle that selective attention processing (i.e., maintaining focus on the target stimulus) takes more time when there is more perceptual evidence to be processed. Therefore, when more stimuli (more flankers) are presented, then selective attention processing takes more time to filter the stimuli in order to correctly identify the target stimulus and respond to the task parameter. Competitive selection must dictate which stimulus is most important (the target) while the working memory and salience filtering are also actively processing and eliminating irrelevant stimuli (the flankers).

These operations take time, albeit mere milliseconds, and this is reflected by increased response times of participants (Eriksen & Eriksen, 1974). Selective attention, as well as almost every other component of attentional processing, happens extremely quickly. However, the processes can be slowed depending on the number of stimuli presented during a task, as evidenced by the increased reaction times of the participants (Eriksen & Eriksen, 1974). The more stimuli presented, the more difficult the task becomes for the attention processes to carry out their actions.

Feedback and Performance

Attention becomes even more complicated when considering performance and feedback. Humans perform every day: performing in a job, in the classroom, on the road, or on the monkey-bars. In all of these examples, humans are showcasing their abilities, and in most cases these performances call for feedback. Feedback often drives performance whether positive or negative (Krenn, Würth, & Hergovich, 2013). The feedback on performance can either motivate the act or further diminish and replace the act altogether. For example, when driving a car an individual is making a commitment to obey traffic laws and other drivers. However, if the individual disobeys the laws and causes a traffic accident, they may feel guilty and upset based on what others have said about the accident. The individual then has the opportunity to use this feedback to motivate improvements on their driving. Feedback is important for an individual to assess their progress in their performance.

Krenn et al. (2013) defined feedback as allowing an individual to compare their current and realistic state to their goal and target state, which allows for understanding any discrepancy between the two. For example, a student is writing a first draft of an essay and brings this essay to their peer tutor who provides many comments. The comments on this essay allow the student to asses that their current essay needs work before it can be considered a final draft, and what needs to happen between the current state and the goal state to achieve the desired essay grade. Feedback is important for an individual to understand the distance between their actual and achieved states which allows them to determine a course of action to arrive at the achieved state (Krenn et al., 2013). Krenn et al. (2013) also discussed that feedback can have positive, negative, or debilitating effects on the performance of a task. For example, suppose an individual is composing a symphony and their mentor gives them harsh feedback about a particular section of the symphony. The individual can either use this harsh feedback to work more diligently to reconstruct the symphony, discourage and frustrate them about how to change the section, or discourage them from finishing the symphony at all. Although this might seem like an extreme example, feedback does result in such responses.

Much like Krenn et al.'s (2013) discussion of the effects of feedback, Bannister (1986) discussed that feedback serves two functions: motivation and error detection. Take an example in which an individual who works as a nurse receives negative feedback that a patient has lost weight despite intravenous feeding. This nurse, in response to the feedback, may investigate the patient's chart and realize that an error in calculations has been made and the patient is receiving less calories than they should. Here, feedback is serving the function of detecting (and then correcting) errors in order to operate at an acceptable level. Further, feedback, whether positive or negative, may serve to motivate an individual to either continue their current behavior or to modify their behavior in order to promote more positive outcomes. Moreover, when considering Krenn at al.'s (2013) discussion of the effects of feedback, the individual responsible for the error may be completely deterred by the feedback they receive on their error. Feedback can be motivating and important for detecting errors, but how that feedback is perceived also plays an important role in the responses.

Ilgen, Fisher, and Susan (1979) further explored that feedback is vital for an individual to recognize and motivate their performance in any particular setting. These researchers further identified that feedback response is dependent on the individual's personality as well as the feedback itself and the source of the feedback. There are three sources of feedback discussed by

Ilgen et al. (1979): observer, task environment, and individual. Whereas, the other researchers' discussions of feedback are limited to the type and response to feedback (Bannister, 1986; Krenn et al., 2013). Aside from discussions of feedback type and response, Ilgen et al. (1979) included personality and source of feedback are also very important components for response to feedback.

Ilgen et al. (1979) began defining source of feedback with a definition of observer feedback as when an individual has a direct observer watching them perform a task. The most obvious example of this is in a sports competition where an athlete performs their event with judges watching the entire performance. Another example is during a psychological study in which the participant is directly observed by the experimenter. In both cases, the recipient of the feedback may respond in a variety of ways depending on their opinion and relationship to the observer (Ilgen et al., 1979). Take the previous example of symphony composer and the various responses to feedback. When the composer receives live feedback from their audience or a fellow composer, they may respond more positively to a fellow composer's feedback due to a prior relationship than an unknown audience.

Next, Ilgen et al. (1979) discussed that the environment a participant is in during a task was another source of feedback. This source can happen in two ways: the feedback is inherent to the task or the feedback is augmented to the task. If the feedback is inherent to the task, it is obvious to tell whether or not the individual is performing the correct activity needed to complete the task. This could be when a child is asked to clean up their toys, but they play with them instead. If feedback is augmented to the task, the feedback is added to the operation, such as when an individual is taking a timed quiz and is told how long each question is taking them. Ilgen et al. (1979) further discussed that the responses to these sources of feedback is also dependent on the nature of the individual. For some individuals augmented feedback may either motivate them or deter them. For other individuals, then, inherent feedback may result in more or less motivation to perform the task, depending on what the individual is doing instead of the instructed task.

Lastly, Ilgen et al. (1979) discussed that individuals can be their own source of feedback. This occurs when individuals may have prior experience with a task or are familiarized with the operations of the task. Individuals are able to judge their own performance based on any prior knowledge or experience of the tasks and can compare themselves to what should be expected. Much like both other sources of feedback, response is dependent on the individual. It is important to consider the source of feedback, as well as the type of feedback, when examining the effects that feedback has on an individual. Ilgen et al. (1979) discussed the implications of sources of feedback on the motivation of an individual, and this motivation is further connected with attention.

Rothermund (2003) considered how feedback and attention intertwine. Rothermund (2003) discussed that the motivational state of an individual directs information processing by modulating selective attention. Rothermund (2003) discussed that attention is modulated by information that does not match the present motivational state. That is, individuals are more sensitive to what could go wrong in the task than what could go right if they were in a more positive mood to begin with. To support this claim, Rothermund (2003) discussed a study completed in 2001 by Rothermund, Wentura, and Bak. These researchers studied positive and negative outcome focuses on a visual detection task. Rothermund et al. (2001) found that positive and negative goal outcomes increased the detection of distractor stimuli, exemplifying that the type of motivation an individual is fixated on broadens their attention. This finding agreed with Bannister's (1986) conclusion that feedback is motivational. Therefore, it can be hypothesized that individuals with positive or negative goal states will already experience attention limitations, and when they receive feedback this may further hinder the attentional state. Rothermund (2003) indicated this idea, and discussed that when individuals were in a positive mood, they were more fixated on a negative outcome. If an individual in a positive state received negative feedback about their performance, it was suggested that their attention dwindled. If this individual is performing a selective attention task, their detection of distractor stimuli will increase.

Further, feedback may be very useful, but there is caution in continuing to present feedback to an individual as discussed by Nease, Mudgett, and Quiñones (1999). Nease et al. (1999) discussed that continual and repeated feedback may result in a decrease of effort of an individual; this result may be a consequence of changing cognitive responses to lower goals, reject feedback, or totally withdraw from the task. Repeated feedback may, essentially, desensitize an individual to the effects of the feedback itself, resulting in a state in which the benefits of feedback are nonexistent. In these cases, feedback may be initially helpful, but because of the continual presentation of the feedback, the effects may dwindle. Feedback and performance on selective attention tasks have clear connections, but the emotions of an individual are also important to consider.

Emotions

Finally, attention becomes more complicated when emotions and perceptions are considered. Performance on a selective attention task can be influenced by the emotions felt by an individual (Gray, 1971, 1982). Controlling emotions might be a key aspect in controlling attention. Gray (1971, 1982) presented two systems that explain the effect of emotions on informational processing. The first system is the behavioral activation system (BAS) which describes the signals related to reward promotes active avoidance, which results in turn facilitates selected responses. The BAS system is more of a positive reward system of hope and relief that facilitates selected responses and may promote more attention. For example, on an attention task that individuals know they will be rewarded for their performance this may give them hope and facilitate them to focus more on the task, improving their performance. The second system is the behavioral inhibition system (BIS) which is activated by punishment signals that result in anxiety and non-reward frustration. Where BAS is focused on positive emotions, BIS is focused on negative emotions. Each facilitates or inhibits attention, respectively. Gray (1971, 1982) focused on identifying these two systems, whereas other researchers identified specific emotions and their effects on attention.

Finucane (2011) was one of the researchers that discussed how specific emotions, fear and anger, enhanced selective attention. In her study, Finucane (2011) supported that when female participants were shown fearful images, they facilitated their attention more than the control participants. Finucane (2011) also discussed that a happy mood broadened the scope of attention and enhance creative problem solving of the individuals. Emotions, such as fear and anger, may narrow the scope of attention allowing for more facilitation of attention on an attention task. Happy mood may elicit other emotions or physical responses that then broaden the scope of the attention allowing for worse performance on the task (Finucane, 2011).

Fredrickson (1998) also discussed that specific action tendencies are important to highlighting the function of emotion and emotions serve as evolved adaptations. Fredrickson (1998) and Finucane (2011) both presented that fear and anger facilitated attention and that positive emotions expand attentional focus. Both researchers support that negative emotions facilitate attention. Fear and anger are commonly regarded as fight or flight emotions; these emotions are important for activating innate systems for survival. In a survival situation, it is important to eliminate anything that is not relevant and focus solely on what is important, therefore fine-focusing attention.

Derryberry (1991) may have an explanation for the findings of Fredrickson (1998) and Finucane (2011). Derryberry (1991) stated that if attention is affected by emotion, these effects and their ramifications are widespread and have a domino-effect on other types of cognition. To investigate this statement Derryberry (1991) tested participants by using positive and negative emotional signals to assess the effects on central arousal, response, and attentional processes. Derryberry’s (1991) results, however, did not yield his expectations. The researcher explained that these attentional experiments suggest that positive and negative cues attract greater attention than neutral ones. Further, the positive experiments attract more attention than the negative cues, which can be explained by the BAS (Gray 1971, 1982) being a stronger system. It is clear that selective attention is affected not only by feedback on performance, but also by emotions of the individual. Further, the emotions of the individual have interactions on the feedback of performance.

Perceptual Load and Selective Attention

In 2004, three researchers (Lavie, Hirst, & de Frockert, 2004) studied how the perceptual load and cognitive load of a task influenced the amount of attention devoted to task irrelevant stimuli. Lavie et al.’s (2004) research lead them to develop a load theory of selection attention. In their research, perceptual load is the number of irrelevant stimuli that appear alongside the target stimuli. In all, their findings support that lower perceptual load results in lower detection of irrelevant stimuli. When cognitive load is high, perception of irrelevant stimuli increases (Lavie et al., 2004).

Huang-Pollock et al. (2002) presented a study that provides some explanation for the findings of Lavie et al. (2004). Huang-Pollock et al. (2002) found that children experience more distraction in low perceptual load tasks. This was opposite of adults where less distraction is experienced in low perceptual load tasks. They explained these findings by discussing that children have not yet developed the same top-down processing that adults have and may not be able to ignore the presentation of irrelevant stimuli. In this instance, top-down processing refers to processing that begins in the brain and then elicits a behavioral response (Miller & Cohen, 2001). Couperus (2011) agreed with this thought and discussed that across development selective attention changes based on perceptual load; throughout development the effects of perceptual load becomes more dependent on the amount of perceptual load presented. Huang-Pollock et al. (2002) did find that children and adults perform similarly in high perceptual load conditions, which is suggestive that when the perceptual load of a task is high, the attention systems are not able to function properly which may be because of the overloading the capacity of the systems.

Easterbrook (1959) also discussed that emotions have a role with perceptual load. Easterbrook (1959) presented that, as with other types of tasks, the effect of emotions would depend on the number of cues in the task. Therefore, if there are more cues in the task, emotion may hinder the proficiency of the individuals' performance on the task. For example, a growing number of additional stimuli may overwhelm the individual and cause them to worry and become upset at the task, hindering their response performance. These negative emotions will hinder performance on a selective attention task, as discussed by Fredrickson (1996) and Finucane (2011). Conversely, in conjunction with Lavie et al.'s (2004) load theory, emotions can be used to influence cognitive load. Lavie et al. (2004) used memory tasks to manipulate cognitive load, but the more emotional an individual is, the more their performance is likely to be affected by their emotions.

While there is a lot of support for Lavie et al.'s (2004) load theory, there are some researchers that challenge it. Lachter, Forster, and Ruthruff (2004) presented the slippage theory, which describes that attentional selection occurs early in visual processing. This is to say that if an individual is participating in a task with one target stimulus and eight irrelevant stimuli, attention is discriminatory during the visual processing of the task and will eliminate the irrelevant stimuli. Therefore, if attention is discriminatory during visual processing, there may be no detection of irrelevant stimuli. Further, if this information is not attended to receives little, if any, processing beyond recognizing physical features (features that may be important to discriminating the target stimulus).

However, there is little evidence to support that irrelevant stimuli were completely unattended, which would negate that irrelevant stimuli are completely ignored beyond early visual processing. Gaspelin, Ruthruff, and Jung (2014) supported that the slippage theory has more evidence for explaining flanker compatibility effects (Eriksen & Eriksen, 1974). In other words, why when the flanker matches the target that participants are able to respond more quickly. If an individual has early visual processing of the stimuli (or if they are recognizing simple physical features) and are able to selectively attend to the target stimulus quickly, they then will be able to respond more quickly on a task. Further, flanker compatibility effects (Eriksen & Eriksen, 1974) explain that visual processing happens early on and very quickly if all stimuli are the same (as in the congruent conditions); if the target stimulus is different, visual processing may be slowed due to the additional processing of the different stimuli features.

Although Gaspelin et al. (2014) explained flanker compatibility effects by a slippage theory, Benoni and Tsal (2012) presented a dilution theory of attention. Benoni and Tsal (2012) developed this theory in which features of a stimulus are identified during the search of a target stimuli but are then diluted by the identification of the target object. This theory recognizes that irrelevant stimuli may be perceived but that they are diluted during the serial search for the object. Chen and Cave (2013) further discussed this dilution theory by exemplifying that distractor interference may not be because there is a lack of perceptual resources to detect the stimuli. Instead when the incongruent stimuli are perceptually strong, the stimuli compete and this degrades the quality of the representation of the stimuli. If the stimuli are degraded enough, detection is no longer necessary. This is very analogous to the idea of diluting apple juice for children: the juice starts very strong, but is watered down (degraded) until the juice is more subtle.

Present Study

The present study examined Lavie et al.'s (2004) theory using a selective attention task with a fixed perceptual load, but changing cognitive conditions. The present study utilized a version of the Eriksen Flanker task (Eriksen & Eriksen, 1974) to examine perceptual load; the perceptual load was presented in a high perceptual load (four additional objects) and a low perceptual load (target object only). Perceptual load was fixed at these levels, so more complex varying perceptual loads was not examined. Moreover, the changes in cognitive conditions was centered around feedback about their performance. Cognitive load changes were assessed by providing the participant with only positive feedback, only negative feedback, or no feedback regardless of their performance.

The researcher predicted that participants who receive only negative feedback on the task will exhibit narrowed attention on the task (exhibited by faster reaction times), but will eventually plateau as the feedback becomes irrelevant. Further, it was hypothesized that individuals who only receive positive feedback may have slightly faster reaction times in the beginning of the task due to encouragement, but will not continue with this trend. Overall emotionality of participants was assessed through questionnaires only, as emotionality was not the main focus of this study. Emotionality was only used as anecdotal evidence, and was not be empirically examined.

The researcher expected that individuals who receive mixed feedback would show a trend of faster and slower reaction times; negative feedback would serve to encourage faster responses and positive feedback would serve as a maintenance of current reaction times. To serve as a control, all participants began in a no feedback condition on the task.

Experiment 1

In the present study, Experiment 1 served as a pilot study, based off of the research by Leuenberger, Andrews, Kovack-Lesh, and Simmering (2018). Leuenberger et al. (2018) studied adults using a battery of attentional tasks. The Directional Flanker task served as a pilot in the present study as it inspired the question of the role of feedback on the performance of the individual.

Method

Participants

The participants in Experiment 1 were recruited using the Ripon College email system; eligible adults that were on campus during the summer of 2018 received an invitation to participate in a study for the Ripon College Infant Cognition Lab (ICL). There were a total of 16 participants in this study from the Ripon College community with their ages ranging from 19 years old to 66 years old (*M* = 29.71, *SD* = 16.79). All participants signed a consent form prior to participating in the study, and were treated in accordance with the "Ethical Principles of Psychologists and Code of Conduct" (American Psychological Association, 2002). Participants were given the option to enter in a drawing to win a Ripon College travel mug to thank them for their participation.

Materials

Participants were tested in a battery of tasks designed by the Ripon College ICL and the University of Wisconsin (UW) Madison's Spatial Perception, Action, Cognition & Embodiment (SPACE) Lab. The researcher used a Samsung tablet to run two of three games; Pop the Bubbles and Color Flanker are proprietary applications of UW-Madison. The researcher used a Dell laptop to run the other game called Directional Flanker task; this task was run using Python 2.7, coded in Enthought Canopy 2.1.9, and uses PsychoPy Standalone Package 1.90 object installations to create the program. Participants responded to task parameters using a wired numeric keypad. To record the sessions, the researcher used two Logitech web-cameras and the program OBS Recording Studio to record the two cameras simultaneously.

Procedure

At the beginning of the study, participants entered the Ripon College ICL in Todd Wehr Hall. The risks of participating in the study and other important information detailed on the consent form were explained to the participants. If they agreed to the risks of participating in the study, participants signed the consent form.

After signing the consent form, participants were taken into an adjacent room within the laboratory suite (see Appendix A) and instructed to sit in a chair at a table with a tablet and webcamera in front of them. The researcher then started the two cameras and detailed the instructions of the first task – in total there were seven tasks across the three different games.

The first task and the first game is called Pop the Bubbles, one of the games created by researchers at UW-Madison and Ripon College. This game is based on the task designed by Ross-Sheehy, Schneegans, and Spencer (2015). In this version of Ross-Sheehy et al.'s (2015) task, participants use a tablet for their responses. For more information about this task, refer to the research by Andrews, Leuenberger, Kovack-Lesh, and Simmering (2018).

The second and third tasks are the flanker task; participants were counterbalanced in the order of flanker task that they participated in, but each flanker task was run twice in a row. Participants were assigned their first flanker task using an online randomizer for either the Directional Flanker or the Color Flanker. For the purpose of this explanation, assume that the participant was randomly assigned to participate in the Directional Flanker first.

The Directional Flanker was run using the laptop, so the researcher rearranged the table to set the computer and numeric keypad in front of the participant (see Appendix B). Participants were instructed that they would first see a small cross appear in the center of the screen and then a row of fish. Participants were instructed to look at the middle fish and identify the direction that the fish was facing – either left or right; other fish could appear on both sides of the middle (target) fish, but these were to be ignored. Once they identified the direction of the fish, participants were instructed to respond using the arrow key on the keypad that matched the direction. There are three conditions in this task (Figure 1 visually displays the conditions): neutral (no additional fish displayed), congruent (additional fish displayed matching the direction of the target fish), and incongruent (additional fish displayed not matching the direction of the target fish). Participants were run in a total of 72 trials of the task, which was separated between two 36 trial blocks. Each block consisted of 36 trials due to the counterbalanced nature of the task. Each participant had the same number of neutral, congruent, and incongruent condition trials but the order was randomly selected by the program.

Further, in the Directional Flanker task, participants received performance dependent feedback. If the reaction time of the participant exceeded one second, their reaction time (in milliseconds) and a message was displayed in red front prompting the participant to be faster. If the reaction time of the participant was under one second, their reaction time was displayed in blue font. If the participants responded with the incorrect direction, a message in red font appeared alongside their time feedback telling them that they responded with the incorrect direction. If the direction was correct, no message was displayed (see Figure 1 for feedback messages).

The fourth task is another round of Pop the Bubbles. The fifth and sixth task was the Color Flanker task. This task was also on the tablet. This task was created by the researchers at UW-Madison and Ripon College (Leuenberger et al., 2018) in response to the poor performance of children on the Directional Flanker task; the task was designed to be more appropriate for child participants. Participants were instructed to start with their hands on the mat on the table in front of them. The participants were told they would see a green circle, and then a row of circles, and they were to respond to the color of the middle circle and select a square on the bottom of the screen that matched the middle circle (see Figure 2). The green circle served the purpose of showing where the middle circle would be. In this task, participants did not receive any feedback on their performance or whether the color identification was correct. The task is designed to run thirty trials if the participant answers correctly each time; if participants answered incorrectly an additional trial was added by the program for each incorrect trial. The seventh and final task were the remaining block of Pop the Bubbles.

Upon competition of every task, participants were given a chance to submit their names to a drawing to win the Ripon College travel mug to thank them for their participation. The researcher explained the purpose of the research to each participant and answered any questions that the participants may have had. The researcher would then walk the participants out of the lab.

Results and Discussion

The descriptive statistics for the average reaction time of the 16 participants in Experiment 1 are displayed in Figure 3. A single factor within-subjects Analysis of Variance (ANOVA) was utilized to analyze the mean reaction times of the participants on each flanker condition type. This ANOVA revealed a significant difference in the reaction times of the participants across the flanker types, F (2, 30) = 44.088, p = 0.000, η^2_p = 0.746, with an observed power of 1.00. To analyze where this significance lies, a series of Bonferroni post-hoc tests was run; these post hoc tests revealed that there is a significant difference in the average reaction times of the congruent trials and the incongruent trials, $p < 0.0001$, with the reaction times on the congruent trials being significantly faster than the reaction times on the incongruent trials. Further, the post-hoc tests revealed significant between the incongruent trials and the neutral trials, $p < 0.0001$, with the neutral trials having significantly faster reaction times. These post-hoc tests did not reveal a significant difference in the average reaction times of the congruent and neutral trials, p = 1.000.

The researcher expected that the results from Experiment 1 would show that the congruent condition facilitated the fastest reaction times, the neutral condition would have slightly faster reaction times than the congruent, and the incongruent would have the slowest reactions times. The observed results almost match the expected results exactly, with the exception that the neutral trials yielded the fastest reaction times instead of the expected congruent trials. Further, the results of Experiment 1 match the results of the flanker study completed by Eriksen and Eriksen (1974). First, Experiment 1 supports Eriksen and Eriksen's (1974) finding that when more stimuli is presented the reaction time of the participant is slowed; Experiment 1 demonstrates this by the comparison of reaction times of the three trial types. Although there is no significant difference between the reaction times on the congruent and neutral trial types, the mean reaction time on the neutral conditions is still a bit faster. However, the incongruent trials did yield the slowest reactions times of all three trial types, consistent with the findings of Eriksen and Eriksen (1974). Eriksen and Erickson (1974) explained these results by stating that the process of selective attention is slowed when more stimuli are presented.

These results are also consistent with the explanation of the slippage theory (originally proposed by Lachter et al. in 2004) by Gaspelin et al. (2014). This theory describes that attentional selection occurs early in visual processing which would allow for irrelevant stimuli to be filtered out (Lachter et al., 2004). Gaspelin et al. (2014) used the slippage theory to provide an explanation for flanker compatibility effects by stating that when early visual processing of the stimuli occurs, participants are able to selectively attend to the target stimulus quickly.

Experiment 2

Experiment 2 was modeled after the Directional Flanker task used in Experiment 1. However, in Experiment 2 the emphasis was focused less on the effects of condition type (neutral, incongruent, and congruent) and more on the effects of the type of feedback participants receive. The feedback participants received was irrelevant to their actual performance on the task. Further, whereas Experiment 1 tested participants in a battery of attention tasks that transitioned between a laptop and a tablet, Experiment 2 tested only the Directional Flanker using a laptop.

Method

Participants

Participants in Experiment 2 were volunteer participants from the Ripon College community and the hometown of the researcher. Participants in this study were recruited from classes in the psychology department, on-campus postings, and Greek life and other living organizations. Participants that were in Experiment 1 were not allowed to participate in Experiment 2, in order to eliminate any effects from the first study. There was a total of 104 participants in this study, with their ages ranging from 18 to 31 years of age (*M* = 20.355, *SD* = 2.140); sixty-one of the participants were females and 43 of the participants were males. All participants signed a consent form prior to the experiment. All participants were treated in accordance with the "Ethical Principles of Psychologists and Code of Conduct" (American Psychological Association, 2002).

Materials

A Lenovo ThinkPad laptop was used to run participants in the Directional Flanker task. The researcher utilized the same programs that ran the task in Experiment 1 (Leuenberger et al., 2018) with changes to the number of trials per block and the feedback displayed. Participants used wired numeric keypad to respond to the results of this task. The researcher used books of word searches and coloring for in between each block.

Procedure

All participants were tested in a quiet, distraction free environment on or off Ripon College campus, such as a private student lounge or the researcher's dorm room. Participants entered the testing room, and were instructed to sit at a table with the computer in front of them. Participants each signed a consent form and were informed of their risks in participating in the study. Written on the consent form was a message that deception may be used in the study; participants were not informed what the specific deception was prior to the study. After the consent form had been signed, participants were instructed in how to participate in the task. The participants were told that they would see a small cross on the screen and then a row of fish and they were expected to identify the direction of the fish in the middle of the row and respond with the same arrow on the keypad in front of them.

All participants began the testing with a version of the task the provides them with no feedback whatsoever. The no feedback condition serves as a control and was always first in order to eliminate any effects of receiving feedback in the first block of the task and no feedback in the next block. It is noteworthy to mention that this is a confound in the design of the study because the participants go from receiving no feedback on their performance to receiving some type of feedback on every single trial; however, the researcher was unable to eliminate this confound. Further, in a typical within-subjects design the order of the groups would be randomized, but because of the feedback nature of this study this randomization is not possible. Participants did not know their reaction times or whether they got the direction of the fish correct. Here, and throughout the study, is where deception played a role, as participants were receiving types of feedback without acknowledgement of their true performance. This is to serve as the control group for the study. The no feedback version of the task cycles through 72 trials of the task in the same counterbalanced method described in Experiment 1.

Twenty-six participants were in a group where they were given only negative feedback for 72 trials and only positive feedback for 72 trials. This group was known as the neg-pos group for the transition from negative to positive feedback. The only negative feedback condition displayed the message “TRY TO BE FASTER” in red regardless of the response time of the participant. The only positive feedback condition displayed the message “GREAT WORK!” in green regardless of the response time of the participant. In every condition (no feedback, only positive, and only negative) participants’ reaction time was not be displayed, and in the no feedback and only positive feedback conditions, information about the direction response was not be displayed. In the only negative feedback condition, information about the direction response will be displayed if the direction is incorrect. The purpose of not showing the reaction time was to minimize any carry-over effects between groups if participants recognized that the feedback is not performance based. Twenty-six other participants were then be a group where they are given only positive feedback for 72 trials and only negative feedback for 72 trials. This group was known as the pos-neg group for the transition from only positive to only negative feedback. Twenty-six other participants were tested in 144 trials of only positive feedback; this group was known as the only-pos group. Finally, 26 remaining participants were tested in 144 trials of only negative feedback; this group is known as the only-neg group.

Each 72 block of trials was separated by a two-minute break in which participants were allowed to complete either a word search or a coloring book task. These tasks were irrelevant to the study as a whole and served only the purpose of allowing for participants to rest their eyes and look away from a computer screen for several minutes, so as to minimize fatigue. Further, imbedded within the Directional Flanker programs were three short breaks. When these breaks occur, participants receive a message that says “You can take a short break, then press ENTER to go on to the next trial". Participants were allowed to take as much or as little time as they needed for these breaks.

At the end of the testing period, all participants answered questions to a short demographic survey that assessed their emotionality as well as some aspects of their attention (see Appendix C). Lastly, before participants were allowed to leave, they were asked to list at least five happy thoughts on a sheet of paper that they took with them. The purpose of this was to minimize any lingering bad moods by continual negative feedback. Participants were offered a piece of candy which served to thank them for their participation and to elevate their moods. Nutrition facts of the candy were displayed in case of any food allergies. The participants were given a full debriefing session informing them of the purpose of the research, why the task was designed in this specific manner, and what role deception played in the task.

Results and Discussion

The descriptive statistics for the average reaction times for each feedback condition (no feedback, positive feedback, and negative feedback) in each Flanker condition (congruent, incongruent, and neutral) of the 104 participants is displayed in Table 1. In this experiment, the independent variable was the type of feedback participants receive and the dependent variable was the mean reaction times.

To analyze the data, the researcher ran a 2x2x3x3 partially repeated measures ANOVA on the following groups: positive feedback to negative feedback, negative feedback to positive feedback, positive feedback to positive feedback, and negative feedback to negative feedback. This ANOVA allowed the researcher to observe if there was a significant difference in the type of feedback, the type of flanker, which feedback occurred after the control condition (known as the first feedback), which feedback occurred after the first feedback (known as the second feedback).

Main Effects

This 2x2x3x3 partially repeated measures ANOVA revealed significance in the main effect of feedback type, F (2, 200) = 131.260, $p < 0.0001$, $\eta^2_p = 0.568$, with an observed power of 1.00. To analyze where the significance lies in this main effect, the researcher ran a series of Bonferroni post-hoc tests; descriptive statistics are displayed in Figure 4. The post-hoc tests revealed a significant difference in the reaction times of participants receiving no feedback and their first feedback, $p < 0.0001$, with the no feedback yielding a significantly slower reaction time. This post-hoc also demonstrated that there was a significant difference in the reaction times of participants when they transitioned from receiving no feedback to their second type of feedback, $p < 0.0001$, with the no feedback yielding a significantly slower reaction time than the third type of feedback. Finally, the post-hoc tests revealed that there was a significant difference in the reaction times when participants transitioned from their first feedback type to their second feedback types, $p < 0.0001$, with their first feedback type yielding significantly slower reaction times than the second feedback type.

Further, this ANOVA revealed significance in the main effect of flanker type, F (2, 200) = 35.649, $p < 0.0001$, $\eta^2_p = 0.263$, with an observed power of 1.00. To analyze where the significance lies in this significant main effect, the researcher ran a Bonferroni post-hoc test, descriptive statistics are displayed in Figure 5. This post-hoc test revealed that the reaction times on the congruent and incongruent trials were significantly different, $p < 0.0001$, with the congruent trials yielding significantly faster reaction times than the incongruent trials. Next, the post-hoc tests showed that the reaction times on the congruent and neutral trials were significantly different, $p = 0.037$, with the reaction times on the congruent trials being significantly faster. Finally, the post-hoc test revealed significance in the reaction times on the incongruent trials and the neutral trials, $p < 0.0001$, with the neutral trials yielding significantly faster reaction times than the incongruent trials.

This ANOVA did not, however, demonstrate significance in the main effect of first feedback received, F (1, 100) = 0.921, $p = 0.340$, $\eta^2_p = 0.009$, with an observed power of 0.158. Finally, this ANOVA did not reveal significance in the main effect of second feedback received, F (1, 100) = 0.098, $p = 0.755$, $\eta^2_p = 0.001$, with an observed power of 0.061. Descriptive statistics for the main effect of first feedback received and second feedback received are displayed in Figures 6 and 7, respectively.

Interactions

Two-Way

All descriptive statistics for the two-way interactions of first feedback and second feedback, first feedback and feedback type, first feedback and flanker type, second feedback and feedback type, and second feedback type and flanker type are displayed in Tables 2 – 6, respectively. First, this ANOVA did not reveal significance in the interaction of first feedback received and second feedback received, F (1, 100) = 1.111, $p = 0.295$, $\eta^2_p = 0.011$, with an observed power of 0.181. The ANOVA further demonstrated that there was no significance in the interaction of feedback type and the first feedback received, F (2, 200) = 0.051, $p = 0.951$, $\eta^2_p = 0.001$, with an observed power of 0.058. Likewise, no significance was found in the interaction of flanker type and first feedback received, F (2, 200) = 1.531, $p = 0.985$, $\eta^2_p = 0.000$, with an observed power of 0.323. No significance was also found in the interaction of feedback type and second feedback received, F (2, 200) = 0.636, $p = 0.531$, $\eta^2_p = 0.006$, with an observed power of 0.155. The ANOVA demonstrated marginal significance in the interaction of flanker type and second feedback type, F (2, 200) = 2.88, $p = 0.058$, $\eta^2_p = 0.028$, with an observed power of 0.559.

Finally, the ANOVA did show significance in the interaction of feedback type and flanker type, F (4, 400) = 10.182, $p < 0.0001$, $\eta^2_p = 0.092$, with an observed power of 1.000. A series of Bonferroni post-hoc tests was run on the significant interaction; descriptive statistics are displayed in Figure 8. This post-hoc test revealed that on the congruent trials, no feedback was significantly different from the first type of feedback received, $p < 0.0001$, with the no feedback yielding significantly longer reaction times than the first type of feedback. Further, significance was found in the difference in reaction times on the no feedback and second feedback received on congruent trials, $p < 0.0001$, with no feedback yielding a significantly slower reaction time than second feedback received. Further on the congruent trials, significance was found when transitioning from first type of feedback to second type of feedback, $p < 0.0001$, with first type of feedback yielding significantly longer reaction times than second type of feedback.

On the incongruent trials, the post-hoc test revealed a significant difference in the reaction times of no feedback and first feedback received, $p < 0.0001$. In this case, the no feedback yielded significantly longer reaction times than the first feedback received. Next, the post-hoc test showed a significant difference in the reaction times of no feedback received to second feedback received, $p < 0.0001$, with no feedback yielding significantly slower reaction times than second feedback. This post-hoc test also demonstrated that there was a significant difference in the reaction times of first type of feedback received and second feedback received, $p < 0.0001$, with first feedback yielding significantly longer reaction times.

Lastly, on the neutral trials the post-hoc test revealed a significant difference in the reaction times on the no feedback and first feedback received, $p < 0.0001$, with no feedback exhibiting significantly longer reaction times than the second feedback received. There was also a significant difference in the reaction times of the no feedback and second feedback received, $p < 0.0001$, where no feedback has a significantly longer reaction time. Finally, the post-hoc test showed a significant difference between first feedback received and second feedback received, $p < 0.0001$, with first feedback taking significantly longer than second feedback received.

Three Way

The 2x2x3x3 partially repeated measures ANOVA showed that there was no significant interaction with feedback type, first feedback received, and second feedback received F (2, 200) = 0.002, $p = 0.984$, $\eta^2_p = 0.000$, with an observed power of 0.050. Descriptive statistics for this interaction are displayed in Table 7. Further, no significant difference was found in the interaction of flanker type, first feedback received, and second feedback received (descriptive statistics are displayed in Table 8), F (2, 200) = 2.483, $p = 0.086$, $\eta^2_p = 0.024$, with an observed power of 0.495. No significant difference was found in the interaction of feedback type, flanker type, and first feedback received (descriptive statistics are displayed in Table 9), F (4, 400) = 0.382, $p = 0.882$, $\eta^2_p = 0.004$, with an observed power of 0.138. Finally, this ANOVA did not show a significant interaction of feedback type, flanker type, and second feedback received F (4, 400) = 2.241, $p = 0.064$, $\eta^2_p = 0.022$, with an observed power of 0.656. Descriptive statistics for this interaction are displayed in Table 10.

Four Way

The 2x2x3x3 partially repeated measures ANOVA revealed that there was no significance in the four-way interaction of feedback type, flanker type, first feedback received, and second feedback received, F (4, 400) = 0.089, p = 0.986, η^2_p = 0.001, with an observed power of 0.068. Descriptive statistics for this four-way interaction are displayed in Table 1.

Discussion

Experiment 2, much like Experiment 1, closely demonstrated the flanker compatibility effects (Eriksen & Eriksen, 1974). However, where Experiment 1 followed the trend exactly, Experiment 2 exhibited that the congruent trials yielded the fastest reaction times, which deviates from the expected flanker compatibility effects (Eriksen & Eriksen, 1974). Experiment 2 did demonstrate that the incongruent trials yielded the slowest reaction times, which is on trend with the flanker compatibility effects. However, the effects of the flankers were not the focus of Experiment 2.

Feedback, the main focus of Experiment 2, was observed to be significant in facilitating faster reaction times overall. Experiment 2 did not demonstrate that the type of feedback or the order of the feedback made a difference, but rather feedback itself served to be important in decreasing reaction times on the trials. The effects of feedback demonstrated that feedback itself was important for decreasing reaction times (i.e., yielding faster responses from participants) throughout each block of the experiment. The first block, no feedback, exhibited the slowest reaction times overall. The second and third blocks respectively yielded faster reaction times, regardless of the feedback type (negative or positive) and order (neg-pos, pos-neg, pos-pos, neg-neg) received.

This finding that feedback was important overall, regardless of type and order, can be explained by Krenn et al. (2013). These researchers explained that feedback allows an individual to compare their current state to their goal state and identify actions they need to take to achieve their goal state. In Experiment 2, participants received irrelevant feedback on their performance of the task, which allows them to compare their current and goal states. However, the feedback the participants received instructed the participants that they either were performing fine on the task or needed to be faster; only the negative provided the participants with a realistic way to improve their performance by noticing current and goal state discrepancies. The results of Experiment 1 showed that the effects of feedback increase across the first, second, and third blocks. It is intriguing that the type of feedback (positive or negative) does not have a difference in the changing of reaction times, rather just the pure addition of feedback influenced the reaction times. This is intriguing because, based on the reports of Krenn et al. (2013), positive feedback does not allow for noticing of discrepancy because the ‘goal state’ is being achieved already.

This lack of discrepancy may be explained by Bannister’s (1986) discussion that feedback serves to motivate individuals and detect any errors. The negative feedback would motivate individuals to continue to try and be faster as well as knowing when errors have been made because the program provides feedback on this. Further, the positive feedback would motivate individuals to continue to perform at the same level instead of becoming slower and slower throughout the task as the researcher expected.

General Discussion

The aim of this study was to examine Lavie et al.’s (2002) load theory of selective attention by using a selection attention task that utilized a fixed perceptual load and changing cognitive conditions. The selective attention task used was modeled after the Eriksen Flanker Task (Eriksen & Eriksen, 1974) to examine high perceptual load and low perceptual load conditions. In both Experiment 1 and Experiment 2 the changes in perceptual load showed that increasing the perceptual load from target only (neutral) conditions to irrelevant stimuli (incongruent and congruent) conditions the reaction times of the participants increased. This data modeled the flanker compatibility effects described by Eriksen and Eriksen (1974) in which the more stimuli presented the slower the response times will become. Lavie et al. (2004) further supported the idea of flanker compatibility effects with their load theory by describing that lower perceptual loads results in lower detection of irrelevant stimuli.

Moreover, the researcher predicted that participants that received only negative feedback on the task would show faster reaction times. The researcher also predicted that individuals that only received positive feedback would have slightly faster reaction times at the beginning of the testing period. The results of Experiment 2 showed that feedback affects reaction times but not in the way that the researcher expected; Experiment 2 showed that, overall, feedback was important for facilitating faster reaction times, but the type of feedback and the order of the feedback did not matter. Rather, Experiment 2 showed that feedback (no matter the type) facilitated faster reaction times as the testing blocks went on. An explanation for these results is that feedback allows individuals to recognize and motivate their performance (Ilgen et al., 1979; Krenn et al., 2013). Although there were positive and negative types of feedback in this study, the feedback allowed the individuals to monitor their progress and allow them to try and change their response times. On the control condition where no feedback was giving the slow responses times indicated that participants did not have a motivating factor to facilitate their response times and subsequently their attention. It is noteworthy to mention, however, that the control condition was the first exposure to the task and this learning period may had artificially inflated the reaction times.

These results, further, were not consistent with Lavie et al.’s (2004) theory in which high cognitive load leads to more perception of irrelevant stimuli. Experiment 2 demonstrated that feedback, regardless of type and order, facilitated faster reaction times throughout each block. The no feedback condition yielded the highest reaction times overall, whereas the third round of feedback received yielded the fastest reaction times, directly inconsistent with the theory that high cognitive load leads to greater detection of irrelevant stimuli (Lavie et al., 2004). However, this inconsistency can be explained by the motivating factor provided by the feedback given to the participants (Ilgen et al., 1979; Krenn et al., 2013). The researcher expected that the negative feedback would demonstrate the effects on high cognitive load, but the results of Experiment 2 show that feedback may not serve as cognitive load. These results, however, are more consistent with the slippage theory proposed by Lachter et al. (2004).

Lachter et al.'s (2004) slippage theory described that attentional selection occurs early in visual processing, which would minimize the effects of the flankers (Eriksen & Eriksen, 1974). While flanker compatibility effects were observed in Experiments 1 and 2, the slippage theory still holds true because irrelevant stimuli are not completely unattended as shown by the longer reaction times (Lachter et al., 2004). Gaspelin et al. (2014) supported this idea and further explained that if additional stimuli were presented on the trial, participants would respond more quickly if the additional stimuli matched the target stimulus because early visual processing would facilitate quick identification of the matching stimuli. Gaspelin et al.'s (2014) explanation not only integrated the slippage theory (Lachter et al., 2004) but also provided an interpretative and descriptive analysis of the flanker compatibility effects (Eriksen & Eriksen, 1974).

Moreover, Experiment 2 demonstrated that there was a significant interaction of flanker type (incongruent, congruent, neutral) and feedback type (negative, positive, and no feedback). As already mentioned, both flanker type and feedback type have separate explanations for their occurrence, but the co-occurrence has not yet been commented on in prior research. The researcher originally did not expect flanker type and feedback type to have a significant interaction and hypothesized that feedback type would be the main proponent in any significance found in Experiment 2. However, the significant interaction indicates that not only has Experiment 2 demonstrated that feedback matters and irrelevant stimuli matter, but the two interact to facilitate faster reaction times.

Rothermund's (2003) study on how feedback and attention intertwine provides an explanation for the interaction found in Experiment 2; Rothermund (2003) presented that selective attention is modulated by the motivational state of the individual. The feedback the individuals received may have served to motivate them to continue their current performance state (positive feedback) or to try and achieve the prompted state (negative feedback). These motivational responses to feedback carry over into the observed flanker compatibility effects (Eriksen & Eriksen, 1974) by modulating attention to the specific task. This modulation of attention would then yield similar effects because, although the individual is motivated in one way or another, the individual is focusing more on the task to achieve their goal state, but due to the level of perceptual load their attention is slowed when more and differing stimuli are present (Eriksen & Eriksen, 1974; Gaspelin et al., 2014; Lavie et al., 2004).

Beyond attention and feedback, Gray (1971, 1982) presented that emotions influence performance on selective attention tasks and that controlling emotions may be vitally important for controlling attention. The researcher collected survey data that measured average happiness and average anger of participants as measures of overall emotionality of participants. This survey revealed that on average participants rated themselves as being happier and having low anger. These results indicate to the researcher that participants experience more positive emotions which would facilitate attention via the BAS, as seen with the lower reaction times (Gray, 1971, 1982). More negative emotions inhibit attention which would inflate reaction times on the task. Finucane (2011) also discussed that fear and anger enhance selective attention. Participants reported low average anger, which leads the researcher to expect that anger would not have facilitated attention in this case. However, the researcher agrees with the findings of Finucane (2011) on the facilitation of attention via the fear and anger emotions based on the biological context of the fight or flight process. Further research is necessary to further support how fear and anger can facilitate attention.

Although this study found significance in the role of feedback on a selective attention task as well as demonstrated the flanker compatibility effects (Eriksen & Eriksen, 1974) there are limitations to the study. The first, and major, limitation to this study was the confound in the design of needing the no feedback condition to occur first. This confound was necessary due to the desire to limit any effects of transitioning from receiving feedback to receiving no feedback. However, this confound in the design of the study removes the possibility of being a truly randomized partially within-subjects design. To eliminate this confound, further research must be completed with more participants in order to have completely separate groups of feedback, eliminating the within-subjects component of the design.

Another major limitation in the design of this study is the restriction of the program used to run the directional flanker task and the researcher's lack of experience with complex computer programming. With more computer programming experience, the researcher may have been able to interweave positive and negative feedback into a single block, rather than having the types of feedback completely separated. This would allow the researcher to see how participants respond to varying types of feedback within the same task which would be a more real-world model of the reception of feedback. Further, the researcher could consider interweaving no, negative, and positive feedback types into one block, but with hesitation on the no feedback component. Here again, further investigation is necessary.

A few future directions for this study have been identified, but another future direction of this study is to conduct the study with active military members and civilians. Anecdotally, a participant of Experiment 2 commented on their experiences in the Army and receiving negative feedback, and how they were trained primarily with negative feedback as their motivator. The researcher found this to be incredibly interesting and an avenue of research into feedback itself as a motivator should be conducted between active military members and civilians to note any significant difference in performance when certain types of feedback are presented. The researcher hypothesizes that individuals in the military may perform better with constant negative feedback if that is how their military training has been conducted. Therefore, the researcher hypothesizes that civilians would perform worse on with constant negative feedback as they are not accustomed to this as much.

A final future direction of this study is to continue to note how changing perceptual and cognitive loads influence an individual's selective attention. The researcher is interested in identifying levels of changing perceptual load but needs more complex research materials. Experiment 1 and Experiment 2 offer only fixed perceptual load, where there was either no additional stimuli presented or four additional stimuli presented. Further, there is interest in identifying the effects of more and more perceptual load by adding more items. Changing cognitive load offers another avenue for further research. The researcher wants to conduct further research using a variety of cognitive tasks (such as working memory tasks, long-term memory tasks, verbal tasks, etc.) to note how changing cognitive load and perceptual load by varying degrees affects the performance of an individual on a selective attention task.

Despite the limitations in the present study, the original hypothesis that feedback would influence the reaction times of the participants was supported. The researcher originally thought that the type and order of the feedback would make a significant difference in the reaction times on the selective attention task which was not supported by the results of Experiment 2. Despite refuting part of the original hypothesis, the researcher still found meaningful data with feedback type and an additional support of the flanker compatibility effects (Eriksen & Eriksen, 1974). Further, the present study had some limitations, but these limitations are important for inspiring future studies on the same topics.

References

American Psychological Association. (2002). Ethical principles of psychologists and code of conduct. *American Psychologist*, *57*, 1060-1073. Retrieved from https://www.apa.org/ethics/code/principles.pdf

Andrews, C. M., Leuenberger, R., Kovack-Lesh, K. A., & Simmering, V. R. (May 2018). *How does attention influence looking versus pointing? Eye-tracking in a novel touchscreen paradigm*. In L. Colosimo (Chair), Action, Perception, and Learning. Paper presented at the 48th Annual Meeting of the Jean Piaget Society, Amsterdam, Netherlands.

Baddeley, A. (1992). Working memory. *Science*, *255*, 556-559. Retrieved from https://www.jstor.org/

Braun, J. (1994). Visual search among items of different salience: Removal of visual attention mimics a lesion in extrastriate area V4. *The Journal of Neuroscience, 14*, 554-567. Retrieved from http://www.jneurosci.org/content/jneuro/14/2/554.full.pdf

Bannister, B. D. (1986). Performance outcome feedback and attributional feedback: Interactive effects on recipient responses. *Journal of Applied Psychology, 71*, 203-210. doi: 10.1037/0021-9010.71.2.203

Benoni, H., & Tsal, Y. (2012). Controlling for dilution while manipulating load: Perceptual and sensory limitations are just two aspects of task difficulty. *Psychonomic Bulletin Review*, *19*, 621-639.

Chen, Z., & Cave, F. R. (2013). Perceptual load vs. dilution: The roles of attentional focus, stimulus category, and target predictability. *Frontiers in Psychology, 4*, 1-14. doi: 10.3389/fpsyg.2013.00327

Couperus, J. W. (2011). Perceptual load influence selective attention across development. *Developmental Psychology 47,* 1431-1439. doi: 10.1037/a0024027

Crawford, H.J., Brown, A.M., & Moon, C.E. (1993). Sustained attentional and disattentional abilities: Differences between low and highly hypnotizable persons. *Journal of Abnormal Psychology, 102*, 534-543. doi: 10.1037/0021-843X.102.4.534

Derryberry, D. (1991). The immediate effects of positive and negative feedback signals. *Journal of Personality and Social Psychology, 61,* 267-278. doi: 10.1037/0022-3514.61.2.267

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review, 66,* 183-199. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/13658305

Eriksen, B. A., & Eriksen, C.W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16,* 143-149. doi: 10.3758/BF03203267

Finucane, A. M. (2011). The effect of fear and anger on selective attention. *American Psychological Association, 11,* 970-974. doi: 10.1037/a0022574

Fredrickson, B. L. (1998). What good are positive emotions? *Review General Psychology, 2,* 300-319. doi: 10.1037/1089-2680.2.3.300.

Gaspelin, N., Ruthruff, E., & Jung, K. (2014). Slippage theory and the flanker paradigm: An early-selection account of selective attention failures. *Journal of Experimental Psychology: Human Perception and Performance, 40*, 1257-1273. doi: 10.1037/a0036179

Gray, J. A. (1971). *The psychology of fear and stress.* New York: McGraw-Hill. Retrieved from http://psycnet.apa.org/record/1992-98228-000

Gray, J. A. (1982). *The neuropsychology of anxiety*. London: Oxford University Press. doi: 10.1017/S0140525X00013066

Huang-Pollock, C. L., Carr, T. H., & Nigg, J. T. (2002). Development of selective attention: Perceptual load influences early versus late attentional selection in children and adults. *Developmental Psychology, 38*, 363–375. doi:10.1037/0012-1649.38.3.363

Ilgen, D. R., Fisher, C. D., & Susan, M. (1979). Consequences of individual feedback on behavior in organizations. *Journal of Applied Psychology, 64,* 349-371. doi: 10.1037/0021-9010.64.4.349

Kirby, J. R., & Das, J. P. (1990). A cognitive approach to intelligence: Attention coding and planning. *Canadian Psychology, 31*, 320-33. doi:10.1037/h0078948

Knudsen, E. I. (2007). Fundamental components of attention. *Annual Review of Neuroscience, 30*, 57-78. doi: 10.1146/annurev.neuro.30.051606.094256

Krenn, B., Würth, & Hergovich, A. (2013). The impact of feedback on goal setting and task performance: Testing the feedback intervention theory. *Swiss Journal of Psychology, 72,* 79-89. doi: 10.1024/1421-0185/a000101

Lachter, J., Forster, K. L., & Ruthruff, E. (2004). Forty-five years after Broadbent (1958): Still no identification without attention. *Psychological Review, 111,* 880-913. doi: 10.1037/0033-295X.111.4.880

Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *American Psychological Association, 133,* 339-354. doi: 10.1037/0096-3445.133.3.339

Leuenberger, R. E., Andrews, C. M., Kovack-Lesh, K. A., & Simmering, V. R. (2018, July). *Comparing flanker effects in direction and color over development*. Poster presented at the 40th Annual Meeting of the Cognitive Science Society, Madison, WI.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex functions. *Annual Review of Neuroscience, 24*, 167-202. doi: 10.1146/annurev.neuro.24.1.167

Nease, A. A., Mudgett, B. O., & Quiñones, M. A. (1999). Relationships among feedback sign, self-efficacy, and acceptance of performance feedback. *Journal of Applied Psychology, 84,* 806-814. doi: 10.1037/0021-9010.84.5.806

Parkhurst, D., Law, K., & Niebur, E. (2002). Modeling the role of salience in the allocation of overt visual attention. *Vision Research, 42,* 107-123. doi: 10.1016/S0042-6989(01)00250-4

Petersen, S. E., & Posner, M. I. (1990). The attention system of the hum brain. *Annual Review of Neuroscience, 13,* 25-42. doi: 10.1146/annurev.ne.13.030190.000325

Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years later. *Annual Review of Neuroscience, 35*, 73-89. doi: 10.1146/annurev-neuro-062111-150525

Ross-Sheehy, S., Schneegans, S., & Spencer, J. P. (2015). The infant orienting with attention task: Assessing the neural basis of spatial attention in infancy. *Infancy, 20,* 467-506. doi: 10.1111/infa.12087

Rothermund, K. (2003). Motivation and attention: Incongruent effects of feedback on the processing of valence. *Emotion*, *3*, 223-238. doi: 10.1037/1528-3542.3.3.223

Rothermund, K., Wentura, D., & Bak, P. M. (2001). Automatic attention to stimuli signaling chances and dangers: Moderating effects of positive and negative goal and action contexts. *Cognition and Emotion, 15,* 231-248. doi: 10.1080/02699930126213

Treisman, A. M. (1969). Strategies and models of selective attention. *Psychological Review, 76,* 282-299. doi: 10.1037/h0027242

Yantis, S., & Jonides, J. (1984). Abrupt visual onsets and selective attention: Evidence from visual search. *Journal of Experimental Psychology: Human Perception and Performance, 10*, 601-621. doi: 10.1093/applin/aml015

Table 1

Average reaction times (in seconds) of feedback groups (Neg-Pos, Pos-Neg, Pos-Pos, and Neg-Neg) on condition of feedback (no, first, and second) and on flanker condition (congruent, incongruent, neutral).

	Neg-Pos	Pos-Neg	Pos-Pos	Neg-Neg
Experimental Condition	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
No Feedback				
Congruent	0.523 (0.094)	0.510 (0.057)	0.577 (0.091)	0.544 (0.109)
Incongruent	0.623 (0.145)	0.685 (0.371)	0.651 (0.170)	0.721 (0.383)
Neutral	0.539 (0.077)	0.585 (0.158)	0.579 (0.098)	0.523 (0.087)
First Feedback				
Congruent	0.448 (0.045)	0.448 (0.057)	0.505 (0.072)	0.481 (0.09)
Incongruent	0.512 (0.121)	0.560 (0.198)	0.556 (0.125)	0.481 (0.240)
Neutral	0.470 (0.059)	0.509 (0.117)	0.497 (0.074)	0.460 (0.068)
Second Feedback				
Congruent	0.435 (0.042)	0.433 (0.045)	0.495 (0.072)	0.0450 (0.0713)
Incongruent	0.498 (0.0931)	0.514 (0.104)	0.532(0.096)	0.538 (0.168)
Neutral	0.449 (0.045)	0.493 (0.084)	0.0483 (0.057)	0.449 (0.084)

Note. All groups had n = 26.

Table 2

Average reaction times (in seconds) of the first feedback (negative or positive) and then second feedback (negative or positive) received.

First Feedback	Second Feedback	*M (SD)*
Negative	Negative	0.529 (0.101)
	Positive	0.501 (0.101)
Positive	Negative	0.527 (0.101)
	Positive	0.542 (0.101)

Note. All groups had n = 26.

Table 3

Average reaction times (in seconds) of the first feedback (negative or positive) and the overall feedback type received.

First Feedback	Feedback Type	*M (SD)*
Negative	No	0.580 (0.101)
	First	0.495 (0.066)
	Second	0.470 (0.050)
Positive	No	0.598 (0.101)
	First	0.513 (0.066)
	Second	0.492 (0.050)

Note. All groups had n = 26.

Table 4

Average reaction times (in seconds) of the first feedback (positive or negative) received on condition of the flanker task (congruent, incongruent, neutral).

First Feedback	Flanker Type	*M (SD)*
Negative	Congruent	0.481 (0.045)
	Incongruent	0.582 (0.132)
	Neutral	0.482 (0.061)
Positive	Congruent	0.495 (0.045)
	Incongruent	0.584 (0.132)
	Neutral	0.525 (0.045)

Note. All groups had n = 26.

Table 5

Average reaction times (in seconds) of the second feedback (negative or positive) received and overall feedback type (no, first, and second).

Second Feedback	Feedback Type	*M (SD)*
Negative	No	0.595 (0.101)
	First	0.508 (0.066)
	Second	0.480 (0.050)
Positive	No	0.582 (0.101)
	First	0.500 (0.066)
	Second	0.482 (0.050)

Note. All groups had n = 26.

Table 6

Average reaction times (in seconds) of the second feedback (negative or positive) received and flanker type (congruent, incongruent, and neutral).

Second Feedback	Flanker Type	*M (SD)*
Negative	Congruent	0.478 (0.045)
	Incongruent	0.602 (0.132)
	Neutral	0.504 (0.061)
Positive	Congruent	0.497 (0.045)
	Incongruent	0.564 (0.132)
	Neutral	0.503 (0.045)

Note. All groups had n = 26.

Table 7

Average reaction times (in seconds) of the first feedback (negative or positive), second feedback (negative or positive), and overall feedback type (no, first, or second).

First Feedback	Second Feedback	Feedback Type	*M (SD)*
Negative	Negative	No	0.597 (0.132)
		First	0.510 (0.081)
		Second	0.480 (0.076)
	Positive	No	0.562 (0.132)
		First	0.480 (0.081)
		Second	0.461 (0.076)
Positive	Negative	No	0.594 (0.132)
		First	0.506 (0.081)
		Second	0.480 (0.076)
	Positive	No	0.602 (0.132)
		First	0.520 (0.081)
		Second	0.504 (0.076)

Note. All groups had n = 26.

Table 8

Average reaction times (in seconds) of the first feedback (negative or positive), second feedback (negative or positive), and flanker type (congruent, incongruent, or neutral).

First Feedback	Second Feedback	Flanker Type	*M (SD)*
Negative	Negative	Congruent	0.792 (0.066)
		Incongruent	0.617 (0.188)
		Neutral	0.478 (0.086)
	Positive	Congruent	0.469 (0.066)
		Incongruent	0.548 (0.188)
		Neutral	0.487 (0.086)
Positive	Negative	Congruent	0.464 (0.066)
		Incongruent	0.587 (0.188)
		Neutral	0.530 (0.086)
	Positive	Congruent	0.525 (0.066)
		Incongruent	0.580 (0.188)
		Neutral	0.520 (0.086)

Note. All groups had n = 26.

Table 9

Average reaction times (in seconds) of the first feedback (negative or positive), overall feedback type (no, first, and second), and flanker type (congruent, incongruent, or neutral).

First Feedback	Feedback Type	Flanker Type	*M (SD)*
Negative	No	Congruent	0.534 (0.066)
		Incongruent	0.673 (0.203)
		Neutral	0.532 (0.076)
	First	Congruent	0.465 (0.050)
		Incongruent	0.673 (0.203)
		Neutral	0.466 (0.061)
	Second	Congruent	0.443 (0.040)
		Incongruent	0.518 (0.086)
		Neutral	0.450 (0.050)
Positive	No	Congruent	0.542 (0.066)
		Incongruent	0.668 (0.203)
		Neutral	0.582 (0.076)
	First	Congruent	0.477 (0.050)
		Incongruent	0.559 (0.203)
		Neutral	0.504 (0.061)
	Second	Congruent	0.464 (0.040)
		Incongruent	0.524 (0.086)
		Neutral	0.489 (0.050)

Note. All groups had n = 26.

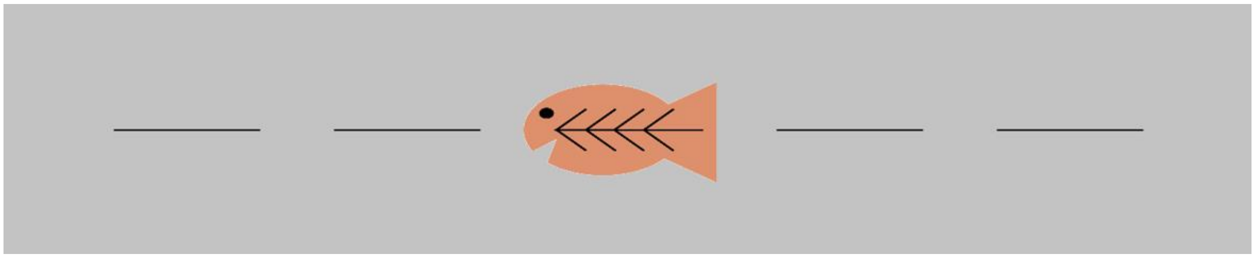
Table 10

Average reaction times (in seconds) of the second feedback (negative or positive), overall feedback type (no, first, or second), and flanker type (congruent, incongruent, or neutral).

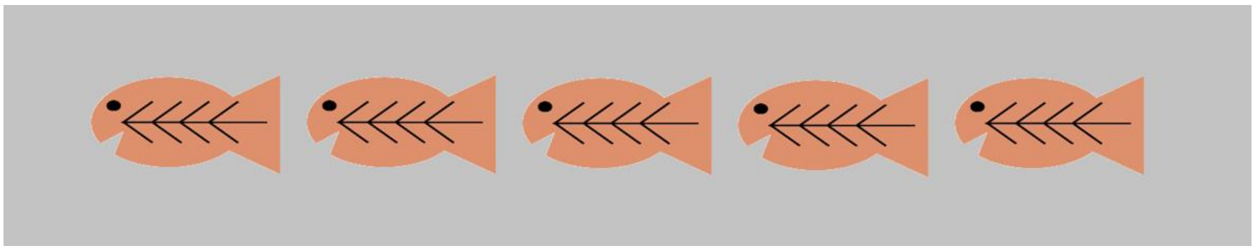
Second Feedback	Feedback Type	Flanker Type	*M (SD)*
Negative	No	Congruent	0.527 (0.066)
		Incongruent	0.704 (0.203)
		Neutral	0.554 (0.076)
	First	Congruent	0.465 (0.050)
		Incongruent	0.575 (0.203)
		Neutral	0.485 (0.061)
	Second	Congruent	0.442 (0.040)
		Incongruent	0.527 (0.086)
		Neutral	0.472 (0.050)
Positive	No	Congruent	0.549 (0.066)
		Incongruent	0.638 (0.203)
		Neutral	0.560 (0.076)
	First	Congruent	0.477 (0.050)
		Incongruent	0.539 (0.203)
		Neutral	0.484 (0.061)
	Second	Congruent	0.465 (0.040)
		Incongruent	0.515 (0.086)
		Neutral	0.467 (0.050)

Note. All groups had n = 26.

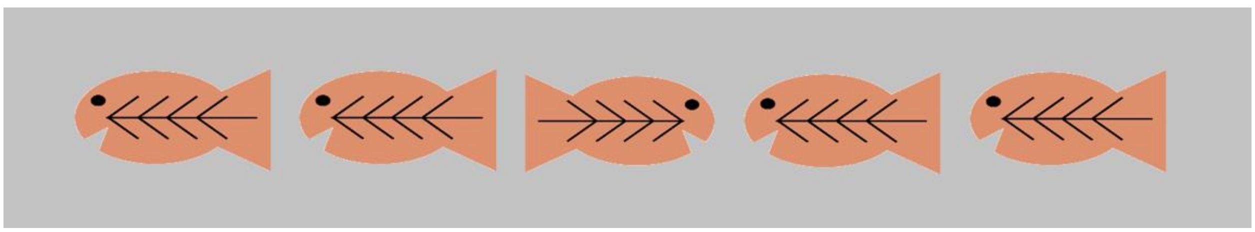
A



B



C



D

E

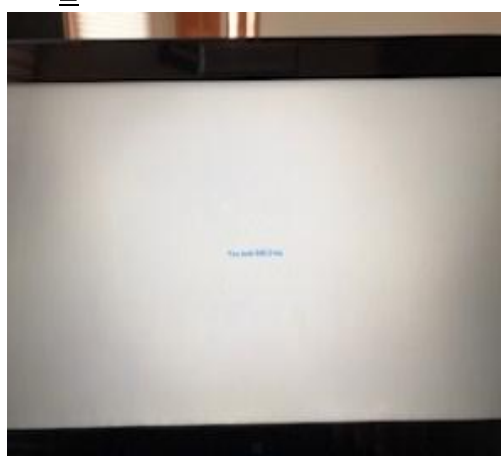


Figure 1. A, B, and C show the directional flanker task conditions. A is the neutral condition, B is the congruent condition, and C is the incongruent condition. D and E show the performance relevant feedback participants receive

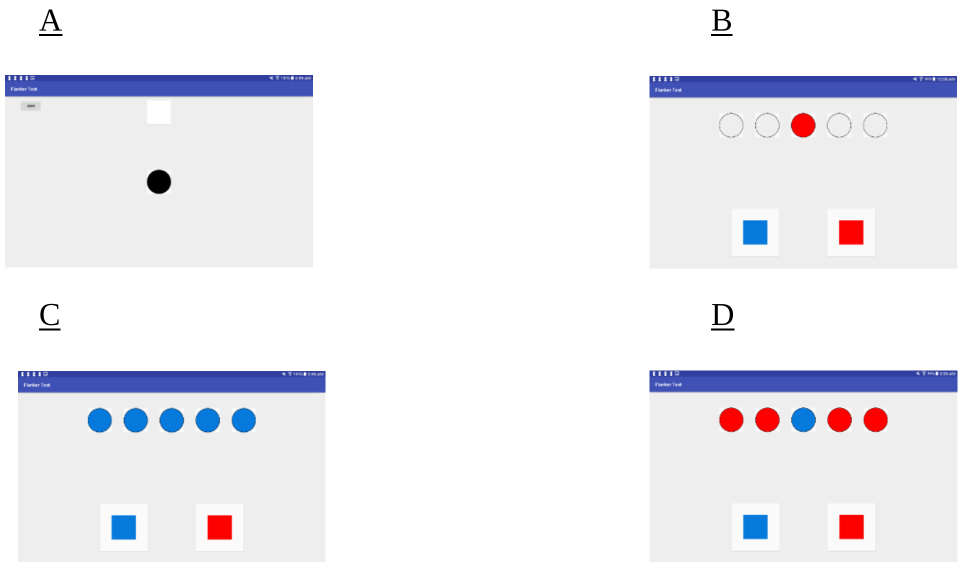


Figure 2. B, C, and D show the color flanker task conditions. B shows the neutral condition, C shows the congruent condition, and D shows the incongruent condition. A shows the original start screen of the task.

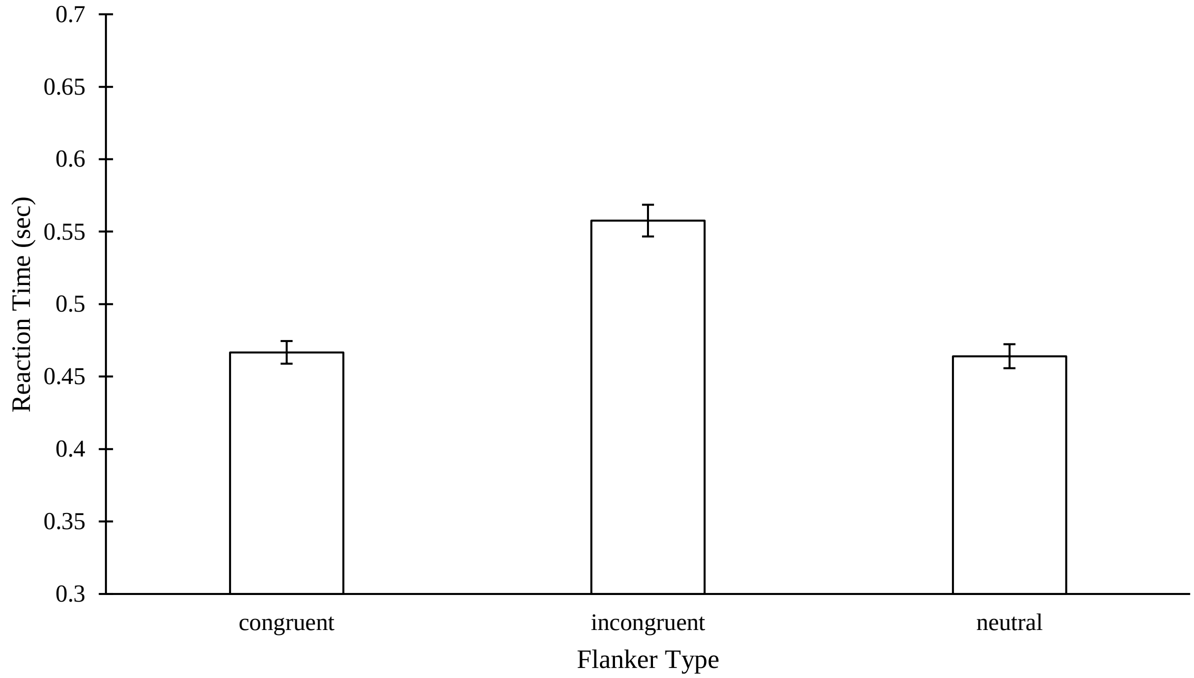


Figure 3. Average reaction time (in seconds) on the congruent, incongruent, and neutral conditions of the directional flanker task in Experiment 1. Error bars are measured in standard error.

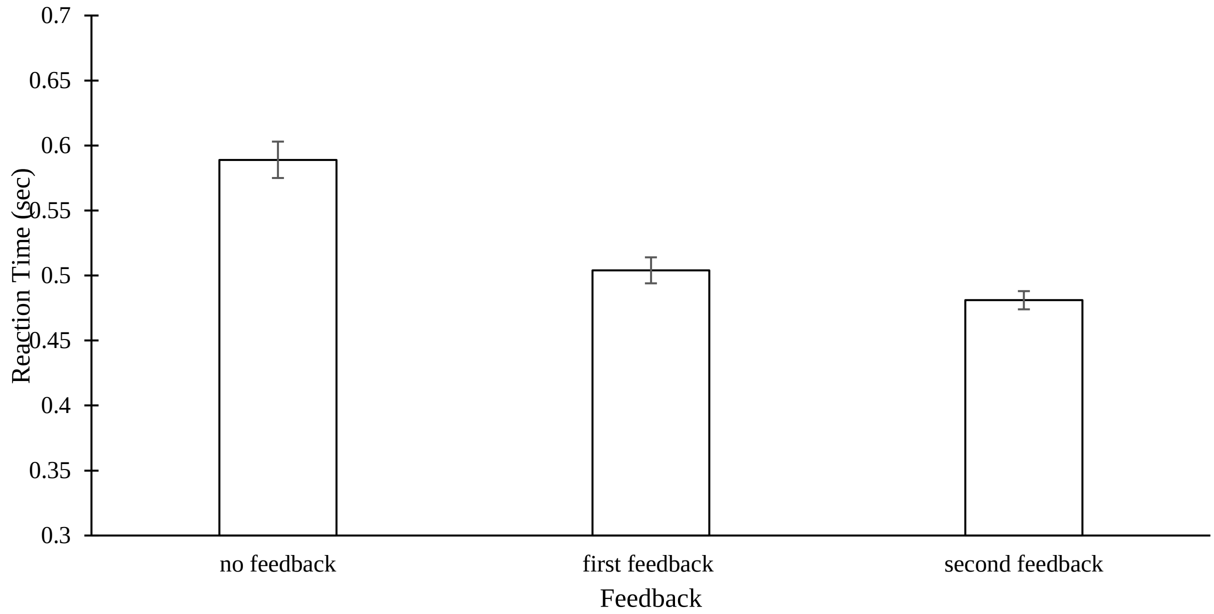


Figure 4. Average reaction time (in seconds) on the no, first, and second types of feedback that participants received in Experiment 2. Error bars are measured in standard error.

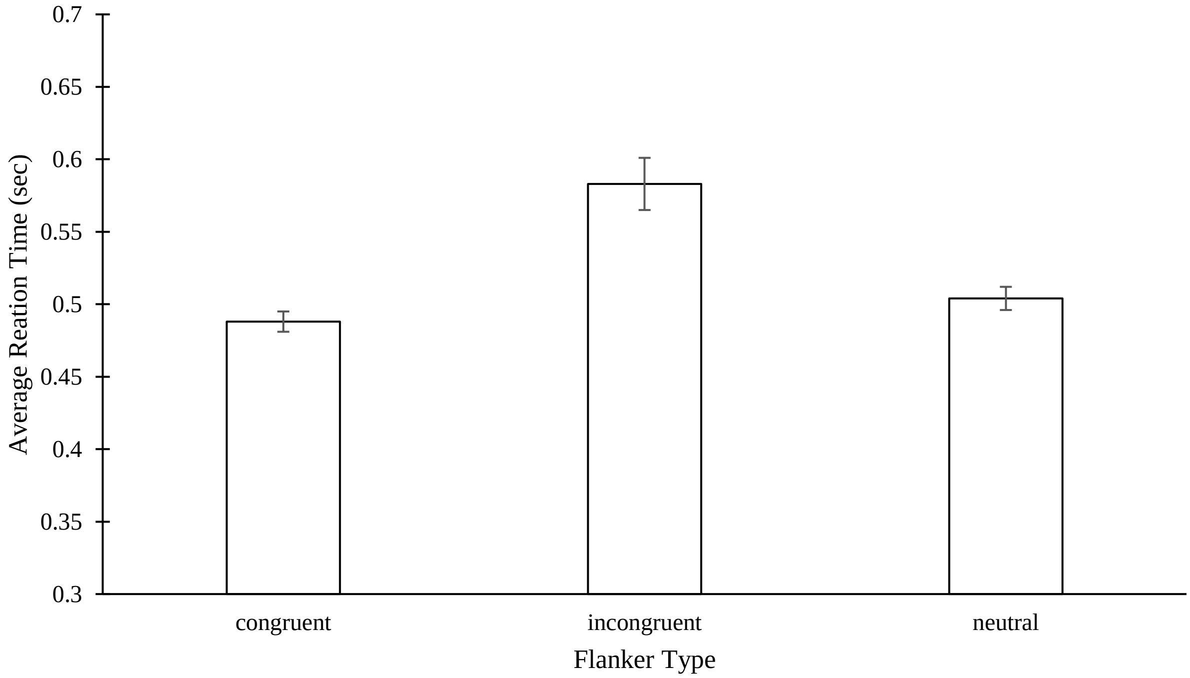


Figure 5. Average reaction time (in seconds) on the congruent, incongruent, and neutral conditions of the directional flanker task in Experiment 2. Error bars are measured in standard error.

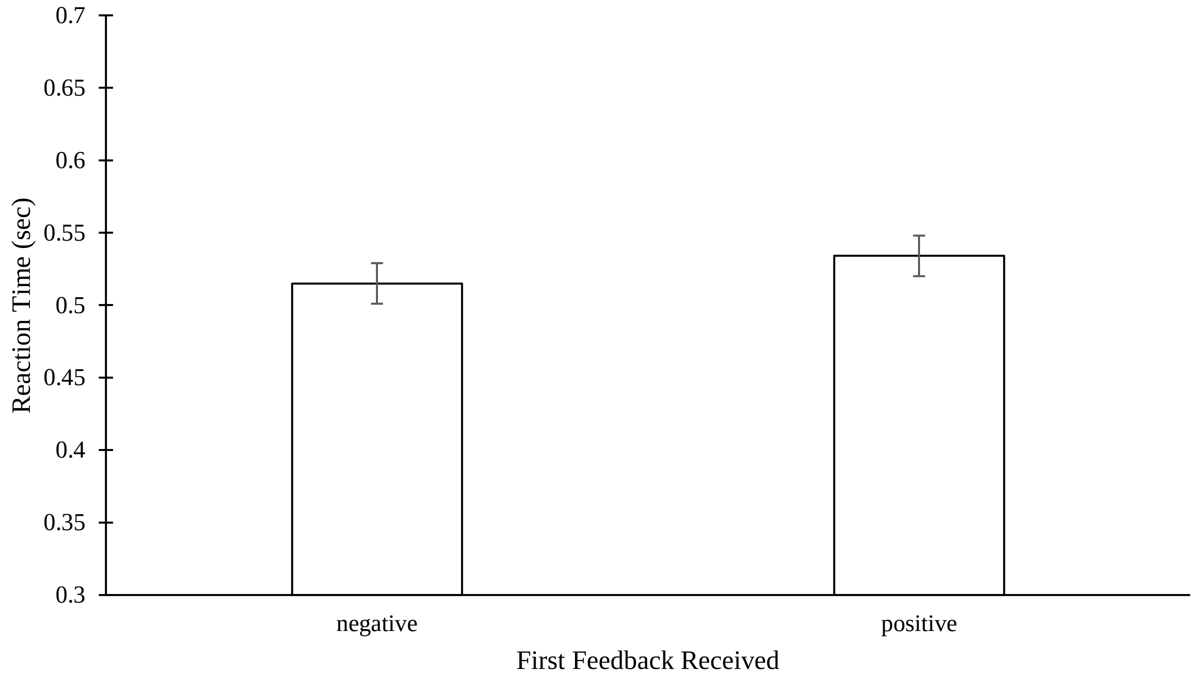


Figure 6. Average reaction times (in seconds) of the first feedback type (negative or positive) that participants received in Experiment 2. Error bars are measured in standard error.

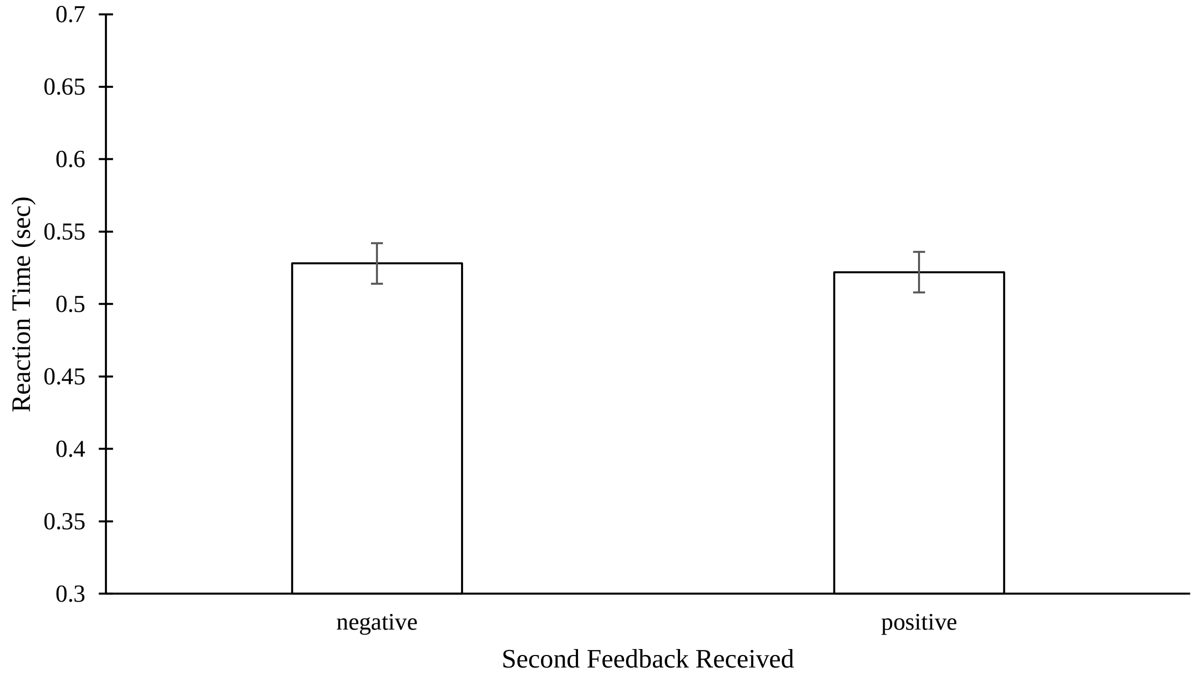


Figure 7. Average reaction times (in seconds) of second feedback (negative or positive) that participants received in experiment 2. Error bars are displayed in standard error.

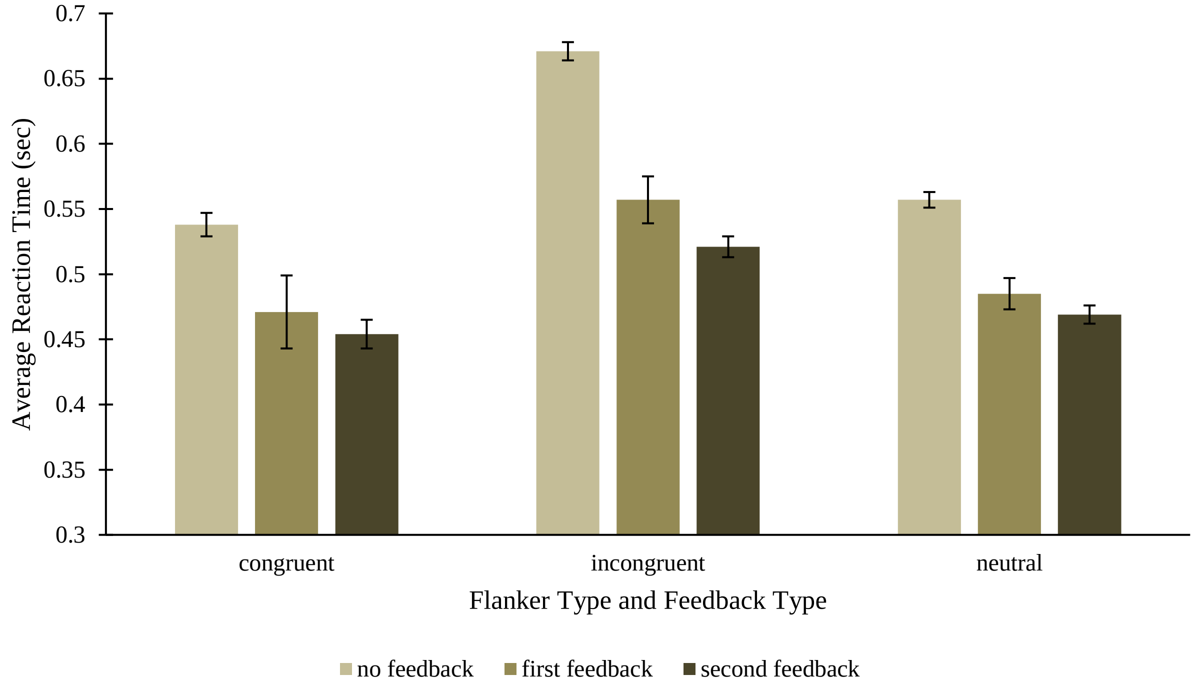
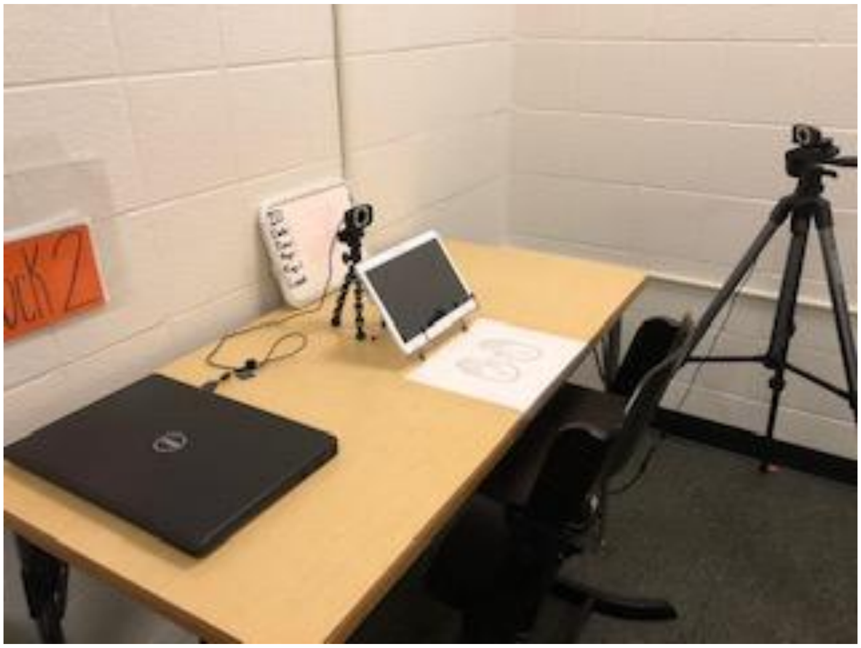
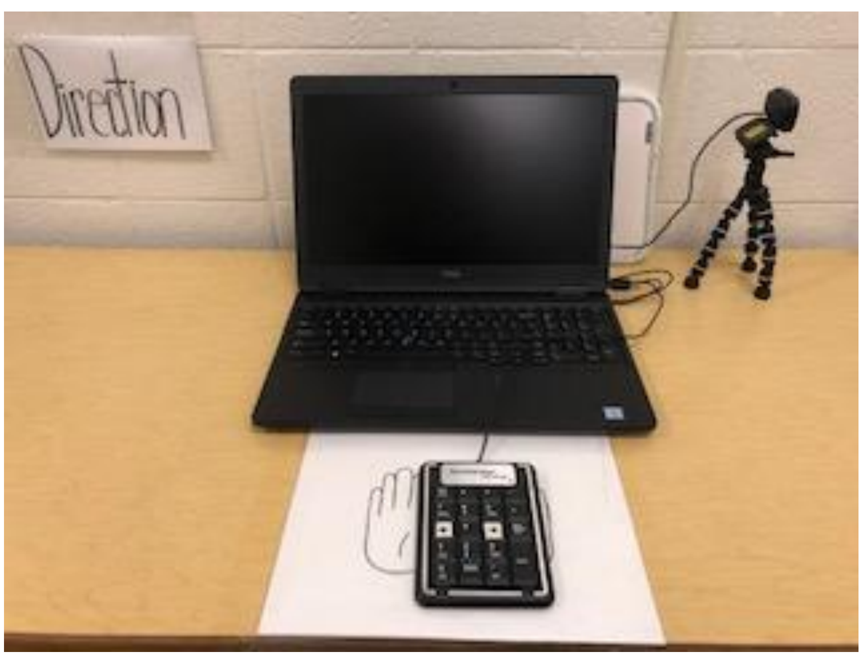


Figure 8. Average reaction times (in seconds) of participants on overall feedback types (no, first, and second) and flanker condition (congruent, incongruent, and neutral). Error bars are displayed in standard error.

Appendix A



Appendix B



Appendix C

Survey

1. Please rate your average happiness (day-to-day) on the scale below.

   High 5 4 3 2 1 Low

2. Please rate your average anger (day-to-day) on the scale below.

   High 5 4 3 2 1 Low

3. On average, do you find it difficult to start tasks?

   High 5 4 3 2 1 Low

4. On average, do you find it difficult to maintain your focus on tasks?

   High 5 4 3 2 1 Low

5. On average, do you find it difficult to stop one task and start another task?

   High 5 4 3 2 1 Low

6. Do you feel overwhelmed in crowded situations?

   High 5 4 3 2 1 Low

7. Do you ever forget what you are doing while performing a task?

   High 5 4 3 2 1 Low

8. Do you play video games?
   a. If so, how often (i.e. how many hours a week)? What types of games (i.e., console, computer based)?

9. Did you find this task easy or difficult? Why or why not?

10. Please indicate your year in school (if no year, write N/A):

11. Please indicate your age in years:

12. Please indicate your gender: