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Accuracy of Target Detection in Two RSVP Tasks

A Capstone Project Submitted in Partial Fulfillment of the
Requirements of the Renée Crown University Honors Program at
Syracuse University

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and Renée Crown University Honors
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Honors Capstone Project in Psychology

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Abstract

Rapid Serial Visual Presentation (RSVP) is an experimental method in which participants are asked to detect a target within a sequence of stimuli, such as letters or numbers, in order to test the abilities of our visual systems. In previous RSVP studies, participants were above chance at recognizing a target at a very rapid rate of 13ms per item, even when given the target after presentation of the scene (Potter, Wyble, Hagmann, and McCourt, 2014). Researchers have also found that participants are more accurate in a single feature search condition than in a two-feature, or conjunction, condition in the spatial domain. In this study we aim to answer the following questions: a) at what speed is the visual system able to recognize and detect simple stimulus features? b) how does accuracy change with increased speed of presentation performance in typically developing adults? and c) does performance differ as a function of the difficulty of the search task?. To this end, we tasked participants to complete two different RSVP conditions. In the feature search condition, participants were tasked with detecting a violet letter target in a sequence of black letters. While in the conjunction search condition, we asked participants to detect a black letter in a sequence of violet letters and black numbers, a task that is much more difficult as it requires parallel processing and the ability to combine multiple features. Our results are consistent with past findings, extend these to the temporal domain, and examine the effects speed and difficulty of task have on accuracy.

Executive Summary

Rapid Serial Visual Presentation (RSVP) is an experimental method used in psychology experiments. In an RSVP experiment, a series of items, such as letters or numbers, are shown in succession on the middle of a computer screen. Participants in these experiments are tasked with detecting a target, such as finding a specific letter within a stream of numbers or finding a colored number in a stream of numbers. Visual search tasks typically examine the use of one feature versus the combination of two or more features. For example, in a single feature visual search task with one feature, a participant might be asked to detect a red circle in a stream of red squares. Here, the only feature that separates a target from its distractors is shape. In a visual search task containing multiple features, a participant could be tasked with detecting a red circle in a stream of red squares and blue circles. In this task, a participant must process both shape and color. Performance in tasks containing two or more features is typically worse than performance in tasks with one feature because a participant has to correctly combine the features of shape and color. There have been many different experiments conducted using these methods. In these studies, all of the stimuli are presented on the screen at the same time, thus allowing for the measurement of spatial visual search.

Through the use of RSVP experiments, many psychology researchers have learned important information about the abilities of visual systems, not in space, but over time. In 2014, an experiment conducted by Potter, Wyble, Shea, LeBlanc, Kates, and Russo presented a sequence of visual scenes, such as a beach or a forest scene, at five different rates per scene. One of Potter's groups of participants was told the target *before* being shown the sequence of visual

scenes and the other group was told the target *after* viewing the sequence. Both of these groups had above chance accuracy at detecting the given target even at the quickest rate of presentation, 13 milliseconds per scene, or about 4.6 stimuli per second. The research done by Potter shows us that our visual systems and minds are able to collect information, interpret meaning, and retain features of an image in as little as 13 milliseconds. However, the stimuli presented to these participants involved complex, detailed scenes, which may allow for better chance at detection because the intricate details result in significant variation between scenes. In a 2016 study by Hagmann, letters and numbers were used to decrease the complexity of stimuli. In this study, three different groups of participants, typically developing children, typically developing adults, and children with Autism Spectrum Disorder (ASD) were given two types of RSVP tasks, color and category. Participants in the *color task* were asked to find a purple letter within a sequence of black letters and in the *category task* the target was a black letter within a sequence of black numbers. The results of Hagmann's experiment showed that the children with ASD had the same accuracy as the typically developing adult participants and that these children were more accurate in each task than the typically developing children. Furthermore, performance in children with ASD plateaued as speed of presentation increased, while performance in typically developing adults and children decreased linearly with increasing speed. Thus, we wonder once a certain speed is met, accuracy in typically developing adults and children will also reach a plateau.

As a result of our research, the goals of our study were to replicate and extend these findings. Our purposes were to find out the quickest speed of presentation that our mind can process simple features, to investigate how accuracy changes as speed of presentation increases, and to analyze if changes in accuracy would differ as a function of the difficulty of the search task. We recruited a group of 20 typically developing adults who were participating for credit in research studies for their introductory psychology course at Syracuse University. These participants were given two different tasks: a *feature search task,* where participants were tasked with recognizing a black letter target within a sequence of black numbers and a *conjunction search task*, where participants were tasked with detecting a black letter within a sequence of violet letters and black numbers. At the end of each trial, five random letters, with one being the target letter, were presented to the participant in the middle of the screen and participants responded by pressing on the keyboard which of the five letters corresponded with the target they saw. Five different speeds of presentation were shown during each task: 13, 26, 39, 65, and 91ms and there were 42 trials for each speed.

To examine the results of our study, we calculated the mean and standard deviation of accuracy of each speed during each task and the mean and standard deviation of accuracy overall for each task. The accuracy of feature search task was higher than the conjunction task at every speed of presentation. To further examine these results, we conducted a repeated measures ANOVA to determine if there were differences between the tasks and across each speed. Analysis of variance (ANOVA) is a statistical method that uses a collection of different procedures and tests to examine the differences between two or more means. More specifically, a repeated measures ANOVA is used when the same subjects are used across multiple measurements. We used the same group of participants in each task, therefore, a repeated measures ANOVA was used to compare the means. Between tasks, we found there was a statistically significant difference between all speeds (26, 39, 65, 91ms) except at 13ms. Statistically significant is the probability that a relationship between variables is a result of something other than chance. In the case of our study, a statistically significant difference means that there is a relationship between tasks at each speed except for at 13ms; because the means of accuracy in the feature search task were higher than the means of accuracy in the conjunction search task, the conjunction search task was significantly more difficult than the feature search task at 26, 39, 65, and 91ms per item. In the feature search task, statistically significant differences in accuracy were noted between each rate of presentation and all other rates, e.g. there was a significant difference between 13ms and all other rates, 26ms and all other rates, etc.. In the conjunction search task, there were statistically significant differences noted between each rate of presentation and all other rates. Therefore, as the rate of presentation increases, 91ms to 13 ms, the performance of participants decreases.

The main results from our study show that the rate of presentation in an Rapid Serial Visual Presentation task affects the performance of participants. In particular, the faster stimuli is presented, the lower accuracy of target detection. We also found that the rate of change in accuracy produces different results dependent upon task. Even though participants were above chance at each speed of presentation during both tasks, the conjunction search task was significantly more difficult than the feature search task. Our results are also consistent with previous research on RSVP feature and conjunction search tasks, but extend these theories to the temporal domain; confirming that a conjunction search task requires more attention and processing than a feature search task. As a result of an increase in attentional demands, people become less accurate in detecting a target with conjunctions.

Research within RSVP tasks can provide us with more knowledge and help us understand the abilities of visual systems in the context of the real world as they unfold over time. There are many activities in which people are required to find an object in a field of distractors containing one or multiple features. For example, in an activity like driving, a person must be able to detect differences in signs and lights. If traffic signs and lights are limited to using one feature, people will become more accurate and efficient in detecting important changes. Using information gathered from research on feature and conjunction searches, we can make identifying targets in the real world easier and with efficiency.

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Introduction

The visual system is able to process information incredibly rapidly and with high levels of accuracy in order to help us make sense of our constantly changing, visual world. Rapid Serial Visual Presentation (RSVP) is an experimental method with which researchers are able to test the limits of our temporal visual systems ability to accurately detect and represent information over the course of time. On these types of tasks, a series of items, such as letters, numbers or natural scenes, are shown sequentially in the middle of a computer screen, and participants are asked to pick out a single target (e.g. a specific letter, or a colored number) from within the series. Using RSVP, researchers have found that participants are able to select a correct target in a stream, when it is presented as quickly as 13 milliseconds (Potter, Wyble, Hagmann, and McCourt, 2014).

In one RSVP task (Potter, Wyble, Hagmann, and McCourt, 2014), researchers asked two groups of participants to detect a target from within a series of six visual scenes presented for 13, 27, 53, and 80 ms per scene. One of the groups was told the target *before* viewing the series of pictures (e.g. look for a beach scene) and the other group was given the target *after* being presented the pictures. The participants then went through the same procedure again but were presented twelve visual scenes instead of six. Potter, Wyble, Hagmann, and McCourt (2014) found that while participants who received the target before they viewed the series of six scenes were the most accurate of the two groups at 80 ms, the performance of the group given the target after they had been presented the scenes had above chance accuracy even at the quickest speed at 13 ms per scene. This tells us that our mind is capable of acquiring the meaning of an image in as quick as 13 ms and that the features of a scene can be retained, allowing us to connect a name to its scene even when given a target after briefly viewing a sequence. However, visual scenes are intricate and present many details that allow participants to readily detect the given target which may contribute to accuracy. Thus, we wonder whether it is the complexity of a scene that allows people to be above chance in an RSVP task at this speed, or if the visual system can also complete this task in the absence of numerous, complex features.

A different study aimed to answer this question by asking participants to detect a target in two different RSVP tasks (Hagmann, Wyble, Shea, LeBlanc, Kates, Russo, 2016). This experiment used three different groups of participants, typically developing children, typically developing adults, and children with Autism Spectrum Disorder (ASD). In the Color Task, participants were asked to detect a purple letter target within a stream of black letters. In the Category task, participants were asked to detect a black letter within a stream of black numbers. Each of the tasks were presented to the participants at different rates including 50, 83.3, and 116.7 ms per item. The authors found that children with an ASD were more accurate at detecting the target than typically developing children and had the same accuracy as adults. When selecting the target within the color task, the performance of children with an ASD plateaued as the speeds increased. However, the performance of the typically developing children and typically developing adults decreased linearly as the speeds of presentation increased. Thus, we question whether accuracy will continue to decrease linearly as the speed of presentation increases in each task or if, when a certain speed is obtained, accuracy will plateau.

In the present study, we used visual search tasks to investigate our questions and hypotheses. Visual search tasks can involve one or more features. In a search task with one feature, the target varies from the set of distractors by one feature category, such as finding a violet letter within a stream of black letters (Zhuang, 2011). Color is the only difference in stimuli in this example. In feature search tasks, it has been found that accuracy of target detection remains unchanged as the number of distractors increases but in these studies all of the information is presented to a participant at one time on the screen. A search task containing multiple feature categories is called a conjunction search task (Zhuang, 2011). Distractors in these tasks differ from the target on multiple dimensions, such as detecting a black letter in a stream of violet letters and black numbers. In this case, in order to correctly detect the target, one must combine the features of letter and color. It has been found that accuracy of target detection decreases as the number of distractors is increased again, in the spatial domain. Thus, it is more difficult to detect a target in a conjunctive search task than in a single feature search task in the spatial domain.

Many researchers have studied these types of tasks to find why detection in a conjunction task is more difficult than detection in a feature task while stimuli is presented at the same time in space. Parallel processing is thought to be used in feature tasks, while serial processing is used in conjunction tasks (Zhuang, 2011). In serial processing, you process each stimulus one at a time, while in parallel processing, your mind is able to process all stimuli at once; therefore, our minds process stimuli in conjunction tasks at a slower rate, which has an effect on accuracy of target detection. In 1995, Lavie tested her own hypothesis based on attentional capacity. Attentional capacity refers to the amount of information that can be both attended to and processed at a specific time (Weber, 1988). Lavie believed that by increasing the features of stimuli, the attentional capacity accessible to a participant to process a distractor would decrease because there would be more information to be attended to in stimuli with multiple features as opposed to one feature. To test her theory, she set up two visual search tasks. In both tasks, the stimuli was presented at the same time in space. During each task, either a compatible, neutral, or incompatible distractor would be present in juxtaposition to the target letter. In the feature demand condition, participants were only asked to give their response when the target letter was in the presence of a blue shape. In the conjunction demand condition, participants were asked to respond when a blue square or red circle was present and to ignore opposite conjunctions. Thus, the conjunction condition should produce less accurate results and a higher demand for attentional capacity because in addition to process an item by its color, they also had to process the conjunction of color and shape. Lavie's results confirmed her hypothesis and showed that reaction time was longer and participants were less accurate in the two-feature condition and that the incompatible distractor inhibited target detection more than a neutral distractor did in the only the feature condition. This is because the distractor was distinct from the target in the single feature condition but not in the conjunction condition. Therefore, based on feature integration process, Lavie theorized the demand for attentional capacity is higher in conjunction search tasks rather than a single feature search task.

The aims of this project were to ask: a) at what speed can the visual system detect simple stimulus features in the temporal domain? b) how does accuracy change with increased speed of presentation performance in typically developing adults? and c) to examine whether accuracy changes would differ as a function of the difficulty of the search task, extending Lavie's work to information presented over time, rather than across spatial locations. To this end, we asked participants to complete a feature search task and a conjunctive search task in an RSVP paradigm at five different speeds of presentation. In the *feature search task*, we asked participants to pick out a letter within a stream of numbers while in the *conjunction search task*, we asked participants to detect a black letter within a sequence of violet letters and black number.

Methods

Participants

A group of 20 typically developing adults were recruited using the Psychology Research Participation Pool at Syracuse University, containing students completing research studies for credit in their introductory psychology course. All experimental procedures were approved by Syracuse University's IRB and all participants provided written consent to participate in this study.

Experimental Tasks

The experimental tasks were presented on a CRT computer screen set to a 72Hz refresh rate. The experiments were programmed using STREAM (Wyble, Wade, & Hess, 2013), a programming toolbox that uses MATLAB and Psychophysics toolbox (Brainard, 1997). In the center of the computer screen, stimuli was angled 1.2° vertically and 1.3° horizontally.

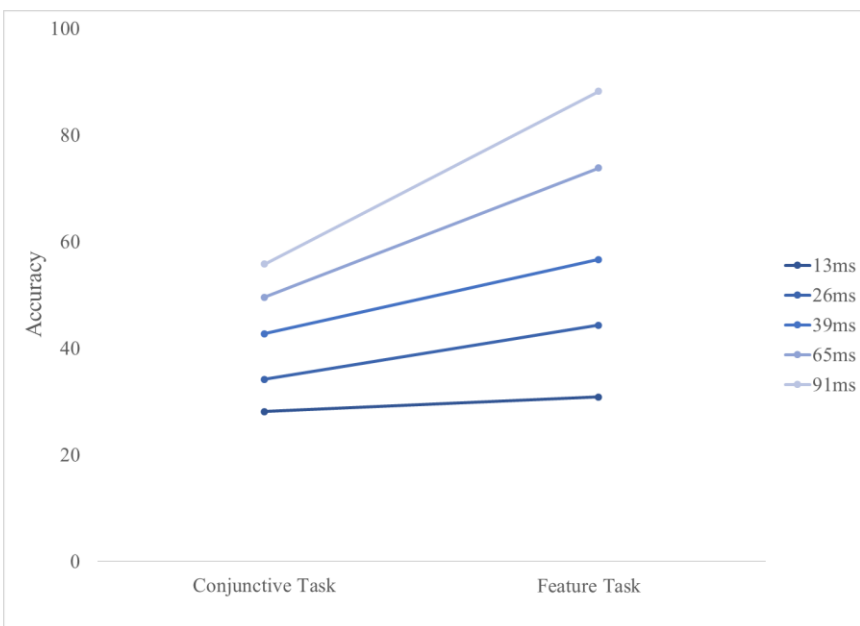
In the *feature search* task, participants were told they would see a stream of black numbers with one black letter among them. Participants were tasked with detecting the letter target while viewing the stream and recognizing the target at the end of the stream. In the *conjunctive search* task, participants were told they would see a stream of violet letters and black numbers with one black letter among them. They were asked to report the black letter. Regardless of the task, after each trial, five letters were randomly presented across the center of the screen with one being the target letter. Participants responded by pressing the key of the letter they saw using the keyboard. The targets and distractors were presented at the center of the screen in 48-point Arial font on a grey background. The letter elements consisted of A, B, C, D, F, H, J, K, L, N, P, R, T, V, X, and Y and the number elements consisted of 2, 3, 4, 5, 6, 7, 8, and

9 and randomly appeared during each trial. The trial began with a fixation cross for 200 ms followed by the stream of distractors and the target. The target randomly appeared in positions 6 through 12 in the 20-item long sequence. The speeds of presentations were 13, 26, 39, 65, and 91ms. Participants were shown the stream and then presented with a response screen that allowed them to select their letter from an array of five letters. Participants were tasked with 42 trials at each speed of presentation during each task.

Procedure

The experiment took place in the Center for Autism Research in Electrophysiology lab (CARE Lab) at Syracuse University. Each participant read and signed an informed consent form before participating in the experiment. Before the experiment, an IQ test was administered. Participants also completed a questionnaire examining traits of autism spectrum disorder called the Autism Quotient (Baron-Cohen, 2001), this aspect of our experiment was for a larger study and will not be examined in these results. Participants sat in a room with the lights turned off while completing the experiment sitting in front of a computer monitor.

Results



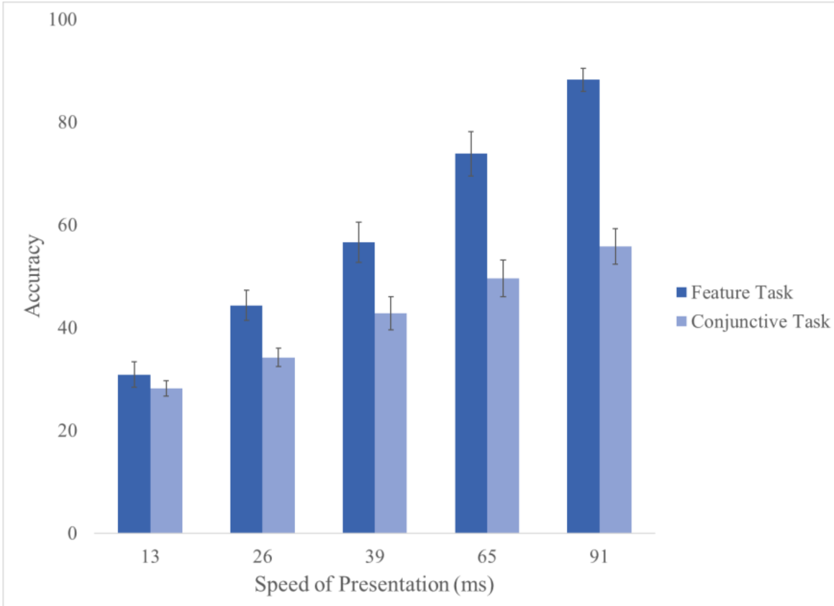


Figure 1. Accuracy of responses in the Conjunction and Feature Search Tasks.

	Feature Search Task		Conjunction Search Task	
Speed	Mean	SD	Mean	SD
13	0.309	0.117	0.281	0.66
26	0.443	0.14	0.342	0.085
39	0.566	0.187	0.428	0.156
65	0.738	0.207	0.496	0.169
91	0.882	0.11	0.558	0.165
Overall	0.588	0.257	0.421	0.167

Table 1. Mean and standard deviation of accuracy in target detection in Conjunction and Feature Search Tasks.

Descriptive statistics: The means and standard deviations of the accuracy of participants' responses at each speed and for each task are presented in Table 1. To test whether there were differences between the tasks and across the different speeds, a repeated measures ANOVA with the within factors of task (conjunctive, feature) and speed (13, 26, 39, 65, 91 ms) was conducted. There was a main effect of task ($F(1, 22) = 85.724$, $p < 0.01$, $\eta^2 = 0.796$) with overall accuracy being higher on the feature search task (M = 0.588, SD = 0.257) than the *conjunction search task* (M = 0.421, 0.167). There was also a main effect of speed, ($F(4,19) = 92.433$, $p < 0.01$, $\eta^2 = 0.951$), indicating that accuracy increased as speed decreased. A significant interaction between speed and accuracy was also noted ($F(4, 19) = 21.304$, $p < 0.01$, $\eta^2 = 0.492$). To examine this interaction, we conducted follow up analyses of simple effects that we corrected for multiple comparisons using Bonferroni corrections.

Between task effects: At 13 ms, there was not a statistically significant difference between the accuracy of responses to the conjunctive and feature tasks, $p = 0.262$. A statistically significant difference between the conjunctive and feature tasks was found at all other speeds 26, 39, 65, 91 ms, $p < 0.01$. Table 1 shows that the overall accuracy for the conjunction search task (M = 0.421, 0.167) was lower than the overall accuracy for the feature search task (M = 0.588, SD = 0.257). This was also true at each speed; accuracy in the conjunction task was lower at each rate of presentation than accuracy in the conjunction search task. Therefore, across all speeds except for 13ms, the conjunction search task was significantly more difficult than the feature search task.

Within task effects: In the feature task, there were statistically significant differences in accuracy between the fastest rate of presentation (13ms) and all other rates ($p < 0.01$), between 26ms and all other rates ($p < 0.01$), between 39ms and all other rates ($p < 0.01$), between 65ms and all other rates ($p < 0.01$), and between 91ms and all other rates ($p < 0.01$). In the conjunctive task, statistically significant differences in accuracy was noted between 13ms and all other rates

($p < 0.01$), between 26ms and all other rates ($p < 0.01$), between 39ms and all other rates ($p < 0.01$), between 65ms and all other rates ($p < 0.01$), and between 91ms and all other rates ($p < 0.01$). These results suggest that as rate of presentation increases, accuracy of target detection decreases.

Discussion

Our main findings from this study show that speed of presentation impacts performance such that faster presentation rates produce lower accuracy, and that the rate of change in accuracy as a function of speed differs based on the task the participant is asked to complete. Participants were above chance on both of the given tasks, but overall, the results show that participants found the conjunction search task more difficult than the feature search task. Of note, at 13ms, there was no difference in accuracy between the feature and conjunction tasks. This could be because at 13ms, it is too difficult to distinguish a target from distractors, even in a single feature search task, and that there is a certain point in time where the difficulty of speed overcomes the difficulty of task.

Similar to Hagmann's study in 2014, our results showed that accuracy decreased linearly as speed increased. We could not determine from our results whether or not there is a certain speed at which accuracy of target detection plateaus in typically developing adults since there was a significant difference between all speeds in the feature task and all speeds in the conjunction task. To investigate the psychophysical curve of accuracy even further and try to determine if there is a point at which accuracy will stop decreasing linearly, the intervals between speeds of presentation could be decreased and a faster speed of presentation could be introduced. These experiments could begin at the interval of 13 ms since there was not a significant difference between tasks at this speed, meaning these tasks had the same accuracy at 13 ms.

Our results are also consistent with Lavie's findings in 1995 and support her hypothesis, based on attentional capacity and feature integration theory, but extend this to the temporal domain. Similar to her study, we tasked participants with a single feature condition, i.e. the *feature search task*, and a two-feature condition, i.e., the *conjunction search task*. In Lavie's task, participants were more accurate in the single feature condition where the target and distractors were separated only by color than in the two-feature condition where the target and the stimuli were separated by both colors and shapes. Similarly, in our study, participants were more accurate in the feature search task where the target and distractors were separated only by their alphanumeric features than they were at the conjunction search task where the stimuli was separated by both their alphanumeric features and color. However, in our study, the stimuli was presented in a sequence, while in the study conducted by Lavie, the stimuli was all presented at once in space. Therefore, our results provide further evidence that execution of a conjunction task requires more attention, which makes the task more difficult and produces less accurate responses and extends Lavie's theory on attentional capacity to the temporal domain.

Studies in target detection and rapid serial visual presentation tasks have many real world applications. In our everyday lives, humans spend a large portion of their time identifying and detecting objects and are required to separate their features. In particular, these types of tasks are important in activities such as driving, searching for keys, baggage screening in airport security, and even in the medical field, where radiologists might be required to recognize multiple targets in an X-ray and/or MRI, for example if a patient has multiple tumors or fractures (Adamo et al. 2013). Target detection plays a crucial role in the execution of these tasks and failure to recognize an object when participating in some of these activities could be dangerous and potentially life-threatening. Using information gathered from our findings and previous studies, we can improve performance in these activities, such as limiting traffic signs or lights to one feature. By limiting stimuli in our world, people could become more accurate and efficient at detecting items and would require less attentional capacity to do so.

References

Adamo, S.H., Cain, M.S., and Mitroff, S.R. (2013). Self-Induced attentional blink: A cause of errors in multiple-target search. *Sage Journals*, 24(12), 2569-2574.

Cohen-Baron, S., Wheelwright, S., Skinner, R., Martin, J., Clubley, E. (2001). The autism-spectrum quotient (AQ): evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians.. Journal of Autism and Developmental Disorders, 31(1), 5-17.

Hagmann, C. E., Wyble, B., Shea, N., LeBlanc, M., Kates, W. R., Russo, N. (2016). Children with Autism Detect Targets at Very Rapid Presentation Rate with Similar Accuracy as Adults. Journal of Autism and Developmental Disorders, 46(5), 1762-1772. doi: 10.1007/s10803-016-2705-9

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. Journal of Experimental Psychology: Human Perception and Performance, 21(3), 451-468. doi: 10.1037/0096-1523.21.3.451

Potter, M. C., Wyble, B., Hagmann, C. E., McCourt, E. S. (2014). Detecting meaning in RSVP at 13 ms per picture. Attention, Perception, & Psychophysics, 76(2), 270-279. doi: 0.3758/s13414-013-0605-z

Weber, A.M. (1988). A new clinical measure of attention: The Attentional Capacity Test. Neuropsychology, 2(2). doi: 10.1037/h0091732

Wyble, B., Wade, G., & Hess, M. (2018, January 31). Stream. Retrieved from osf.io/tdvxm

Zhuang, X., Papathomas, T.V. (2011). Cue relevance effects in conjunctive visual search: Cueing for location, color, and orientation. Journal of Vision, 11(7). doi: 10.1167/11.7.6