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The effect of global and local processing in the attentional blink

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The Effect of Global and Local Processing in the Attentional Blink

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Abstract

The attentional blink (AB) is an individual's inability to perceive the second of two targets presented in a rapid serial visual presentation (RSVP). The constructs of global and local attention have been a principle concern in modern psychology. The perception of an object as an overall form is referred to as the global aspect, while the separate parts compose the local aspect. The purpose of this study was to explore whether the following factors affect the characteristics of an individual's AB: (1) When target one (T1) and target two (T2) were the same or different letters (2) Whether T1 was global or local (3) Whether T2 was global or local (4) When T1 occurred within the RSVP relative to T2 (5) When T2 occurred within the RSVP relative to T1. Participants were shown Navon letters (e.g., an X made up of M's) in an RSVP sequence. Previous research has shown that the presentation of a letter in global or local form as well as the position of a target letter can affect an individual's AB. We found that there was a significant interaction between the variables of same/different, whether T2 was presented in global or local form, and the position of T2 suggesting that there was not as strong of an AB when T1 and T2 were presented as the same letter. The findings of our research contradict those of previous studies.

Introduction

The current study investigated the characteristics of the attentional blink (AB). The AB was first suggested by Raymond, Shapiro, and Arnell (1992). Later, Shapiro (1994) defined it as an individual's inability to perceive the second of two targets that is presented within 200 – 500 milliseconds of the first target within a random serial visual presentation sequence (RSVP). The RSVP sequences consist of targets being presented among many distractors at a high presentation rate, usually 4-12 stimuli/second (Broadbent, & Broadbent, 1987). Many researchers have used multiple-task RSVP sequences to demonstrate that the amount of attention it takes to identify the first target is a temporary, but long lasting, cost to identifying stimuli presented after the first target (Raymond et al., 1992; Broadbent & Broadbent, 1987; Weichselgartener & Sperling, 1987).

Raymond et al. (1992) determined that if attention is allotted to a target stimulus, then attention cannot be switched to any other item that is presented during the interval of 180 msec to 450 msec. These findings suggest that the AB is limited when attentional demand cannot be allotted to all visual information being presented within the RSVP. In other words, individuals allocate attention to visual stimuli episodically and in a serial fashion (Raymond et al.,1992; Sperling & Weichselgartner, 1990).

Research conducted between the constructs of global and local have been studied with the use of color photographs (Potter, 1976), numbers, traditional letters (Weichselgartner & Sperling, 1987), shapes (Adamo, Cain, & Mitroff, 2013), symbols (Chun, 1997), and words (Kanwisher, 1987). It has been suggested that longer blinks can occur with different types of stimuli. Potter (1976) asked participants to look for a target picture within a RSVP sequence. Participants were either shown a photograph of the target picture for 5 seconds or were given a brief description of the picture (i.e., picnic basket in a field) prior to the sequence beginning. Researchers found that

participants were able to identify the target more than 60% of the time. Potter (1976) concluded that individuals are quickly able to identify a presented target photograph and compare it to the description within their memory. However, for a short duration after the initial target, the individual's memory experiences an interference in which they are unable to process targets or distractors presented after the first target.

Weichselgartner & Sperling (1987) instructed participants to view a serial stream of letters presented to the left of a serial stream of numerals and to shift their attention from the letter stream to the numerical stream upon detecting a target letter "C." Participants were asked to recall the earliest four numbers they could remember. Weichselgartner & Sperling (1987) determined that participants tended to remember target numbers that appeared 300 to 400msec after the presentation of the first target. They concluded that it takes a participant about 300 +/- 100 msec to shift their visual fixation from the letter stream to the numerical stream upon detection of the target letter "C."

Adamo, Cain, & Mitroff (2013) asked participants to detect T-shaped targets presented in a RSVP sequence among L-shaped distractors. Researchers related the AB to the subsequent search misses resource depletion theory (Cain & Mitroff, 2013) and proposed that an AB could suggest a participant's inability to switch attention from an initial target to a second target due to the fact that they are still using their cognitive resources to process the initial target (Adamo et al. 2013; Chun & Potter, 1995; Jolicœur, 1998). The more cognitive resources a participant requires to process the initial target, the larger the AB will be (Visser, 2007). Researchers concluded that multiple-target searches result in a participant being less likely to detect the second of two targets (Adamo et al. 2013; Tuddenham, 1962). Adamo et al. (2013) also discovered that the AB occurs in relation to distractors presented after the first target (Di Lollo, Kawahara, Shahab Ghorashi, &

Enns, 2005; Olivers & Meeter, 2008) and that when distractors were presented prior to the second target, participants experienced a decrease in detection of the second target.

Chun (1997) asked participants to search for target letters that would appear within a RSVP among keyboard symbols. At the end of each sequence, participants were asked to record their responses and include whether the targets had been presented in uppercase or lowercase format. Researchers concluded that increasing the difference between the targets and the distractors removed the AB effect. In a similar study, Kanwisher (1987) asked participants to view a RSVP sequence and determine which word had been repeated. They concluded that individuals had a difficult time with confidently identifying the repeated word. Kanwisher (1987) also found that it is very difficult for individuals to identify repetitions when there were several distractors between the appearance of the first word and the appearance of the repeated word.

Work on AB stimuli eventually shifted to complex stimuli that have global and local features. The constructs of global and local attention are a principle concern in modern psychology and involve the relationships between perceiving an object as a whole versus perceiving an object as a single entity (Navon, 1977). The perception of an object as an overall form is referred to as the global aspect, while the separate parts compose the local aspect. Examination between the differences of these two constructs have mainly been studied with the use of Navon letters with which the distinctiveness of the letters vary based on whether an individual's attention is to be focused on the complete image or to its separate parts (Lawson, Crewther, Junghans, Crewther, & Kiely, 2004; Perfect, 2003). Navon figures are composed of one large identifiable letter made up of different smaller letters in which the letter for the global and local components of the figures are either the same (i.e., a C made up of C's; see Figure 1) or different (i.e., an X made up of M's). Navon forms can be used to demonstrate that individuals

must first detect an object in its entirety before they can break it down into smaller entities as show in Navon's original (1977) study.

Navon (1977) determined that individuals detect global differences more often than local differences when looking at stimuli in what came to be known as the principle of "global precedence." This theory proposes that the perceptual practices individuals encounter are organized temporally and because of this the individual will deconstruct a visual prospect as opposed to creating it. In short, individuals process visual structures in a global to local manner, suggesting that attention is first allocated to global features and then to local features (Navon, 1981). Through previously reviewed literature, Navon also determined that perception is a two-way process suggesting that local features can act as components in global structures and that in identifying the global structure allows for an individual to better reduce the number of options for a target local feature. Through this, Navon (1977) concluded that an individual's spatial organization must come before their interpretation of the details.

The principle of global precedence can be used to demonstrate that the AB will be longer when an individual is processing local stimuli as shown in a study conducted by Crewther, Lawson & Crewther (2007). They determined that the AB duration was shorter in the condition in which the targets were both presented globally which agrees with the global precedence proposition of Navon (1977). Prior to the experiment, they trained participants on the difference between global and local aspects of Navon letters within an RSVP paradigm to an accuracy of 80%. The experimental task was to determine whether or not they saw a feature of a red target letter "X" in either global or local form. Researchers showed participants a series of movies consisting of 25 Navon letter sequences. All stimuli were presented in white font on a black background and no letters were repeated consecutively. The stimuli were presented to participants

at a rate of either 250 ms or 167 ms per each letter stimuli and the sixth letter in each sequence was designated as the red target letter "X". The researchers concluded that the AB duration was longer in local-local conditions suggesting that in order for individuals focus on the local features of a stimulus, they must first overlook the more salient global features of the same stimulus (Crewther et al., 2007, Navon, 1981). Crewther et al. (2007) also found that there was a slightly longer time course than typically found with the AB. Global and local stimuli can be used to validate the belief that attentional efforts are stronger for global stimuli than for local stimuli. Lawson et al. (2004) showed this when they found that accommodation will be more efficient when focusing from global to local stimuli.

In their study, Lawson et al. (2004) concluded that it is less taxing for individuals to expand their attentional efforts than it is for them to confine it. Participants were trained on the identification of Navon figures in global-local form, presented in a RSVP to an accuracy of approximately 80%. Researchers then presented sequences of Navon figures to participants and asked participants to identify a red target letter "X" that was presented in either a global or local form. Researchers also asked participants to identify the target letter "X" in the same RSVP which was also shown in either global or local form. Participants were shown sequences of Navon letters at the rate of 1 letter/s. Researchers found that there was a significant increase in accommodation for the global-local condition among participants (Lawson et al., 2004). The finding that individuals are more readily able to expand their visual efforts (view things globally), as opposed to restricting them (view things locally), gives precedence to the belief that the attentional state of the individual can affect the duration of their attentional blink as shown in the study conducted by Lawson, et al. (1998).

Lawson et al. (1998) concluded that the duration of the AB is reliant on the attentional state of the individual as driven by the magnocellular pathway. Prior to the experiment, researchers trained participants on global-local letter identification to an accuracy of approximately 80%. Participants were asked verbally and in written form to identify a red target letter, which was presented in either global or local form, as well as the target letter "X" which was also presented in either global or local form. Researchers presented participants with movie sequences of Navon figures. Each sequence consisted of approximately 50 letters that were randomly selected in either global or local form and were presented at a rate of 4 figures/s. Researchers included a control movie sequences in which the target letter "X" did not appear at all in order to control for false-positives (Lawson et al., 1998). After each video sequence, participants were asked to indicate whether or not they had seen the red target letter as well as the target letter "X". Researchers concluded that the positioning of the target letter "X" within each video sequence, in combination with the attentional state, predicted the percentage of correct answers for each individual (Lawson et al., 1998). The findings that the positioning of a target letter, along with the presentation of the letter in either global or local form, can influence the period of time in which the AB will occur gives precedence to new research on this topic. The constructs of global and local features are significant to modern research because they explain how individuals process visual input as well as how they allocate their attention to various visual stimuli.

Purpose and Hypotheses

The current study predicted that several variables could affect the strength of the AB. Strength here refers to the detection of target two (T2) such that a weaker AB would have less of a detection deficit and vice versa. Hypothesis 1: Whether target one (T1) and (T2) were presented

as the same letter or different letters. No known previous research has investigated this variable. Because participants are searching for the same letter for both T1 and T2, logic holds that when the target letters are the same, individuals should show a weaker AB, and have less of a detection deficit. We hypothesized that having T1 and T2 as the same letter would decrease the detection deficit for T2 and would result in a weaker AB. Hypotheses 2 and 3: Whether T1 was global or local and whether T2 was global or local. Previous findings show that individuals perform better when target letters are presented in global form. Navon (1977) showed that an individual's spatial organization must come before their interpretation of the details. Crewther et al. (2007) determined that detection of the second target decreased in the attentional condition in which the targets were both presented globally. We hypothesized that having T1 and T2 in global form would decrease the detection deficit for T2 and would weaken the AB. Hypotheses 4 and 5: When T1 occurred within the RSPV relative to T2 and when T2 occurred within the RSVP relative to T1. Lawson et al. (1998) concluded that the positioning of the target letter within a sequence can forecast the percentage of correct answers for each individual. We hypothesized that positioning T2 earlier in the RSVP sequence would decrease the detection deficit for T2 and would weaken the AB, based on the fact that this defines the blink itself. In our research we will study the differences across the means of these five variables. Our study will add on to previously published literature on global and local processing by focusing on how the positioning of a target letter in combination with the presentation of the target letter in either global or local form can influence the AB.

Method

Participants

Our participants consisted of 33 university students. One was removed due to technical issues. The analysis was completed on the remaining 32 university students (age range 18-22, M = 20.03; 24 females). Participants were recruited through the participant pool and received class credit for participating in the study. All participants had normal or corrected-to-normal vision and were excluded if they self-reported any history of epilepsy.

Materials

Participants were seated 60 centimeters from the screen of the computer. Participant's responses were recorded on a data sheet and were later tabulated in Excel. Navon letters that contained both vertical and horizontal lines (E, F, H, I, J, L, T) or letters that contained both straight and curved characteristics (B, D, G, K, P, R U) were excluded. PowerPoint was used to create each Navon letter in Arial font. Global letter dimensions were 5.588 x 5.588 centimeters and local letter dimensions were 0.53 x 0.57 centimeters. We ensured that all of the stimuli generated consisted of black global-local letters on a white background with the exception of T1 which was presented as a cobalt blue global-local letter on a white background. We created 40 unique RSVP sequences each made up of Navon letters.

The 40 unique RSVP sequences were created using the following rules: 1) The letter used for T1 and T2 appeared only as T1 and/or T2 but nowhere else in the sequences. 2) Other letters were used a maximum of two times in either global or local form in each sequence. 3) Letters in global and local form were counted to ensure that no one letter was used in an excess compared to others. Each unique RSVP sequence was created in PowerPoint and was presented on a 23 inch desktop computer screen. Target letters one and two (T1 and T2) and distractors were included in

each of these various sequences. In each trial there were two targets, T1 and T2, and the letters shown that were not the target letters were considered as the distractors.

Design

The purpose of this study was to explore whether several factors affect the characteristics of an individual's AB. The design of this experiment was a 2 (same or different letter) x 2 (T1 global or local) x 2 (T2 global or local) x 3 (T1 position) x 5 (T2 position) within-subjects factorial. Crewthers et al. (2007) looked at same or different target letters in terms of their global and local features. We define same or different as whether the targets were presented as the same letter (ie., T1 was global or local "A" and T2 was a global or local "A") or as different letters (ie., T1 was a global or local "S" and T2 was a global or local "Q"). T2 positions were chosen to understand the nature of the AB. T1 positions were chosen in order to keep the overall sequences short while still manipulating when the AB would begin. This helps to prevent anticipation effect from our participants. We created stimuli for the eight combinations of the first three variables (example: same letter for T1 and T2, T1 was global, T2 was global), and then placed them into an 18-item RSVP sequence. T2 was positioned in either the first, third, fifth, seventh, or ninth position after T1. The location of T1, a cobalt blue global-local letter, in the RSVP sequence also varied (appearing second, forth, or sixth) to reduce subject anticipation of its location.

The order of the 120 variable/level combination RSVP sequences were counterbalanced using a Latin Square design such that the same and different variables were presented before repeating each of the RSVP sequences. Sequences were shown to the participants three times and the percent of T2 "Yes" responses were calculated. If the participant missed T1 or got the global/local aspect of T1 incorrect, it was considered to be a trial where the AB did not occur and

the T2 data was not included in the analysis. If T2 was missed or the participant got the global/local aspect of T2 wrong, it was considered a miss ("no").

Procedure

Following the informed-consent procedure, we described the directions for the AB task to participants. When participants felt as though they had comprehended the directions in their entirety, they were given practice sequences at both a slower speed and at a normal speed to ensure that they could see that both T1 and T2 would be presented in the sequence. We did not train participants on global-local letter identification accuracy as was done in Crewther et al. (2007), as we wanted to keep our participants naïve to the task. Participants were provided with the following directions at the start of each sequence: "Please look for the target letter __ presented in global form and the letter __ in the local form. Click the mouse when you are ready to proceed." After the mouse was clicked, a plus sign (+) appeared on the screen as guidance for the fixation point for the upcoming stimuli. The participant was prompted to press the spacebar once seeing the fixation point.

An 18-item RSVP sequence followed at the location of the fixation point at a rate of 0.25 second per stimuli. Each trial concluded with the following questions: "Was target one present? Was target two present?" Participants were prompted to respond with yes or no. If the participant responded with a "yes" for T2, a follow up question of global v local was asked. When participants had completed the practice section of the experiment, they were asked to move on to the first block of the experiment. The 120 experimental trials took participants between 75-120 minutes to complete. Researchers then debriefed participants on the true purpose of the AB task.

Results

Data was organized into a Microsoft Excel spreadsheet and transferred to SPSS for analysis, where a 5-way within-subjects ANOVA was conducted using T1 position, T2 position, Same/Different letters for T1 and T2, and whether T1 and T2 were either global or local as factors.

Main Effects

Preliminary analysis showed that there was a main effect of T2 position [F (4, 56, MSE = .081) = 26.024, p = <.001, η_p^2 = .459]. Detection increased as T2 was presented further (in time) from T1. There was a main effect of whether T2 was presented in global or local form [F (1, 14, MSE = .232) = 11.883, p = .004, η_p^2 = .650]. Detection of T2 was higher when T2 was presented in local form.

Interactions

As shown in the Figure 2, there was a significant interaction between same/different and whether T1 was global or local [F (1, 14, MSE = .070) = 6.778, p = .021, η_p^2 = .326]. T2 detection was lower when T1 was global and the two targets were the different letters; there was no such effect when T1 was local. Figure 3 illustrates a significant interaction between same/different and whether T2 was global or local [F (1, 14, MSE = .072) = 10.241, p = .006, η_p^2 = .422]. T2 detection was higher when T2 was local and targets were the same letter; there was no such effect when T2 was global.

As shown in Figure 4, there was also a significant interaction between same/different and T2 position. Detection was higher when T1 and T2 were the same and when T2 was presented further from T1. [F (4, 56, MSE = .079) = 11.058, p < .001, η_p^2 = .441]. When target letters were the same, the AB was not as strong as when the target letters were different.

Expanding on Figure 2, Figure 5 demonstrates significant interaction between the variables of same/different, whether T1 was global or local, and T2 position [F (4, 56, MSE = .112) = 3.465, p = .013, η_p^2 = .198]. The AB tended to be stronger when T1 and T2 were presented as different letters. Figure 6 expands on Figure 3 and illustrates a significant interaction among the variables of same/different, whether T2 was global or local, and T2 position [F (4, 56, MSE = .083) = 4.245, p = .005, η_p^2 = .233]. There to be a stronger AB when T1 and T2 were different directly following the presentation of T1.

Finally, there was a significant interaction among whether T1 was presented globally or locally, whether T2 was presented globally or locally, and T2 position [see Figure 7; F (4, 56, MSE = .122) = 18.901, p <.001, η_p^2 = .574]. The strength of the AB increased when T1 was local and T2 was global.

Discussion

The present study examined the effect of global and local processing, time, and position on the attentional blink. We had five specific hypotheses.

Hypothesis 1

We hypothesized that having T1 and T2 as the same letter would weaken the AB. The significant interaction between same/different and T2 position indicated an increase in T2 detection in the same condition in the two presentation positions closest (in time) to T1. This distinction was less clear in positions where T2 was further presented from T1. It seems that searching for the same letter results in less of a detection deficit, or a weaker AB. This could be a result of the task requiring less cognitive load to search for two letters that are the same than two letters that are different. Our findings reveal that whether we view the targets global or local feature or whether the targets were the same letter or different letters, similar patterns are shown when the target letters are different. It would be beneficial for researchers to include this variable in future studies in order to expand on the construct of same/different and its effect on the AB.

Hypotheses 2 and 3

We also predicted that having T1 and T2 in global form would weaken the AB. There was a main effect of whether T2 was presented in global or local form. T2 detection increased when T2 was presented in local form. The AB increased when T2 was presented as a global letter. These results conflict with those of Lawson et al., (1998) who found that the positioning of a target letter, along with the presentation of the letter in either global or local form, can influence the period of time in which the attentional blink will occur.

There was a significant interaction between the variables of same/different and whether T1 was presented in global or local form. We found that T2 detection was higher when T1 was global and targets were the same letter; there was no such effect when T1 was local. There was a significant interaction between the variables of same/different and whether T2 was presented in global or local form indicating that detection increased when T2 was presented in local form. We found that T2 detection was higher when T2 was local and targets were the same letter; there was no such effect when T2 was global. According to Navon (1977), the global precedence effect suggests that there should be a weaker AB when the target letter is presented globally and a (longer) stronger AB when the target letter is presented locally. Although our findings for T1 agree with this theory, our findings for T2 contradict this theory. Our findings showed that when T1 was presented globally, detection remained linear and when T2 was presented locally detection remained linear. This suggests that the two targets are not processed in parallel, but are instead processed separately. These findings also contradict with those of Crewther et al., (2007) who determined that the AB was weaker in the global-global attentional condition than in the local-local attentional condition as well as the findings of Lawson et al., (2004) who concluded that it is less taxing for individuals to expand their attentional efforts than it is for them to confine it. We found that the AB was stronger when T1 was local and T2 was global. The AB was not as strong when T1 and T2 were both global or when T1 and T2 were both local. These findings suggest that individuals are more easily able to process local stimuli and then later expand their visual knowledge to include global stimuli.

Hypotheses 4 and 5

Additionally, we theorized that positioning T2 earlier in the RSVP sequence would weaken the AB. There was a main effect of T2 position. Detection increased as the position of

T2 was further from T1 thus suggesting that the AB occurred. It is interesting to note that the position of T1 was not a significant factor, and thus, the position of T1 within the RSVP did not affect whether or not the AB occurred. Our study differed from Crewther et al., (2007), who conducted a study in which T1 always appeared in a fixed position within the RSVP sequence. In our study, T1 could appear in either the second, fourth, or sixth position within the sequence, but this manipulation did not affect the AB.

Summary

When taken together, the significant interactions we found indicated two important concepts regarding our participant's performance: (1) the variable of same/different had an effect on the AB and (2) T1 and T2 were processed differently which contradicts previous findings of global precedence. This contradiction could be due to a participant specifically looking for the local aspect of a target letter as a sort of search tactic. Participants may have also become fatigued during the experiment which may have affected their accuracy in correctly detecting T2. Future studies should expand on the theory of global precedence and whether individuals tend to process targets in a more local or global manner, and whether they process change with the AB-RSVP paradigm. Future studies should also include the variable of same/different and gain further insight into how this variable affects the AB.

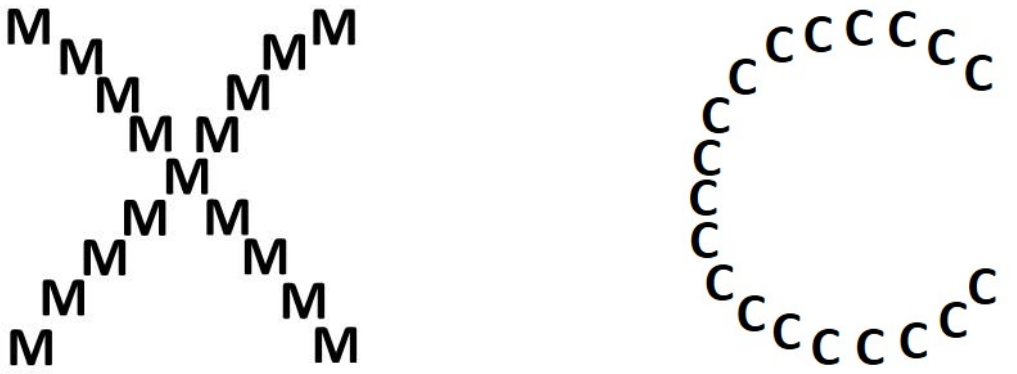

Figure 1. Sample Navon Stimuli used in the study. Left: Different Global and Local stimuli. Right: Same Global and Local stimuli.

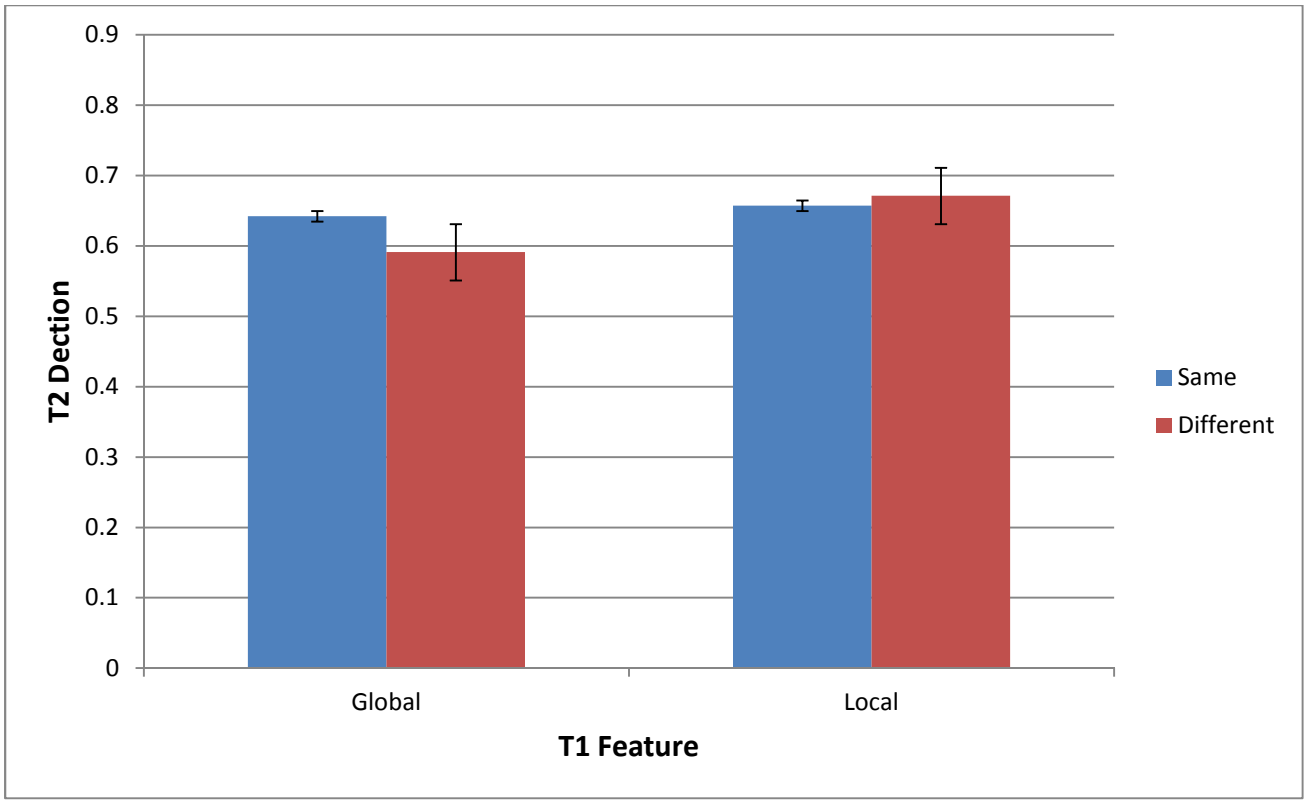

Figure 2. T2 Detection as a function of T1 G/L and Same/Different. Average SEM = .095 (range: .027-.29)

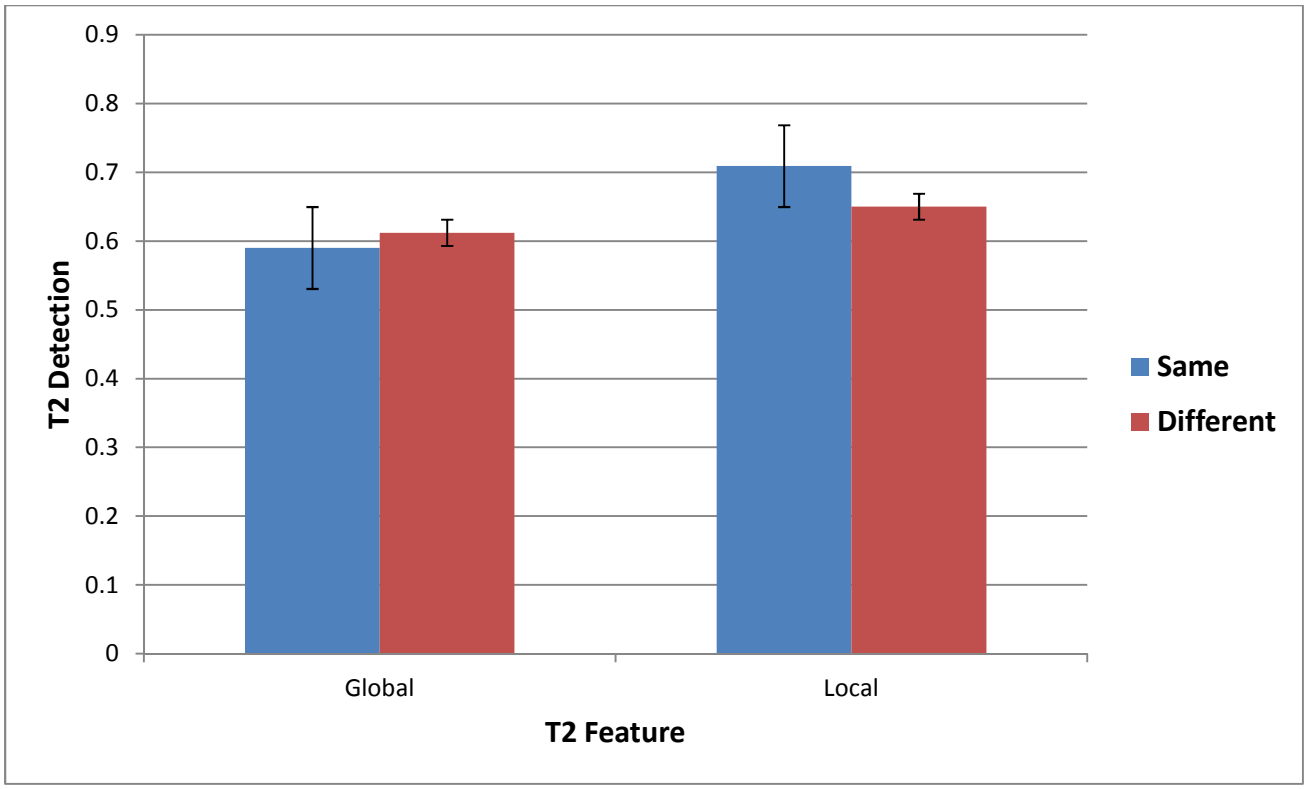

Figure 3. T2 Detection as a Function of T2 G/L and Same/Different. Average SEM = .029 (range: .021-.035)

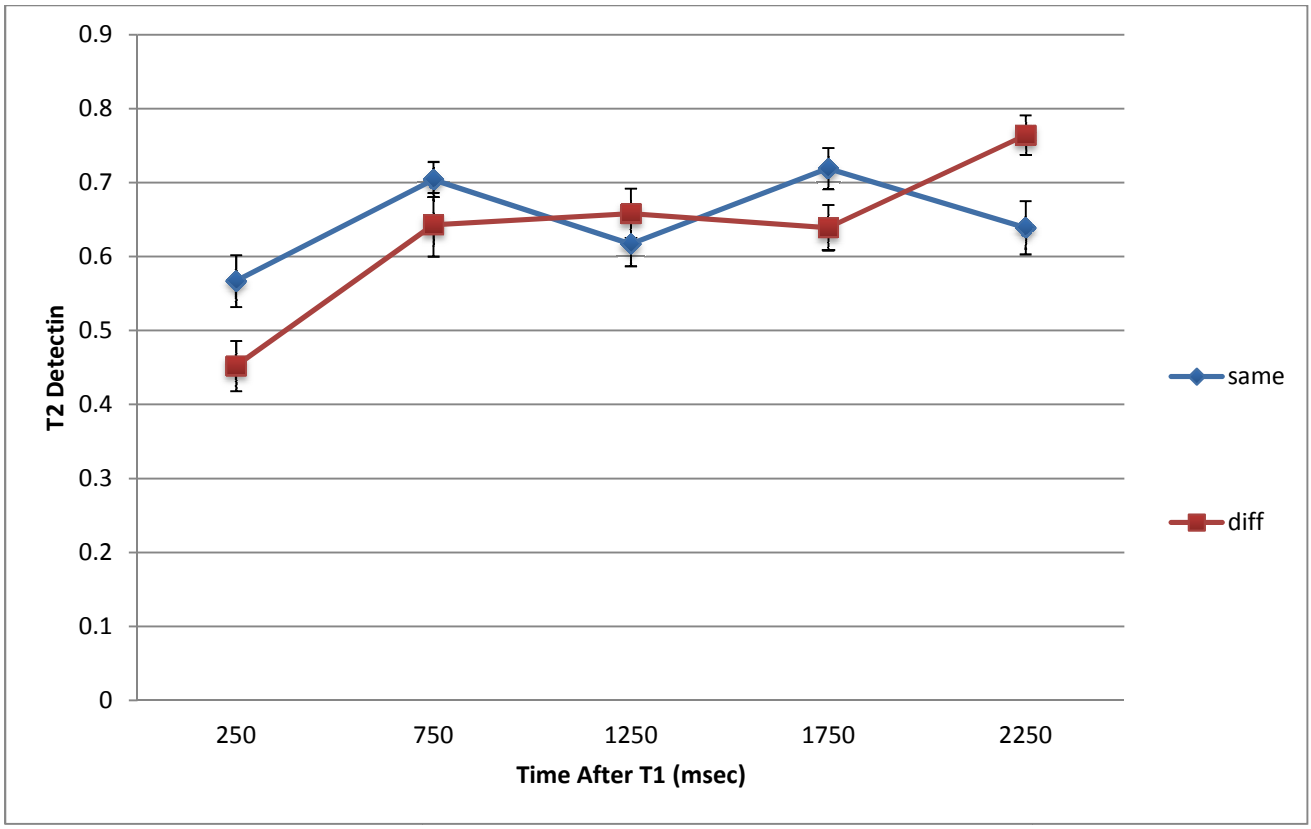

Figure 4. T2 Detection as a function of T2 Position and Same/Different. Average SEM = .032 (range: .024-.043)

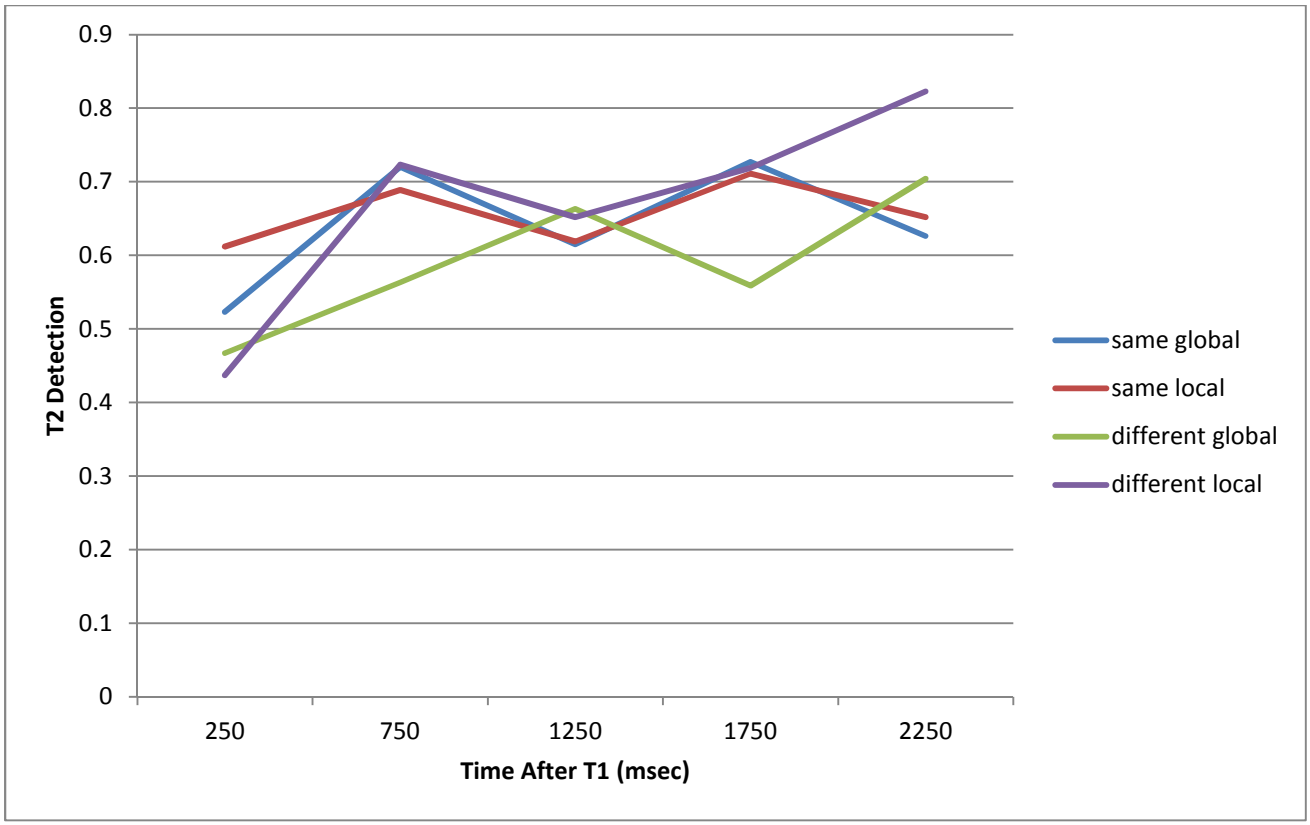

Figure 5. T2 Detection as a function of T2 position, T1 G/L, and Same/Different. Average SEM = .04 (range: .031-.052)

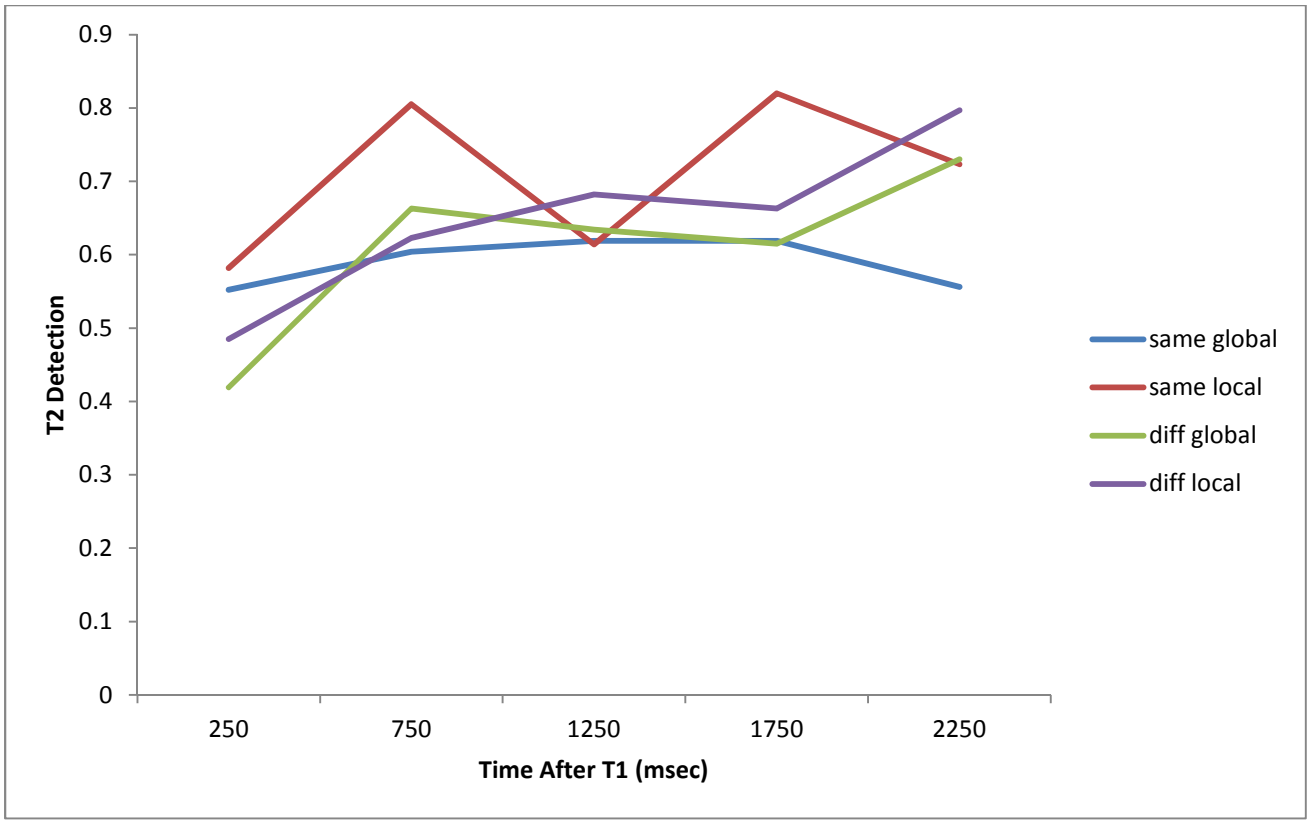

Figure 6. T2 Detection as a Function of T2 position, T2 G/L, and Same/Different. Average SEM = .04 (range: .021-.053)

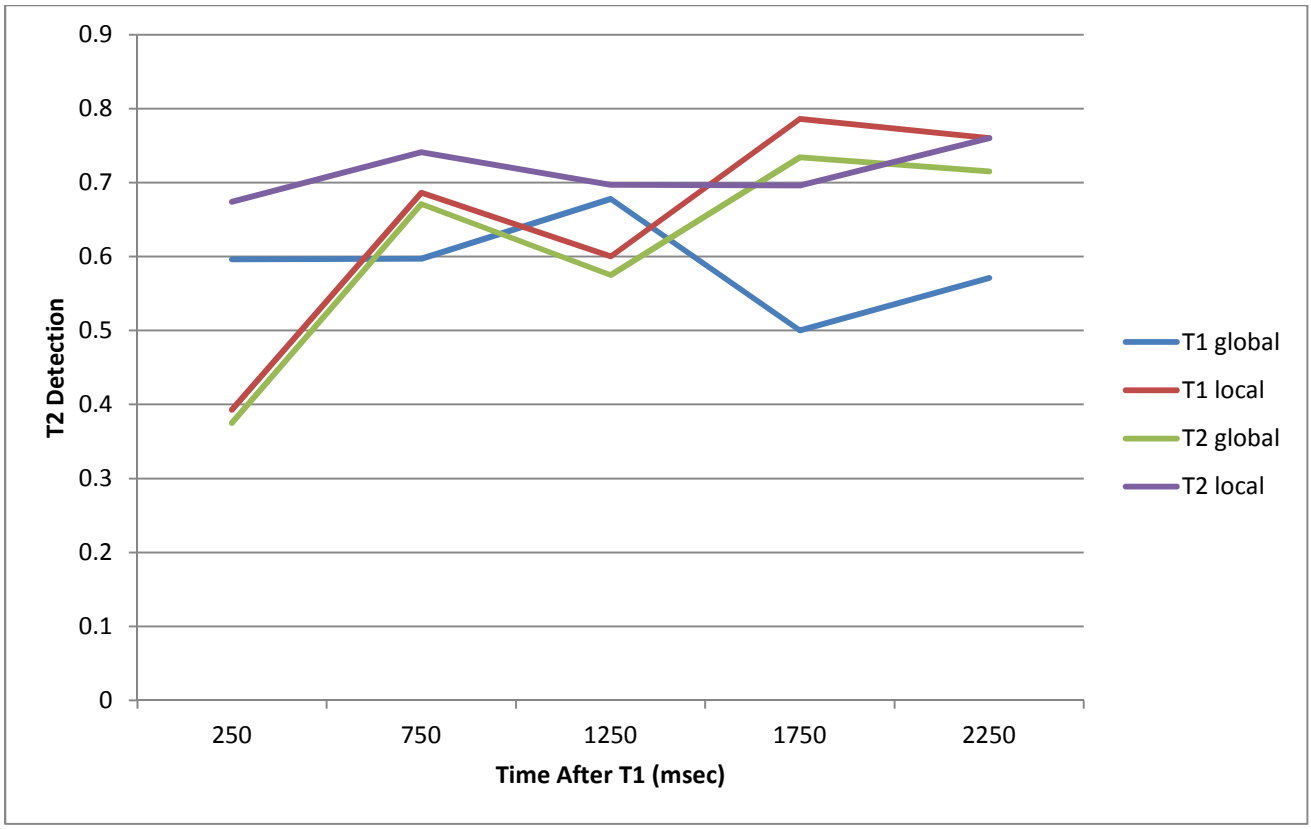

Figure 7. T2 Detection as a Function of T1 G/L, T2 G/L, and T2 Position. Average SEM = .04 (range: .027-.057)

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