Spring 2012

Implicit Encoding Explored Through the Flankers Task

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Abstract

The problem we examined involves the process of selective attention and its relationship with implicit and explicit memory encoding. One task that has been used previously to examine selective attention is the flankers task, which consists of three items with the center item being the item that requires a response - the target. The two items on either side of the target are the “irrelevant” flankers. The correlated flanker effect is the difference in reaction time between the trials in which the flankers that are correlated with the correct response are present (congruent) and trials in which the flankers correlated with the opposite response are present (incongruent). Participants are about 30ms faster to respond on congruent trials than incongruent (Miller, 1987). The current study sought to further understand the mechanisms behind this selective attention task by asking, is incidental (implicit) learning of irrelevant information encoded in memory differently than intentional (explicit) learning? Participants completed a correlated flankers task. Half the participants were told to expect a memory task for the flankers and half were not given warning. Participants also completed an implicit memory task and an explicit memory questionnaire. Response times (RT) on congruent correlation trials and on incongruent correlation trials were measured. In the implicit memory task, participants’ responding to neutral targets surrounded by previously shown flankers was measured. We hypothesized that the greater recall of the irrelevant information in the implicit task over the explicit task. Results demonstrated no presence of the flanker effect yet participants were significantly more accurate than chance on the implicit task but not the explicit task.

Implicit Encoding Explored Through the Flankers Task

Sitting in class on Monday morning, you hear the tapping of a pen, the lights buzzing overhead, the kid in back of you whispering to his friends, and most importantly, the instructor at the front of the room presenting a lecture about relational aggression. While it is apparent that the information your instructor is giving you is the most important piece of the sensory experience in which you are immersed, other pieces of this experience enter your consciousness, meaning you are aware of the fact that they are occurring. The world is too rich with information to be taken in and understood all at once. However, people do have the ability to attend to certain information and have the capacity for learning. Even though the tapping of the pen is competing with your teacher for your attention, you walk out of class with some new understanding of relational aggression. This evidence of learning particular information among the noise of everything vying for attention in the world suggests the existence of a mechanism that filters out information and allows for the learning of specific information. This mechanism is referred to as selective attention.

The term attention has a host of different implications, but for the present research, attention is defined as concentration on a single subject (e.g., conversation, person, or object). Some experimental paradigms suggest that concentration of attention can be so close to complete that a person notices almost nothing about the unattended objects (James, 1890). In selective attention, a filtering process allows select stimuli to proceed from sensory receptors through to the semantic system for processing. The information that advances beyond the semantic system is considered learned, or stored in memory (Miller, 1987). What happens to the information that selective attention does not allow to pass through the filter? Humans do have memory for, that is to say they can recall or recognize, stimuli that were presented alongside the “learned” information, such as the pen tapping from the previous example. What does this say about the processes of selective attention and memory? It is these questions that prompt a need for the current research.

A Brief Overview of Memory Theory

Memory is the means by which we retain our past experiences and use them to navigate our present experiences (Tulving & Craik, 2000). The research into the processes by which humans receive, process, and use information is relatively new. In the short time it has been researched, there have been multiple arguments for the way memories are stored and the capacity of memory systems. Information is perceived, stored, and recalled for later use, a process we have diverse levels of control over. There are three common operations of memory identified by cognitive psychologists: encoding, storage, and retrieval (Tulving & Thomson, 1973). In encoding, one takes in sensory data and forms it into a mental representation. In storage, one keeps the sensory data that have been encoded in memory. Retrieval is the process of pulling out that encoded information from one’s memory. With this basic understanding of memory agreed upon, researchers sought out ways of explaining how these processes might actually work.

Memory research has been modeled dynamically, beginning with the first declarative memory model put together by Atkinson and Shiffrin (1968). These researchers introduced the terms sensory, short-term, and long-term stores. The researchers explained memory in terms of length of time intended for storage; information that is quickly analyzed and forgotten is labeled "sensory", a memory store of small bits of information in a list format is labeled "short-term", and information that is intended for recall or recognition at a later date is labeled "long term" memory. Other researchers built upon Atkinson and Shiffrin's model and introduced new ideas concerning the cognitive processes of memory. A "levels-of-processing" framework was introduced in relation to verbal information, and this framework explained memory in a serial system (Craik & Lockhart, 1972). These researchers proposed that memory does not have serial levels. It is a continuous process with varying subcategories of depth. Basically, this framework demonstrates that there is no limit to the depth with which information can be encoded if it is constantly building on itself in the form of scaffolding. This levels-of-processing framework was extended to non-verbal stimuli, such as pictures of faces or shapes (Burgess & Weaver, 2003). This research is particularly relevant to the present study because the proposed study uses shapes rather than verbal stimuli.

Another particularly relevant contribution to the present discussion and to the field of memory was the establishment of the concept of episodic memory. Episodic memory is knowledge held about one's personal experiences and episodes (Tulving, 1972). The concept was introduced to explain the memory process humans use for word lists or for recalling something from a particular context at a particular time. In other words, episodic memory is one's store of specific personal experiences, unlike semantic memory, which is the storage of everyday world knowledge. One of the most recent models of memory is the connectionist perspective - often referred to as the parallel distributed processing model (PDP). This model asserts that there are connections between nodes (the most basic subpart of the neural network) in the brain and those connections are actually what is commonly refer to as memory (Feldman

& Shastri, 2003). The PDP model is often described as the "working" part of long-term memory – the spreading of knowledge between nodes is only limited by the constraints of working memory.

The PDP model also brings to light a concept heavily explored in the research directly related to the current study – priming. The PDP model states that nodes are primed – meaning that the first presentation of the stimulus activates concepts in memory that are then more accessible to the person's conscious awareness (Neely, 1976). Consciousness implies the feeling and content of awareness, which may be under the focus of attention (Farthing, 1992). What humans have available to their awareness depends heavily on where their attention is focused when they encode that information. Miller's (1987) experiments on automatic processing provide a model study for the current research, and his work discusses the idea that priming is not necessary for unattended stimuli to be identified. Although there have been experiments in which non-primed stimuli could not be later identified (Neisser & Becklen, 1975), these studies were not explicitly concerned with priming (Miller, 1987). The present research builds off the idea that non-primed stimuli can be recalled, based on Miller's priming research. Miller found that the primed stimuli were actually easier to ignore, which provides evidence as to why the proposed research makes no attempt to prime the irrelevant stimuli.

The present research is rooted in the principles of memory research. From the basic level - memory stores and the three basic steps in one's memory process. Beyond the basics, memory research expanded to demonstrate the different levels at which one processes daily information. That expansion led researchers to question the existence of different types of memory, a question the current research is rooted in. Tulving (1972) discussed the existence of episodic memory.

The concept of separate and fundamentally different memory types exists in our assumptions with the present research – looking at explicit versus implicit memory and the role attention plays in that difference.

Attention Models Leading to the Present Research

Dealing with the tremendous moment-to-moment influx of information that humans gain through their sensory experiences presents them with the task of discerning between information that is useful to them in the moment and otherwise useless information. Attention, by definition, is concentration toward an "appropriate" stimulus. It is the means by which one actively processes a limited amount of information from the enormous amount of information presented to the senses and available in memory (De Weerd, 2003). To put it into a real world context, imagine you are having a conversation with your professor and there are other students talking around the pair of you. You hear what your professor says and you are focusing your vision on him – meaning you are attending to the stimuli he presents and mentally unpacking that information. Although there were sources of stimuli around you, such as the other students talking, you concentrated on the "appropriate" information; a mental process called attention. For attention to concentrate on appropriate information, information must primarily be divided into relevant or irrelevant categories. In other words, the process of attention begins with deciding what information is task-relevant and what information can be classified as incidental, or of no use to the task at hand (Druker & Hagen, 1969). The amount of attention humans can dedicate to a set of stimuli depends on their ability to distinguish the information. Humans process irrelevant information alongside relevant information. For instance, studies on children have shown that as they age, they are more apt to make this distinction between what information is relevant and what is irrelevant. Younger children process more information than necessary to perform the central task, or test of some sort, because they have some deficiency in selective "filtering" ability. This decreases with older kids who seem to "give up" some task-irrelevant information in favor of central task information (Druker & Hagen, 1969). Deficiencies in the filtering process are what cause processing of irrelevant (unintentional) information.

The filtering process that underlies task-relevancy information selection is a mechanism researchers refer to as selective attention. As mentioned in the opening example, selective attention is used in order to attend to a specific stimulus or set of stimuli (Broadbent, 1958). According to Broadbent, one filters information as soon as one becomes aware of it at the sensory level. His model includes channels through which information must pass in order to elicit a response. The channels typically include a sensory register (information gathered through the senses), a selective filter, perceptual processes (organization of sensations), and short-term memory - all leading to a response (Broadbent, 1958). In this model, unattended information stops its progression through the channels at the selective filter stage whereas attended information passes through each channel until a response is evoked. One assigns meaning to their sensations in order for this process to take place (Broadbent, 1958). This means that one's attention filters out "unnecessary" information before identifying it due to the assumption that it is not meaningful and cannot be stored. Like theories of memory, there are multiple theories of attention and how humans attend to certain information on different levels – sometimes even unconsciously. The concept of selective attention was explored and supported through an experiment called dichotic listening, which studied a phenomenon called the cocktail party problem (Cherry, 1953). Dichotic listening is an experiment in which a participant hears a separate conversation in each ear, one conversation being the target information and one being something that the participant is told to ignore. Results found that participants listen to the target information and cannot identify alterations made to the information from the other ear – even if the message was switched to a different language or presented backwards - unless the message changed tone or pitch. This supports the idea that one filters the message for meaning but certain properties break through the filter and are analyzed.

This theory applies to more than just a social situation, however. The selective filter model asserts that information of high importance will break through the selective attention filer, such as one's name or other particularly self-relevant information (Gray & Wedderburn, 1960; Moray, 1959). The point at which information was attended and filtered became a topic of debate with Treisman (1960) proposing an attention filter that weakened non-target (irrelevant) stimuli in the environment. Her experiments on dichotic listening suggested that some of the information in the unattended channel was being processed because participants picked up the first few words of the message they heard in the unattended ear (Treisman, 1960; 1964). The Treisman attenuation model proposed that when stimuli reach the senses, humans analyze them for basic properties, such as tone and pitch, and if the stimuli possess the "target" properties, the signal is passed to the next stage. Deutsch and Deutsch (1963) then asserted that the filter came even later after the stimuli had already been processed for its meaning and physical properties. This allowed for people in a dichotic listening experiment to recognize information entering their unattended ear. The modern model provides an important distinction from the previous models – humans process information to the point of identification before filtering it, meaning the information is analyzed and stored to some degree in memory. All of these theories hold one concept in common – the idea of signal detection. The human brain picks out relevant information from a wealth of irrelevant stimuli. The question then becomes the degree to which we are conscious of this process and how much of it is automatic?

Encoding Different Types of Information

Encoding of information is the pathway to all memories and forms of knowledge. The process of encoding has long been a topic of research and scholarly debate. Some psychologists classify information to be encoded as implicit or explicit, terms originally used by McDougall (1924) to refer to the different ways memories could be expressed. Explicit memory can be defined as the active process of committing information to memory. It requires conscious effort and attention to be stored. Implicit memory, on the other hand, is learning and retention that occurs outside of our conscious efforts. For that reason, it has been referred to as an “automatic” process (Schmidt & Dark, 1998). This means it does not require effortful processing and attention, unlike explicit memory.

Although they are recognized as different, there is debate on the actual difference in implicit versus explicit information. According to one study, explicit learning is conceptual and implicit learning is data driven, or that it is directed by external stimuli such as expectations about the nature of a stimulus (Craik, Muscovitch, & McDowd, 1994). It is also purported that implicit memory is best suited for gradual, step-by-step, learning (Musen & O’Neill, 1997). The fundamental difference in the two types of memory is the level of attention needed for the person to process and encode the information. Schmidt and Dark (1998) asserted in their research that automatic learning and processing comes before attentional learning and processing, and automatic learning has no limit. This means that a person will process "automatic" information without any effort and usually with no awareness or conscious knowledge of the process before they will process information with effortful control. It is a common belief that attentional learning leads to long-term memory but Schmidt & Dark's research has demonstrated that participants in an automatic processing task can often recall some of the automatically encoded information. A typical automatic processing task presents the participant with an "irrelevant" stimulus paired alongside a "relevant" stimulus so that the person must focus his or her attention on the relevant information. This recall of automatically encoded information leads researchers to believe that implicitly learned stimuli also could be committed to memory.

Implicit stimuli are thought to be committed to memory because they change task performance; this is due to acquisition of information during a previous episode of retention (Schacter & Graf, 1989). On the other hand, explicit memory is referred to as conscious recollection of information and is expressed on tests such as cued and free recall (Schacter, 1987). Cognitive research has demonstrated that explicit and implicit memory can be independent of one another in certain conditions, but that is not to say that two separate memory systems exist. This idea points to the theory that implicit memory can operate independently of its counterpart – explicit memory – and facilitate recollection of memories in a different way than can explicit memory. Preliminary research into the field of "unconscious memory", which is what implicit memory was formerly referred to as, revealed that participants could write about recent experiences with no conscious awareness of having those experiences (Stein, 1997). While the participants had learned explicit information, something else had affected their response – implicit memories. These studies have given researchers a reason to question how much of what humans are not consciously perceiving, and therefore cannot explicitly remember, is making it to their memory stores and influencing behavior and performance.

Due to the fact that it is difficult to understand the way one's memory system operates without one's conscious knowledge, there has been a fair amount of research on attention and its role in encoding to memory. A great deal of our knowledge concerning explicit and implicit memory comes from studies done with amnesic patients. Amnesiacs are impaired when it comes to standard measures of explicit recall and recognition. They perform well-below average on tasks that require explicit recall, such as recalling the events that have transpired during a round of golf (Schacter, 1983). Researchers were curious as to the potential of amnesiacs to remember implicit information and concluded that normal retention of a list of items by amnesiac patients only occurred when implicit tests were used (Shimamura & Squire, 1984). This research provides sound reasoning for the assumption that selective attention filters the implicit and explicit information at different levels and can therefore be encoded differently. This finding also shows a double dissociation between explicit and implicit memory, meaning the process of explicit memory storage and retrieval and the process of implicit memory storage and retrieval are intimately tied to one another, but function independently of each other - perhaps accounting for the differences in the way encoding of the two types of information happens (Schacter, 1983).

An Automatic Processing Task Designed to Examine Attention

One task that has been used to examine selective attention in a non-disordered population is the flankers task. At its simplest form, the flankers task consists of three items with the center item being the item that requires a response - the target. The other two items on either side of the target are the flankers. Flankers are defined as information presented in conjunction with the target, however this information is irrelevant to the task at hand and thus should be ignored. The flankers task is used, most often, as a tool to induce the flanker effect and make predictions based on the effect. The *flanker effect* is a finding based on previous performance on the flankers task (Eriksen & Eriksen, 1974). Eriksen & Eriksen's original flankers task featured irrelevant flankers that belonged to a target set and the modified task features response-neutral flankers (Miller, 1987). The correlated (also referred to as the modified) flanker effect is the difference in reaction time (RT) between the trials in which the flankers that are correlated with the correct response are present and trials in which the flankers correlated with the opposite response are present (Miller, 1987). This form of the flankers task is being employed in the present research. In the task, each flanker is mapped onto a particular response, meaning it is paired with that response a majority of the time. The *flanker effect* is the finding that participants are about 30ms faster to respond on trials in which the flankers are correlated with correct response than if they are correlated with the incorrect response. Fundamentally, participants are quicker to respond to a stimuli based on the positive correlation that has developed between the information presented and the key used to make that response. Details explaining the specific use of the flankers task in the present research will be given in the methods portion.

Present Research

The present research seeks to further understand the memory mechanisms behind one's performance on the flankers task. Does incidental (implicit) learning of irrelevant information (i.e., the flankers), as evidenced by a correlated flankers task, commit itself to one's memory differently than intentional (explicit) learning and therefore lead participants to experience better recall of implicitly encoded information versus explicitly learned information? The typical flanker effect should be observed in our task. This means that positively correlated (congruent) flankers should yield faster response times than negatively correlated (incongruent) flankers. Previous research also suggests that the results from an explicit memory task may not demonstrate recall of the flankers whereas an implicit, and therefore more sensitive, measure might show memory for the irrelevant flanker information. We also seek to explain whether or not prompting a participant with the information that they will receive a test of their knowledge of the flankers interferes with their performance. Formally, we seek to answer questions raised concerning the strength of our memory for irrelevant information. We hypothesize that participants will more easily recall or identify the flanking stimuli in an implicit memory task in response to the sensitive nature of implicit memory tests than they will recall the flanking stimuli in an explicit questionnaire. We also theorize that the flanker effect does not depend on whether or not the participant is prompted with the knowledge of a memory questionnaire.

Global Implications of Current Research

There are several real world applications of this research. We seek to explain how irrelevant information is processed and encoded in the absence of attention. If the research finds that one does not remember irrelevant information, why does it still have an effect on one's behavior? In classroom settings, the research could be used to design curriculum or presentations of information that incorporate systematic irrelevant information. Understanding the relationship between student learning and effects of irrelevant information will aid instructors in understanding how the student-learning relationship functions and will help them to select ways in which to present their material. Perhaps the clip-art used as a visual aid in a power point is processed as irrelevant information. If implicit learning is taking place and the pictures become noise instead of a learning tool, the instructor should then find a way to make that information meaningful or eliminate it all together. We have also looked at the effect of a prompt concerning implicit information. We would like to understand if an instructor would better aid in their students' learning by saying, "this information will not return" or by ignoring that fact that the extra information is there. The higher-order goal is to make learning easier. If we understand how memory for relevant versus irrelevant information is encoded, we may be able to change the way instruction is given to make relevant or explicit information more salient and easier to learn.

Method

Participants

Forty-eight participants were recruited from those enrolled in General Psychology using the Research Experience Program's sign up system. The participants ranged in age from 18-22. Each had normal or corrected-to-normal color vision and was naïve as to the purpose of the study. Participants provided informed consent before they began the experiment. Random assignment was used to assign participants to each condition. After completion of the experiment and both questionnaires, the forty-eight participants were debriefed and awarded credit for their participation.

Apparatus and Stimuli

The experiment was completed using E-prime software on PC computers. Stimulus displays were viewed from a distance of about 60cm. The stimuli (targets) were capital white letters presented on a black background and included the letters: A, M, O, T, U, and X. Three of the six letters were randomly assigned to the left button and three of the six were assigned to the right button for each participant. The warning stimulus, a white box presented on a black background, was presented for 350ms. Next, the flankers were presented without the target for 150ms. Flankers consisted of red non-descript shapes, green non-descript shapes, white pound signs, and white rotated pound signs. The flankers were separated horizontally from the target by about 0.3˚. In each trial, the flankers on either side of the target letter were identical to each other. The third display consisted of the flankers and the target letter presented on a black background. This display remained until the participant responded. Feedback was given only after error (See Figure 1). Left-hand responses were made on a Standard English language keyboard by using the physical "Z" key by the left hand and right-hand responses were made using the physical "/" key. Both keys had been covered with a white label in order to distinguish them from the rest of the keys. Participants were told to "respond with your left finger on the left button and your right finger on the right button". In this way, the targets were mapped onto those spatial responses rather than particular letters/symbols.

Procedure

Participants first completed 2 practice blocks of 24 trials each in order to become familiar with the task. Participants then completed 8 experimental blocks, each consisting of 48 trials. Of the 6 target letters, 3 were randomly assigned to the right response and 3 were randomly assigned to the left response. This means that the participant received trials that had the congruent target-to-flanker mapping or trials with the incongruent target-to-flanker mapping. This mapping remained consistent throughout all trials.

Participants were informed of the stimulus-response (S-R) mapping and were given directions to respond to the target information with the correct key. They were told to complete the task as accurately and quickly as possible. Participants were randomly assigned to the “prompt” condition or the “no-prompt” condition. Participants in the “prompt” condition were given instruction to ignore the flankers in the experimental blocks, but told that they would later receive a memory task concerning the flankers. Participants in “no-prompt” condition were only told that they should ignore the flankers. Each trial began with the presentation of a warning stimulus followed by the presentation of the flankers. The target display remained on the screen until the participant responded.

After the experimental blocks were complete, the participants were given an implicit memory test similar to the task they had just completed, as well as an explicit memory questionnaire. The order of these tasks was counterbalanced across participants to determine if participants’ responding would be affected in any way by the order in which they received the memory tests. In the implicit task, participants were presented with a situation mirroring the experimental condition with new letters as targets and the same flanker correlations as the experimental condition. These novel letters were not previously mapped onto the left or right response and no mapping was given in the instructions. Instead, participants were given instructions to complete the task as quickly as possible based on how they “felt they should respond”. In other words, we were interested to see if participants had learned which flankers tended to be correlated with either the left or the right response. The explicit memory questionnaire, provided on paper, asked participants to list all flanking stimuli and in what instances those flankers were present. They also were asked if they were aware of any changes to the flankers during the task. Participants were then questioned on whether or not they remembered the target-to-button mapping (See Appendix A for the explicit memory questionnaire).

Debriefing: The participants were debriefed after the surveys were complete. Specifically, they were informed of the goal of the study and the nature of the flankers task.

Results

An alpha level of .05 was used for all analyses. The data from one participant was replaced with an additional participant because of reported color-blindness on the explicit questionnaire. The accuracy rate on the experimental task was 97% with a 3% error rate. This is consistent with prior research (Miller, 1987; Schmidt & Dark, 1998) that used the correlated flankers task.

Flanker effect. To determine if participants were faster to respond when the target and flankers were congruent compared to when they were incongruent, a paired samples *t*-test was conducted. This *t*-test revealed that participants were not faster to respond in congruent trials, $t(47) = 1.33$, *ns*. This result shows that participant response time on congruent trials (M = 580ms, SD = 66ms) was not significantly different than their response time on incongruent trials (M = 593ms, SD = 89ms).

Order of Tests. To determine if participants were more accurate based on the order in which they received the memory questionnaires, a single sample t-test was conducted. The results indicate that, as expected, the order in which the participants received the explicit memory questionnaire did not have a significant effect on their accuracy in the implicit task $t(47) = 2.18$, *ns*.

Flanker Recall on the Explicit Memory Task. The mean proportion of flankers correctly recalled was calculated by dividing the number of flankers correctly identified[1] by four, the total number of flankers to be identified. The average number of correct answers ($M = 2.04$) on question one of the explicit questionnaire, (which questioned the identity of the flankers), was similar to that of chance, $t(47) = .187$, *ns*. In other words, participants could not explicitly report the flanking stimuli (pound sign, rotated pound sign, red and green non-descript shapes) they had seen in the experimental trials.

Flanker Assignment on the Explicit Memory Test. Each participant's randomly assigned flanker-to-target response mapping was identified and the mean proportion of flankers correctly assigned to the correct response was divided by four - the total number of assignments possible. The average number of correct answers on question two ($M = 1.48$) of the explicit questionnaire (which inquired about the flankers associated with each response) was less than that expected by chance, $t(47) = -2.80$, $p = .007$. In other words, the participants, similar to what was shown on flanker recall, could not explicitly report what specific flankers were associated with what particular response.

Implicit Task Accuracy. To determine if participants were more accurate than expected by chance in making the "expected" response (responding with the learned mapping when

[1] See Appendix B for a table of the answers that were accepted and those that were not accepted.

presented with novel stimuli and previously mapped flanker relationships) in the implicit task, a single sample t-test was conducted. The t-test revealed that participants were significantly better than chance at making the expected responses in the implicit task, $t(47) = 2.18$, $p = .034$.

The Effect of a Prompt. To determine if participants were faster to respond based on the presence or absence of a prompt advising them that there would be a memory test at the conclusion of the study, we ran a repeated measures ANOVA. The ANOVA revealed that the presence of a prompt was not significant, $f(1,46) = 0.13$, *ns*.

Discussion

Flankers Task Results

The present research began as an examination of the underlying mechanisms involved in selective attention of implicit versus explicit memory. The correlated flankers task was used as a tool to induce implicit learning in order to examine that mechanism. The results of the main experiment yielded no flanker effect, meaning participants did not have shorter response times for congruent correlated trials as compared to incongruent correlated trials. This is in direct contrast with results of the flankers task in the prototype studies (Miller, 1987; Schmidt & Dark, 1998) used to develop the methodology used in the current experiment (For a comparison among these experiments see Table 2 in Appendix C). In the explicit measure, participants were not able to state the correlational relationship between the flankers and the target response. They were not even able to recall what objects served as flankers in the explicit task at all. Interestingly, participants were better than to be expected by chance at accurately responding to the flankers in the implicit task. These findings lead us to revisit the ideas of memory, attention, and types of information in order to better understand what mechanisms were or were not at work in this experiment.

Because participants did perform at a consistent level of accuracy, one can deduce that they did in fact encode at least the target information into memory. Had there been a flanker effect, one could make the claim that participants encoded the implicit information without conscious awareness. Being that there was no flanker effect, one might infer that the participants were not encoding the implicit information and allowing it to alter their performance on the implicit task. We reason that an early selection mechanism is at work. The flanking information was encoded to the point just before identification and therefore had little bearing on the participant's responding.

In designing the experiment, we believed that the flankers task demonstrated a failure in the selective attention mechanism. If one was affected by the flanking stimuli, even though they were deemed irrelevant, it is reasoned that one did not selectively filter that information as unimportant. The flankers task is a tool used to examine the ability to choose information as task-relevant, something we cannot confirm participants did in this experiment. Would there have been a significant flanker effect, one may have been able to reason that the participants ineffectively filtered the flanking information at a level that allowed them to perform the task accurately but still encoding the irrelevant information.

Commentary on Current Results

It seems as if the implicit information was effectively ignored, based on the response time similarity between the incongruent and congruent trials. However, the participants were better than could be expected by chance in their performance on the implicit memory task. This could be due to actual learning of the implicit relationships between the targets and irrelevant flankers that participants were not able to explicitly report. This could also be due to better than normal guessing mechanisms used by participants. Perhaps prior research findings which demonstrate the idea that implicit information is automatically encoded with little attentional efforts, is making the claim that even though the information is encoded without one's knowledge it does not necessarily mean that the information has the ability to affect one's performance.

Participants collectively had a 3% error rate. This indicates that participants were conscientious in responding to the experiment. This also may account for the lack of an observed flanker effect. When participants are conscientious responders, they often choose more carefully how they will respond, taking less risks, and leading to higher response times and more time spent viewing the target. Literature on the speed-accuracy trade off in a two-choice decision task reveals that young adults as well as older adults display a conservative level of responding when the conditions are challenging (Starns & Ratcliff, 2011). This means that young adults, such as the ones who participated in our experiment, balance the speed-accuracy tradeoff very well until the trade-off is compromised by a more difficult task than the participant is expecting. Participants in the current research spent an average of 600ms responding to each trial. The typical forced-choice task yields a response time of 400ms (Pailing et. al., 2002). Because all experimental variables were similar among the prototype studies and the current experiment, one may be able to attribute the lack of a flanker effect to careful responding by our specific group of participants.

One interesting thing to note about the findings of the secondary statistical analyses is the absence of any significant findings in regard to the "prompt" or "no-prompt" condition. One group of participants was informed that they would be tested on the flanking information at the end of the experimental trials. One group of participants was not informed that they would receive a questionnaire. Participants with and without warning of the memory tests performed equally on them. One might have expected that the participants who were informed of the tests would have outperformed the other group in accurately listing the flankers and their assignment, due to the added instruction to pay particular attention to them. In reference to the order in which participants were presented with, there were also no observable differences in accuracy between the two. Participants, as a whole, performed similarly on the memory tests whether they were given the explicit questionnaire first or the implicit task first. One might have expected those who received the explicit test first to perform better on the implicit task because they had just explicitly defined what the flankers and relationships were.

Limitations

In reviewing the methodology of the current experiment, one specific methodological issue may have contributed to the results not being significant. The current research, although very closely tied methodologically with other studies which reported significant flanker effects, contained an instructions screen that was not necessarily in keeping with the normal instructions given to other flankers task participants. The instructions on the screen read, "Accuracy is more important than speed." The researcher also verbally instructed the participants to be accurate over being fast. Because the literature on other forced-choice tasks does not typically report what the instructions said, we propose that this specific set used in the present research may have caused participants to take more time than they would have if the instructions did not instruct them which performance technique, speed or accuracy, to use in the experiment.

The limitations of the study mainly lie in the fact that there was no observed flanker effect. Other variables such as flanker recall and flanker assignment cannot reliably be reported due to the lack of a reliable measure to demonstrate them. Because there was no observed flanker effect, one expects that there would be no significant effect on one's performance on the implicit task. Because we did see an effect, we are led to believe that our method of testing implicit memory may have been unreliable or invalid. Perhaps changing the target letters to novel stimuli affected performance in ways that were not evident to us. Because the implicit task was novel, it must be included as a limitation due to lack of prior usage and external validity of the measure.

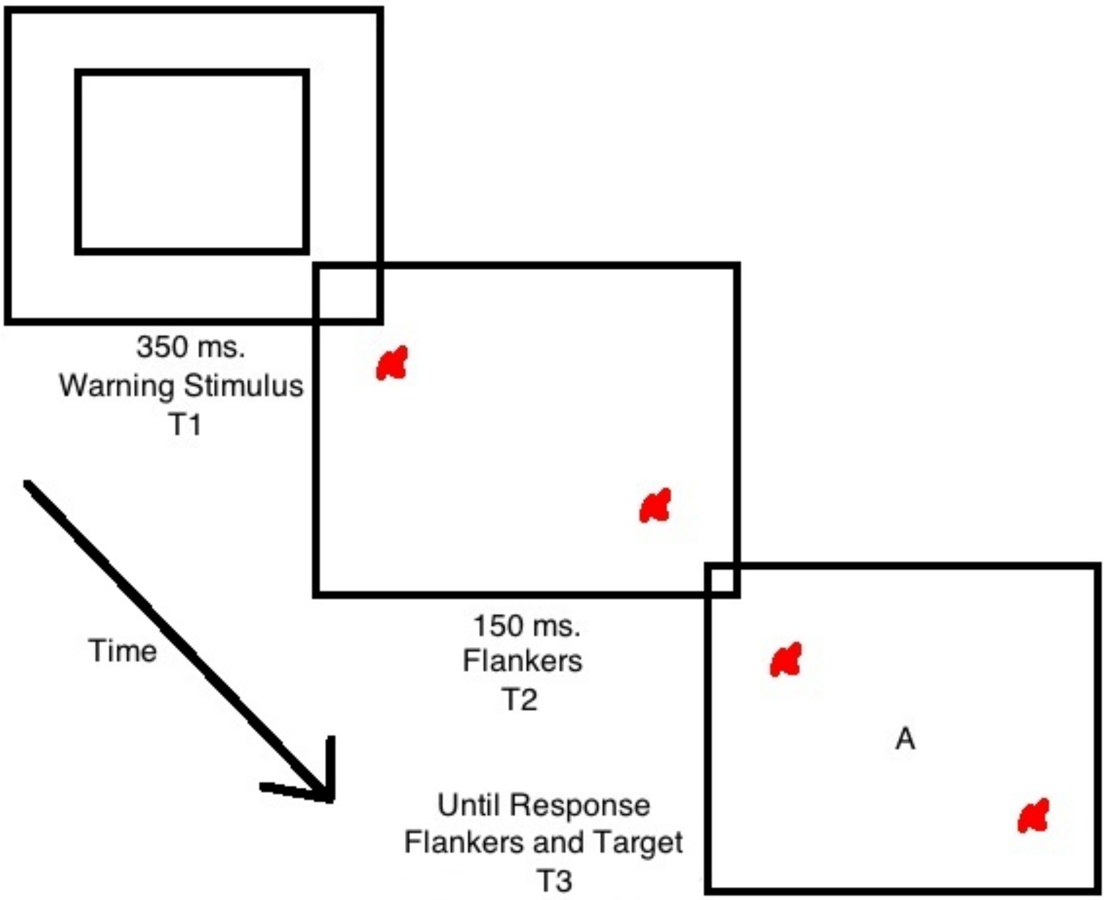
Future Directions

A concern that arose in the examination of the current findings dealt with the unique characteristics of our specific population. Being that the prior research was completed at larger universities than the current research, perhaps the current research should be replicated using a larger population of perhaps less-conscientious students from larger universities like those used in prototype studies like Miller, 1987, and Schmidt and Dark, 1998. The students who participated in the experiment were of the first to complete their research requirements and perhaps this ties in with their level of conscientiousness. Further research should examine the results of this methodology at multiple times throughout the year to be sure this was not a mitigating factor in the results we obtained.

Further research should also explore other implicit memory tasks as well as ways of presenting tasks. Our implicit task was based on a wealth of implicit research but the task itself was new so further studies should explore other implicit tasks in addition to ours or as a replacement. Participants were also instructed to respond as they felt appropriate on the implicit task, so future research should alter the written and verbal directions given to participants to be sure instruction is not a mitigating factor in the results.

Figure 1

One Trial of Flankers Task



Note: This is one complete trial in which the target and flankers were selected randomly.

Appendix A

Explicit Memory Questionnaire

In the task you just participated in you saw a series of targets and flankers. Please answer this short list of questions.

1. For most of the experiment, what items appeared to the side of the letter in the center? Please name at least 4.

2. The outside items (the flankers) were associated with either of the two responses in particular (either the left or the right response). Assign each of the four flankers to a particular response.

   LEFT:

   RIGHT:

3. Please list which targets were assigned to the left key and which targets that were assigned to the right key.

LEFT:

RIGHT:

Appendix B

Flanker Identity Criteria

Acceptable Responses for Flanker Identity	Unacceptable Responses for Flanker Identity
#	Square
Red- Thing, Tetris, mark, blob, shape, splotches, block, scratches, puzzle piece	Animal (bear)
Green- Mark, blob, shape, splotches, block, frog	Blue Thing
Number Sign	Circle
Hash tag	Snowflake
Pound Sign	Colored
Number Sign	White
Rotated Hash tag	White lines
Red	White squiggles
Green	Plus sign
Diagonal Lines	Asterisk
Straight Lines	Triangle
Net Design (#)	*
	Check Marks
	+
	×
	Frog
	Colorless scribbles
	Cows
	Trees

Appendix C

Table 2

Comparable Studies in Relation to Current Experiment

	Miller (1987)	Schmidt & Dark (1998)	Sullivan (2012)
Number of Participants	Experiment 1 - 24 Experiment 2 - 46 Experiment 3 - 27 Experiment 4 - 25 Experiment 5 - 24 Experiment 6 - 40	Experiment 1- 48 Experiment 2 - 26 Experiment 3 - 28	Experiment 1 - 48
Blocks / Total Experimental Trials	Experiment 1 - 2 / 384 Experiment 2 - 2 / 384 Experiment 3 - 3 / 240 Experiment 4 - 3 / 168 Experiment 5 - 3 / 192 Experiment 6 - 8 / 768	Experiment 1 - 6 / 320 Experiment 2 - 6 / 320 Experiment 3 - 6 / 224	Experiment 1 - 8 / 384
Criterion for Elimination	RT over 2s.	Experiment 1 - Accuracy below 90%. Experiments 2 & 3 - Accuracy below 85%.	Accuracy below 90%.
Mechanism of Responding	Standard English Keyboard employing a left and right key.	Standard English Keyboard employing buttons "Z" & "/"	Standard English Keyboard employing buttons "Z" & "/"
Average RT	M= 768ms for Valid Trials. M= 803ms for Invalid Trials.	M= 530ms for Valid Trials. M= 541ms for Invalid Trials.	M = 591ms for Congruent / Valid Trials. M = 602ms for Incongruent / Invalid Trials.

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