

EXAMINATION OF THE MULTI-SOURCE INTERFERENCE TASK

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## ABSTRACT

The Multi-Source Interference Task (MSIT) was developed to examine the neural networks associated with attention and cognitive interference. The MSIT combines different types of interference known to delay reaction time for the purpose of maximizing cognitive interference. The MSIT has been shown to produce activation in the anterior cingulate cortex, a region of the brain implicated in processes of executive attention. Previous work has not addressed the separate influences of each source of interference. This study was designed to decompose the sources of interference to determine their independent contributions. Participants were instructed to identify the number that was different in a three digit array. Font cue, flanker, and spatial interference factors were evaluated. Additionally, blocked versus mixed design was compared. It was found that trials with one type of interference were easier to resolve than trials with two types of interference. Further, the presence of a target font cue diminished interference. Blocking was also found to yield faster response, but only in trials with minimal interference. Finally, trials with congruent types of interference were more difficult than trials with incongruent interference. Results of the study can be used to design a maximally potent MSIT.

## BIOGRAPHICAL SKETCH

Heather Gilmore received her bachelor's degree *cum laude* from Case Western Reserve University in Cleveland, Ohio in 2002 majoring in Psychology and Anthropology with a minor in Childhood Studies. She received Honors in Psychology for her thesis examining self-regulation in children with Attention Deficit Hyperactivity Disorder and children with Bipolar Disorder. She is currently a graduate student in the Department of Human Development at Cornell University. Her research interests include the development of self-regulation and the effect of self-regulation on school performance.

To my parents.  
Thank you for your love and support.

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## CHAPTER 1

### Introduction

The environment provides an extraordinary amount of information, more than one could possibly process at once. Despite the overwhelming amount of stimuli, we are able to selectively attend to pieces of information that are relevant to executing and maintaining our goals because of the attentional systems our brains utilize. Attention is a broad construct that includes many different components of cognitive functioning. This study focuses on the aspect of attention known as control, or executive attention. Executive attention is defined as a higher order process responsible for the execution and maintenance of lower order processes of attention necessary to achieve goals (Posner, 1978; Posner & DiGirolamo, 1998; Posner & Petersen, 1990). This methodological study aims to identify conditions that elicit maximum cognitive interference, thus taxing the executive attentional system. By identifying the types of interference most challenging to people, we can better examine how our attentional systems are designed to overcome cognitive interference and conflict.

Terms commonly used to define executive attention include cognitive control, inhibition, central executive, and attentional bias. Executive attention as defined by cognitive models is required for tasks that involve error detection, decision making, novelty, difficult processing, and overcoming prepotent or habitual responses (Posner & DiGirolamo, 1998). Norman and Shallice (1986) proposed a cognitive model of executive control. The model is marked by three mechanisms of control, one of which is qualitatively different from the others (Shallice, 1994). The first is a subservient mechanism that operates using schemas to coordinate well-learned behaviors and thoughts. Selected or activated schemas remain until the goal is reached or the schema is inhibited by another schema. When a task necessitates something new to be done, the presence of novelty elicits the second mechanism of control. This mechanism is

much like the first and tailors an existing schema to accommodate the new information and complete the task. However, when a necessary response action is qualitatively different from typical processing, as in responses involved in error correction, planning, and overcoming prepotent responses, the first two levels of control are insufficient. A supervisory attentional system intervenes to accomplish the goals of the task. The supervisory system has more control over the schemas and exerts inhibition or activation where needed. This executive control or attention is not always in operation (Posner & DiGirolamo, 1998). It is used only for situations or tasks that require more than routine operations or functions.

Executive attention gives us the ability to maintain goal directed behavior. Under the conceptualization of the Norman-Shallice model of executive control, even the completion of remedial tasks must have started with the implementation of executive attention. As these tasks and processes become rote, a need for executive control is no longer needed. When more difficult or complex tasks arise, executive control is again implemented. Without executive control, maintaining goal directed behavior would be very difficult if not impossible.

Executive attention has been studied in a variety of ways. Cognitive interference tasks are among the most commonly used and require resolving conflict between two different operations. Participants are to give one response while suppressing another. The inhibited response is the prepotent response that the participant has been conditioned to give. Inhibiting the prepotent response is necessary for the correct response. This results in longer reaction times and the more salient the conflict the longer the reaction time.

The most widely studied cognitive interference task is the Stroop task (Stroop, 1935). In the Stroop task the conflicting processes are reading and naming of ink color. A color word is presented either in the same ink color as the word in the

congruent condition or in a different color ink in the incongruent condition. For example, the word “yellow” would appear in yellow ink in the congruent condition and in red ink in the incongruent condition. Participants name the color ink of each word and the increased amount of time to complete the incongruent trials is called Stroop interference. Despite the instruction to identify the ink color, there is an overlearned response to read the word. Thus, to perform the ink naming task the overlearned or prepotent response to read the word must be suppressed.

The Simon task is a cognitive conflict task that uses spatial interference (Simon & Berbaum, 1990). In this task, the location of the target stimulus and the location of the correct response are in conflict with each other. Responses in these trials are longer than in trials where the locations of the target and response are not in conflict. Another widely used cognitive conflict task is the flanker task (Eriksen & Eriksen, 1974). In this task the target stimulus is flanked by distracting stimuli. The presence of distractors slows the response to the target stimulus. What these types of task have in common is that they require the resolution of conflicting operations in order to give a response. Resolution requires inhibition of the prepotent response and this is achieved through the use of executive attention.

Aspects of executive attention undergo dramatic changes in the early years of life. The development of executive attention in children illustrates the mechanisms of executive attention and lends construct validity to the Norman-Shallice model. Young children have difficulty suppressing responses, task switching, and correcting errors, among other things (Posner & Rothbart, 2000). The supervisory control system is not yet developed to organize schemas to complete these tasks. However, we see these abilities improve in the first few years of life (Gerardi-Caulton, 2000). By about age five, when many children start kindergarten, children are able to perform at a level parallel to adults on these functions (Jones, Rothbart, & Posner, 2003). The

supervisory control system has developed and is being used to complete these tasks. Aspects of executive control, such as the ability to make a complex decision or plan a complicated series of actions, continue to develop into adolescence (Casey, Tottenham, & Fossella, 2002).

Several types of tasks are used with children to examine the development of executive attention. Conflict tasks are among the easiest to administer to children. Dramatic improvement is seen between three and five years in this type of task (Jones, Rothbart, & Posner, 2003). In a Simon Says type task, the child is shown two different stuffed animals and instructed to do what one says, and ignore the instructions of the other. Children 3 years old have a difficult time inhibiting their responses and perform correctly only 22% of the time. By age 3.5 accuracy scores are up to 76% and by age 4 they are almost near perfect with accuracy at 91%. Interestingly, a similar pattern emerges for error detection, with young children unable to detect their errors and the older children able to detect the few errors they made. It is likely that improvement in performance is due to the development of executive attention. Other tasks reveal similar patterns in younger children. In a modified Simon or spatial interference task (Gerardi-Caulton, 2000), children as young as 24 months are able to complete the task, but with overall lower accuracy and slower reaction time than children 36 months old. Further, at 30 months of age positive performance is correlated with caregiver ratings of focused attention. As executive attention develops, children are able to inhibit their responses and do so more efficiently with time.

Further understanding of the mechanism of executive attention has been made with the use of neuroimaging techniques. An early study examined neurological correlates of behavioral conflict using the Stroop paradigm (Pardo, Pardo, Janer, & Raichle, 1990). Robust activation was seen in the anterior cingulate cortex (ACC) for this conflict task. This finding led to more extensive research of the ACC and its

function and role in executive functions (see Bush, Luu, & Posner, 2000 for review). The key role of the ACC has since been shown in other tasks requiring executive functions such as task switching, error correction, and inhibition tasks (Bush et al., 2002; Casey, Tottenham, & Fossella, 2002; Dehaene, Posner, & Tucker, 1994).

Cognitive interference tasks that are typically used in behavioral experiments are not always appropriate for use in neuroimaging studies. Neuroimaging techniques require minimal head movement, meaning that tasks that require oral response are often inappropriate. Ideally, responses should be limited to those with one hand on a button glove. Because of these limitations, many conflict tasks that have been modified for fMRI are simple and produce small activation in the regions of interest (Bush et al., 1998). To address this concern, Bush and colleagues developed a conflict task appropriate for neuroimaging.

The Multi-Source Interference Task (MSIT) was developed in order to produce activation in brain regions associated with executive attention, particularly the ACC (Bush, Shin, Holmes, Rosen, & Vogt, 2003). The MSIT combines more than one type of cognitive interference and yields robust ACC activation that does not need to be averaged across subjects. Bush and colleagues purport that there are three types of interference in the MSIT: flanker, Simon or spatial, and Stroop interference, all of which are known to activate the ACC. However, in our examination of the task we were able to identify only flanker and spatial interference. Despite there only being two types of interference, the results of strong ACC activation are very compelling.

In the MSIT, participants were presented with an array of three numbers, two of which were the same. Participants responded by identifying the one number (target) that was different from the other two. The MSIT contained control trials with no interference and experimental trials with two types of interference. Control and interference trials were presented in alternating blocks. Each trial contained a target

that was either larger or smaller than the distractors. Participant responses were recorded via a button glove. Interference trials were more difficult and yielded longer reaction times than control trials.

To date, only one study has examined the behavioral aspects of the MSIT (Stins, van Leeuwen, & de Geus, 2005). The study aimed to explicate the effect of one versus two types of interference and the effect of random stimulus presentation. Trials with flanker only interference were compared to trials with both flanker and spatial interference. Following Bush et al. (2003), each trial contained a target that was either larger or smaller than the distractors. Responses were made by lifting a hand from a home key and pressing another button. Reaction time was slower for trials with two types of interference than trials with one type of interference. Randomization was examined by using a mixed design of trials with one (flanker only), two (flanker and spatial), or no interference (control) and presenting them in random order. The reaction time on the randomized trials was compared to the reaction time of the blocked trials reported by Bush et al., as there was no condition of blocked trials in this experiment. The reaction time for the randomized trials was significantly faster than the reaction time of the blocked interference trials reported by Bush et al. Stins et al. (2005) conclude that multiple sources of interference are more difficult to resolve than one source of interference. Further, randomization of interference trials leads to less cognitive interference.

Conclusions drawn from comparisons of the two MSIT studies are problematic. Participant responses were made in different ways in both studies, making reaction time comparisons invalid. Also, the stimulus size and hence the clarity of the stimulus varied considerably between studies. Differences in reaction times may have been due to differences in the physical characteristics of the stimuli and not interference or blocking effects.

The present study addressed these concerns and attempted to further elucidate the factors causing cognitive interference in the MSIT. Comparisons were made between trials with one and two types of interference in order to examine a possible additive effect of interference. Trials with two types of interference were further divided by those where the two types of interference were congruent with each other and those where the two types of interference were in opposition or incongruent. The latter comparison provided more information about a possible additive effect of interference. The effect of having the target be either larger or smaller than the distractors was also examined. Both of the previous MSIT studies (Bush, Shin, Holmes, Rosen, & Vogt, 2003; Stins, van Leeuwen, & de Geus, 2005) used a target stimulus of different size than the distracting items in all trials. It is possible that a perceptual advantage was created by having the target be a unique size. The present study compared trials with and without a different size target. Finally, both blocked and mixed trials were used to elucidate the effect of blocking on interference.

The first hypothesis was that trials with two types of interference would be more difficult than trials with one type of interference, as measured by reaction time and accuracy. The second hypothesis was that if the target and the distracting items were the same size, a correct response would be more difficult because the participant would have to use purely semantic information, rather than using the perceptual salience of the target. The third hypothesis was that blocking the interference trials would result in faster reaction times because there is greater opportunity to develop a strategy to overcome the conflict. Finally, we predicted that trials where the two types of interference were congruent with each other would be more difficult than trials with incongruent types of interference.

## CHAPTER 2

### Method

#### *Participants*

Seventy-two college undergraduates and graduate students were recruited through Psychology and Human Development courses to participate in this study. Participants were given either one point of extra credit towards a course of their selection or entry into a lottery to win a gift certificate to a popular campus restaurant. Four participants were not included in analysis because they reported having a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD) on the background questionnaire. Additionally, sixteen participants were excluded because their average accuracy was less than 65% for one or more interference conditions. This resulted in the use of 52 participants (42 female) in the analysis. The mean age of participants was 20.3 years old and the range was 18 – 32 years.

#### *Materials*

*Background information.* All participants were given a general background questionnaire gathering information such as age, gender, need for corrective lenses, and a modified inventory assessing handedness (Oldfield, 1971). A second background questionnaire also was given to participants, which asked for past and present diagnoses of ADHD and other mental illness as well as whether the participant was currently on medication for any disorder. After completing this survey, participants were asked to seal the questionnaire in an envelope with their participant identification number on the outside. This procedure was to ensure confidentiality of the participants' responses to the sensitive questions.

*Apparatus.* Stimuli were presented on a 13 inch computer screen with E-prime, version 1.1. Participant responses were recorded via a button press box with 5 buttons. Only the first three buttons were used for this experiment and these buttons

had labels identifying 1, 2, and 3, in serial order. Participants were seated so their eyes were 45 cm from the center of the computer screen. This distance was periodically checked at break points during the experiment.

### *Procedure*

#### *The Multi-Source Interference Task.*

The Multi-Source Interference Task (MSIT) paradigm, developed by Bush and colleagues (2003), was used. Items were presented in white text with a black background. The stimulus arrays ranged from 2.5 – 3.0 cm in width and were approximately 3° of visual angle. In the experimental condition, the stimulus was an array of three numbers, two of which were the same. Participants identified the one number that was different from the other two. The control condition contained one number and two “X”s. Participants responded by identifying the number. Responses were given by pressing the corresponding number on a button box with their dominant hand. The only numbers presented were “1”, “2”, and “3”. The pointer, middle, and ring finger were resting on the buttons representing “1”, “2”, and “3”, respectively. An example stimulus is the array “211”, with the correct response being “2” (see Table 1).

Table 1 *Stimulus Arrays*

Control	Flanker	Incongruent Flanker + Spatial	Congruent Flanker + Spatial
1XX	122	221	331
X2X	133	313	212
XX3	121	233	211
	323	112	332
	113	322	311
	223	131	232

Reaction time was recorded from the onset of stimulus presentation to response. Average responses faster than 200 ms were excluded. The stimulus was presented for 1750 ms and disappeared when a response was recorded. If no answer was given after 1750 ms, the stimulus disappeared and the next stimulus appeared. The interval between stimulus presentations was 500 ms. Participants were instructed to answer as fast as possible without making mistakes. Each block of trials began with a practice session of 6 trials. There were four blocks of trials, lasting a total of 20 – 25 minutes.

*Stimulus Conditions.*

Four conditions were used, one control and three experimental (see Table 1). In the control condition, the target number was presented with two “X”s, with the target number always in the correct serial position that was consistent with the response button position, *e.g.* X2X or XX3. The experimental conditions were flanker, incongruent flanker + spatial, and congruent flanker + spatial. In the flanker condition, the target had two matching distractor numbers, but was in the consistent serial position, *e.g.* 122 or 323. In the congruent flanker + spatial condition the target was in an inconsistent serial location (spatial interference) and had two distractor numbers.

Additionally, the distractor numbers and the spatial location of the target were congruent with each other, *e.g.* 212 (the target “1” is in the second serial location and the distractor numbers are “2”). In the incongruent flanker + spatial condition, the target had two matching distractors and was in an inconsistent serial location, but the interferences were incongruent with each other, *e.g.* 112 (the target is “2” and it is in the third serial location, but the distractors are 1).

As discussed above, the previous MSIT studies used a font cue where the target was bigger or smaller than the distractors. We manipulated the font cue for each of the conditions to explore its effect on interference. In the “font cue” condition, the target was smaller or larger than the other numbers. In the “no font cue” condition, the target was the same size as the distractors.

The previous studies differed in their use of blocked (Bush, Shin, Holmes, Rosen, & Vogt, 2003) or mixed (Stins, van Leeuwen, & de Geus, 2005) trials. We manipulated blocking conditions (blocked vs. mixed) to explore this effect on interference. In the blocked condition, trials were grouped by interference type. In the mixed condition, all interference conditions were presented in a mixed random order.

The stimulus manipulations created 16 conditions (4 interference x 2 font cue x 2 blocking). The trials were grouped based on font cue and blocking status. The design resulted in four experimental runs (Blocked with Font Cue, Blocked without Font Cue, Mixed with Font Cue, and Mixed without Font Cue). Each of the runs contained trials with the four types of interference (control, flanker, congruent flanker + spatial, and incongruent flanker + spatial). All participants completed each of the four runs in one session. The order of the runs was determined by a counterbalanced Latin square design.

An initial ANOVA was conducted with a 2 x 2 x 3 design. The blocking variable had 2 levels (blocked and mixed), the font cue variable had 2 levels (with font

cue and without font cue) and the interference variable had 3 levels (control, flanker interference, and flanker + spatial interference collapsed across incongruent and congruent trial types). The main interests of analysis concerned the interference conditions, so additional ANOVAs were conducted with a 2 x 2 x 3 design, excluding the control condition and dividing the flanker + spatial trials into incongruent flanker + spatial and congruent flanker + spatial trials. An ANOVA also was run without font cue conditions (2 (blocking) x 3 (interference) design). A final 2 x 2 x 2 ANOVA was run with type of dual interference (congruent *vs.* incongruent) using only the incongruent and congruent flanker + spatial interference trials. T-tests were planned between the interference conditions. This was a completely within subjects design.

## CHAPTER 3

### Results

#### *Reaction Time*

Reaction time analysis of the control and interference conditions showed a main effect of interference ( $F(2, 102) = 333.669, p < .001$ ). Planned t-tests revealed that the control condition was significantly faster than the flanker ( $t(51) = -15.843, p < .001$ ) and flanker + spatial ( $t(51) = -21.306, p < .001$ ) conditions. The flanker condition was significantly faster than the flanker + spatial condition ( $t(51) = -13.509, p < .001$ ) (see Figure 1 and Table 2). The control condition was removed from the remaining analyses because it was not a condition of interest and also to ensure that it was not driving the remaining results.

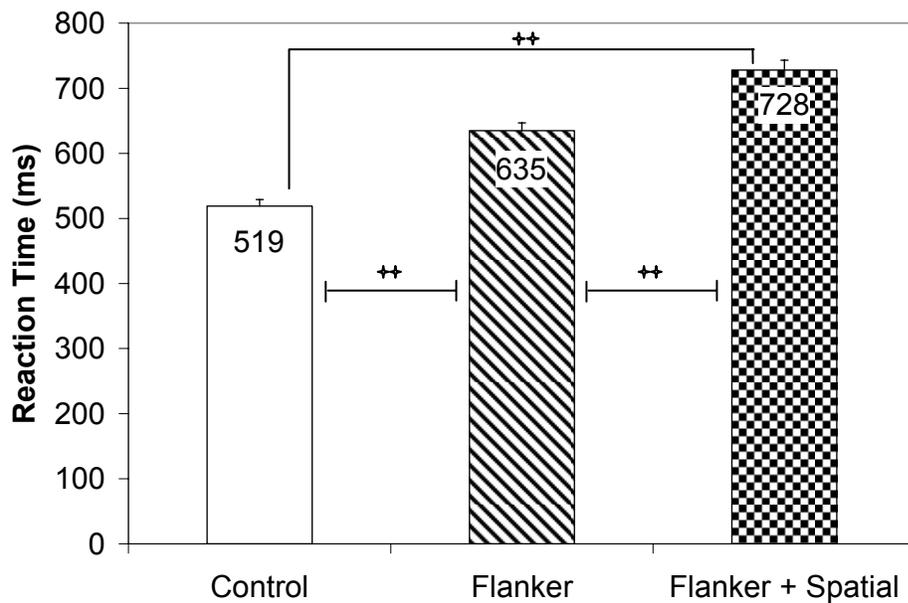


Figure 1 Mean Reaction Time of Control and Interference Conditions

\*\*  $p < .001$

Table 2 Mean Reaction Time by Condition

	Blocked		Mixed	
	With Font Cue ms (SD)	No Font Cue ms (SD)	With Font Cue ms (SD)	No Font Cue ms (SD)
Control	468 (68)	474 (67)	567 (100)	564 (118)
Flanker	592 (111)	632 (101)	635 (94)	682 (132)
Incongruent Flanker + Spatial	702 (130)	742 (140)	703 (112)	741 (122)
Congruent Flanker + Spatial	729 (140)	747 (158)	710 (115)	753 (130)

Reaction time analysis of the flanker, incongruent flanker + spatial, and congruent flanker + spatial interference trials showed a main effect of interference ( $F(2, 102) = 121.877, p < .001$ ). Planned t-tests revealed that performance on flanker trials was significantly faster than performance on both incongruent flanker + spatial interference ( $t(51) = -11.878, p < .001$ ) and congruent flanker + spatial interference trials ( $t(51) = -13.048, p < .001$ ). Additionally, incongruent flanker + spatial trials were faster than congruent flanker + spatial interference trials ( $t(51) = -2.247, p < .05$ ) (see Figure 2).

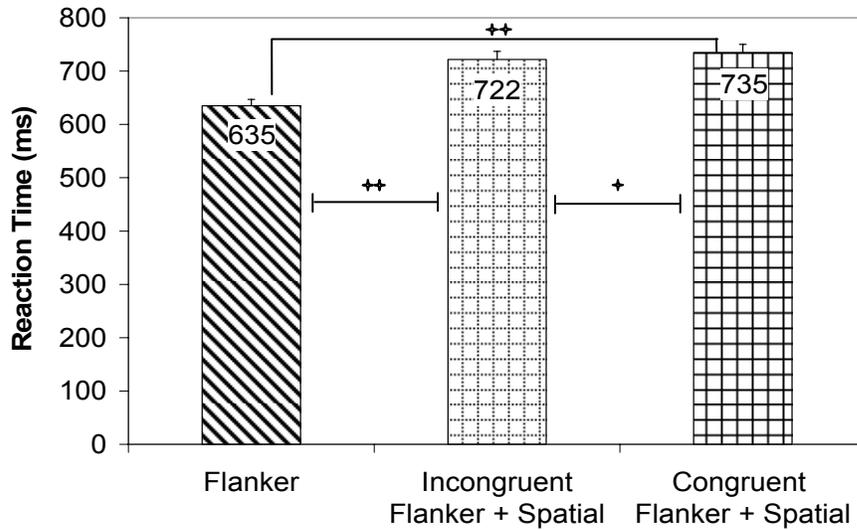


Figure 2 Mean Reaction Time of Interference Conditions

+  $p < .05$

++  $p < .001$

Analysis revealed a main effect of font cue ( $F(1, 51) = 16.609, p < .001$ ).

Performance on trials with a target font cue, meaning the target number was either larger or smaller than the distracting numbers, was significantly faster than trials with all three numbers the same size (see Figure 3).

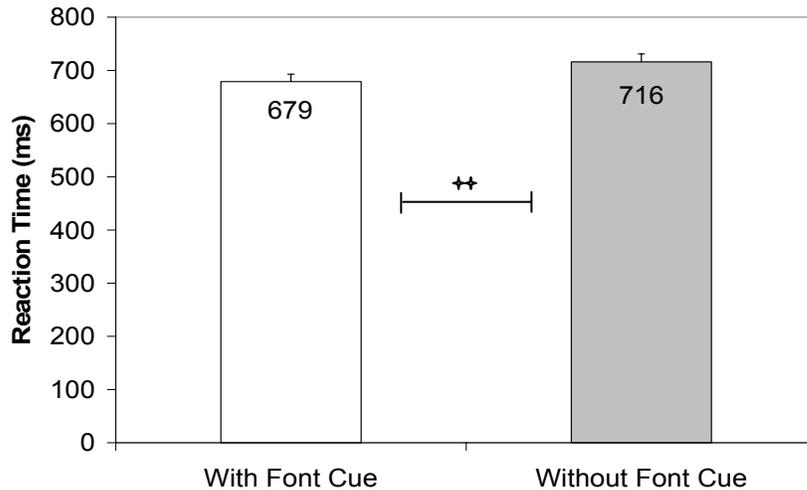


Figure 3 Mean Reaction Time of Trials With and Without Font Cue

++  $p < .001$

There was not a main effect of blocking ( $F(1, 51) = 1.753, p = ns$ ). However, there was a blocking x interference interaction ( $F(2, 102) = 15.264, p < .001$ ). *Post hoc* comparisons were made with a Bonferroni correction and revealed that in the flanker condition only, the blocking condition had an effect. Performance on the flanker trials was significantly faster in the blocked than the mixed trials ( $t(51) = -3.023, p < .005$ ), regardless of font cue (see Figure 4).

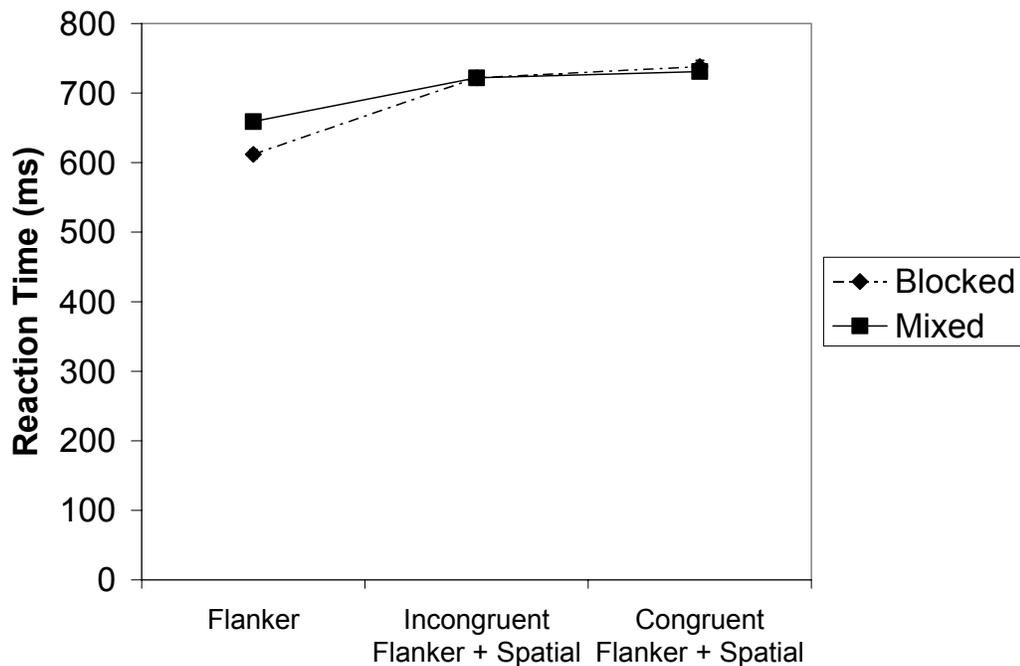


Figure 4 Effect of Blocking on Interference Conditions

As mentioned earlier, target font cue was a main effect, such that trials with a font cue showed less susceptibility to interference than trials without font cue. In order to determine if the trials with font cue were driving these results, a second ANOVA was done with only the trials with no font cue (2 (blocking conditions) x 3 (interference conditions)). The interaction between the blocking and interference variables was significant ( $F(2, 102) = 5.592, p = .005$ ), indicating the font cue was not driving this result.

An ANOVA of the incongruent flanker + spatial and the congruent flanker + spatial trials revealed main effects of type of interference ( $F(1, 51) = 5.049, p < .05$ ) and font cue ( $F(1, 51) = 13.426, p < .001$ ). There was no main effect of blocking and no interactions (see Figure 5). Trials where the two types of interference were congruent were slower than the incongruent trials. Trials without font cue were slower than trials with font cue.

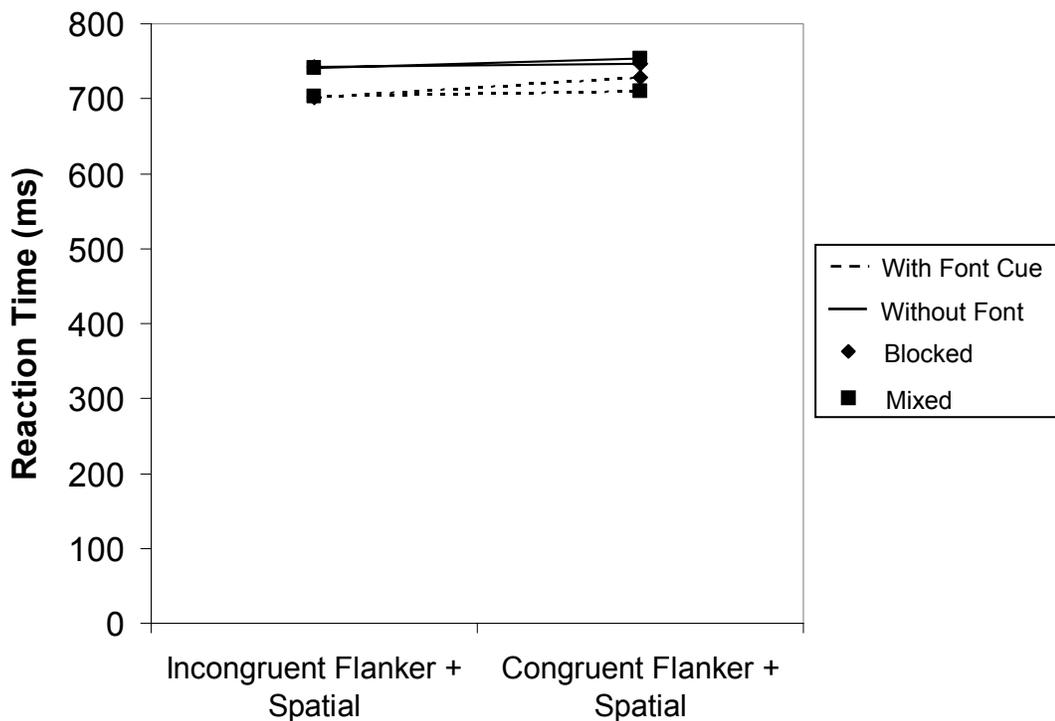


Figure 5 Effects of Blocking and Font Cue on Flanker + Spatial Conditions

### *Accuracy*

Accuracy analysis of the flanker, incongruent flanker + spatial, and congruent flanker + spatial trials showed a main effect of interference ( $F(2, 102) = 31.296, p < .001$ ). Control trials were not included in the analysis. Planned t-tests revealed that performance on flanker trials was more accurate than performance on both incongruent flanker + spatial interference ( $t(51) = 6.790, p < .001$ ) and congruent

flanker + spatial interference trials ( $t(51) = 5.499, p < .001$ ). Interestingly, given the reaction time results, congruent flanker + spatial trials were more accurate than incongruent flanker + spatial trials ( $t(51) = -3.704, p = .001$ ) (see Table 3).

Table 3 *Mean Accuracy by Condition*

	Blocked		Mixed	
	With Font Cue (SD)	No Font Cue (SD)	With Font Cue (SD)	No Font Cue (SD)
Control	.997 (.012)	1.00 (0)	1.00 (0)	.990 (.040)
Flanker	.985 (.035)	.978 (.057)	.976 (.045)	.985 (.032)
Incongruent Flanker + Spatial	.928 (.081)	.923 (.089)	.943 (.055)	.942 (.075)
Congruent Flanker + Spatial	.951 (.058)	.933 (.092)	.953 (.048)	.924 (.076)

There was a main effect of font cue ( $F(1, 51) = 4.149, p < .05$ ). Performance on trials with a target font cue, meaning the target number was either larger or smaller than the distracting numbers, was more accurate than trials with all three numbers the same size. Additionally there was an interference x font cue interaction ( $F(2, 102) = 3.076, p = .050$ ). *Post hoc* comparisons were made with a Bonferroni correction and revealed that congruent flanker + spatial trials were more accurate in trials with a font cue than trials without ( $t(51) = 2.675, p = .010$ ).

## CHAPTER 4

### Discussion

The study aimed to identify conditions that maximize cognitive interference on the MSIT. Specifically we examined blocking, font cue, and interference factors. The data support the first hypothesis that trials with two types of interference were more difficult than trials with one type of interference, as evidenced by the faster performance and greater accuracy on the flanker trials than on the flanker + spatial trials. The second hypothesis also was supported in that trials with a font cue created less interference than trials without a font cue. This suggests that having the target a different size actually serves as a perceptual cue for identification. Rather than relying solely on semantic information, the participant may identify the target based on the perceptual quality of it being larger or smaller than the other numbers. This “font cue” serves as a salient cue to overcome the interference, resulting in faster reaction times.

The data partially support the third hypothesis that blocking the interference trials will result in faster reaction times, but this was only seen in the flanker condition. Flanker trials in the blocking condition were faster than flanker trials in the mixed condition. This finding suggests that the blocking of interference trials leads to faster reaction times in conditions with minimal interference. The flanker condition has less interference than the other conditions, as demonstrated by reaction time and accuracy. Because this interference is easier to overcome, the use of a strategy may be employed when the trials are blocked.

The fourth hypothesis that congruent flanker + spatial trials would be more difficult than incongruent flanker + spatial trials also was supported by the reaction time data. Trials with two types of interference that are incongruent with each other were easier to resolve than trials with congruent types of interference. This finding suggests that multiple types of interference may work together in an additive fashion

to create conflict. Further, this conflict is more potent when the interferences are sending the same distracting message, as evidenced in the congruent flanker + spatial trials.

The MSIT is an effective cognitive interference task. Certain trial types are more difficult than others resulting in slower response reaction times and lower accuracy. Participants perform worse on trials with two types of interference than one, specifically flanker and spatial interference versus flanker interference. An extra source of interference compounds the difficulty of the task. Further, trials with two interference types in which the flanker and spatial interferences are congruent with each other are more difficult under some circumstances. In these trials, the interference is strong because the distracting message is the same for the two different types of interference. The conflict takes longer to resolve because the distraction is stronger.

Despite the interference effects, there are ways to overcome some effect of the interference. Blocking interference trials yields faster reaction times. This suggests that participants may be developing a strategy during the block of trials. When the same type of interference is repeatedly presented, participants anticipate the interference type and become better at resolving the conflict. When trials are mixed, participants are unaware of the next interference type and are not able to develop a strategy. This suggests that people think differently about different types of interference. One strategy is not effective for all interference types, so the way the information is processed must be different.

The presence of a font cue also aids in overcoming interference, regardless of the type of interference. The target number is identified by being the one number different from the other two distracting numbers. The participant must look at all numbers in the array in order to identify the unique one. However, when the target

number is either larger or smaller than the distracting numbers, the array need not be looked at the same way. A quick scan for the smaller or larger number would reveal the target which could then be looked at and identified. The font cue serves as a salient perceptual cue. Rather than relying on the meaning of the numbers, the target can be identified because it is physically different from the other numbers.

All of this information taken together tells us an interesting story about the way people process distracting information. When possible, people will develop and use a strategy to overcome interference. These strategies to reduce conflict rely on anticipating the type of interference to come and perceptual information of the target number. When the interference is very strong, these strategies are rendered ineffective. In order to create maximum interference, it is necessary to use interference and trial types that are difficult to overcome with strategies. The most effective combination is mixed trials of flanker and spatial interference without a font cue. In this combination, participants may solely use semantic information to correctly identify the target number.

In conclusion, the MSIT is effective at creating cognitive conflict and utilizing the executive attentional system to resolve the conflict. Decomposition of the MSIT is essential to understanding the types of interference and how the cognitive conflict is resolved. Further examination should be done to see if strategies can be developed over time for even the most difficult combination of conditions. Also, the effect of spatial interference should be more closely examined, as it likely plays a large role in the flanker and spatial interference conditions. After the MSIT is further understood, it can then be used as a reliable neuropsychological task.

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