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Using Eye-Tracking to Explore Preference for High Value Visual Stimuli

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Abstract

Eye-tracking is becoming more prevalent in studying various phenomena in psychology. The physiological behavior of eye gaze can reveal psychological processes that may not be conscious. The current study explored whether gaze behavior can be linked to political attitudes. Participants looked at pictures of political candidates with an audio clip of one of their speeches playing as an eye-tracker recorded their gaze behavior. Participants were asked to rate the candidates on an attitude scale.

Results showed that only attitudes toward Donald Trump were correlated with gaze duration. In addition, the survey showed that participants gave significantly more extreme answers (either a 1 or a 6) for Trump. This suggests that gaze behavior may correlate only with strong attitudes. This study introduces a possible new way to study attitudes toward visual stimuli.

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Using Eye-Tracking to Explore Preference for High Value Visual Stimuli

by

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Introduction

Eye-Tracking technology is a way of monitoring visual gaze with increasingly growing applications. It may provide unique insight into the participant's attentional capture and the salience of stimuli. The goal of eye-tracking is to measure subtle differences in the participant's gaze behavior (how their eyes react and scan something) to make inferences about their cognitive processes. The dynamic nature of eye-tracking allows for unique applications and real-time results. The technology provides measures of overall visual attention as well as a method to monitor the sequence of gaze.

Purpose and Justification of Eye-Tracking Research in Psychology

Before discussing specific evidence for the different applications of eye-tracking, it is important to justify its use in psychology. Gaze behavior has a uniquely strong relationship with psychological processes. This link is evidenced in neuroscience. The Locus Coeruleus (LC), which is involved in a wide array of neural networks, innervates nerve fibers to the eye muscles. Activation results in excitation of various neural networks in areas such as the cerebral cortex and thalamus. LC activation also results in the release of norepinephrine, which is closely tied to the sympathetic and parasympathetic nervous systems. These parts of the autonomic nervous system are tied to levels of arousal. One of the roles of these systems is the regulation of pupil diameter. When an individual is under threat, their pupils dilate, and they constrict when in a relaxed state. This mechanism has been used to study participants' reactions to a stimulus (Samuels & Szabadi, 2008). Pupillometry, in addition to other gaze measures like gaze duration, provides an additional method of linking psychological phenomena to physiological activity (Herlenius & Lagercrantz, 2001).

Research in eye-tracking involves drawing inferences about broad psychological phenomena simply from how an individual looks at a stimulus. However, there are a lot of implications about how somebody perceives, feels, and understands something based on their visual behavior. Visual gaze has been used as a measure of preference in infants and other nonverbal individuals since infancy became a subject of psychological research (Fantz, 1964). Subtle differences in a stimulus can alter perception which, in turn, can influence behavior. Eye tracking technology makes it possible to explore the length of time an individual looks at a stimulus while also indicating which parts of a stimulus attract the most attention and the sequence of gaze fixations. Eye tracking technology can also be used to measure changes in pupil dilation in response to different stimulus arrays. To translate these gaze variables into psychological concepts, pupil dilation and eye blink rate are good predictors of stimulation while gaze duration demonstrates an individual's level of interest to a stimulus and specific features (Eckstein, Guerra-Carrillo, Miller, Singley, Bunge, 2016).

A question that must be addressed is how data from eye-tracking should be interpreted to justify studying high level cognitive functions such as attitudes. Jacob & Karn (2003) discusses methods of interpreting data based on an individual study's design. The most frequently used approach in psychological research is the top-down perspective. This means that researchers studying broad psychological phenomenon will observe what effects they have on low level actions, such as saccadic movements. For example, if an individual lingers on a certain feature for a longer time than others, something may be inferred about their cognitive state. How data is interpreted should be based on what an individual study is looking for and the characteristics of the cohorts it's studying. An individual lingering on a certain fixation for a longer time than others could indicate interest in a target, or that they are having a more difficult time processing it than others. How individuals attend to what they're seeing can mean different things, thus it's important to design an experiment to isolate what is being researched and to interpret the findings correctly.

An example of gaze data being interpreted into a psychological is found in Matthews, Mitrovic, Lin, Holland, & Churcher (2012). The researchers performed an experiment testing the efficiency of different computer programs called Intelligent Tutoring Systems (ITS). These are learning tools designed to more efficiently teach students a specific subject matter. The goal was to observe if an optimized learning model could be extracted from gaze data. The participants in this experiment experienced four different ITSs and then answered questions based on what they learned. The researchers defined efficiency as a function of correct answers divided by gaze duration times number of gaze fixations (correct / (duration * fixations)). This formula tells the researcher which ITS results in highest knowledge retention rate in the least amount of time. The approach used in this experiment enabled the researchers to successfully identify one ITS as the most efficient by utilizing gaze data.

The next part of the Matthews et.al. (2012) experiment involved having the participants rank the different systems from favorite to least favorite. The researchers found that the most efficient ITS was also the favorite of the participants. This is relevant to the current study as the researchers were able to find a link between gaze behavior and participant attitudes. This application of eye-tracking can assist in building learning tools and programs with optimized retention and user friendliness. In addition, it supports our hypothesis of a link between gaze behavior and attitudes.

Eye-Tracking Research in Predicting Mood State and Mood Disorders

Eye blink rate (EBR) has also been used to infer an individual's mental state during eye-tracking studies. den Daas, Hafner, and de Wit (2013) researched the EBR of individuals when they were shown clothed vs erotic photographs of both genders. The participants with low EBR were defined as being in a reflective state and high EBR was defined as an impulsive state. The researchers found a significant interaction between EBR and type of photograph. Impulsive participants dwelled much longer on the erotic photographs and reflective participants distributed their attention evenly between erotic and non-erotic photographs. This study demonstrates that eye-tracking is functional as a predictor of short term mood state.

One of the potential applications of eye-tracking is to better understand mood disorders. Studying gaze behavior can provides a window into how those with mood disorders perceive the world. Individual's with mood disorders are likely to fixate on mood congruent stimuli or features more so than those with no mood disorders. This suggests that mood congruency may have a role in processing emotional stimuli in this population (Kellough, Beevers, Ellis, & Wells, 2008). With better understanding of how gaze behavior can influence mood, therapists will be better able to diagnose and treat individuals affected by mood disorders.

An interesting application of eye-tracking has been demonstrated by Kellough et.al. (2008) in which the gaze behavior of clinically depressed individuals was studied using eye-tracking technology. Participants were shown a picture of a person showing either a positive mood, dysphoric expression, threatening expression, or a neutral expression. The pictures were rated by an a-priori sample to reflect these categories prior to the experiment. The results showed that clinically depressed participants spent significantly more time attending to the dysphoric images than did the control group. This application of eye-tracking indicates success in predicting mental states. The results of this study indicate that individual's gaze behavior and attention may be influenced by mood congruency. They are going to pay more attention to stimuli that accurately reflect their current emotional state.

The findings of Kellough et.al. are reinforced by another study where eye-tracking was used as a means of studying disengagement of attention to emotional stimuli (Sanchez, Romero, & De Raedt, 2017). This experiment studied the attentional disengagement abilities of those with Major Depressive Disorder (MDD) and neurotypical controls. The experiment's trials showed photographs of 2 faces (neutral and emotional), with a frame around the neutral face. Participants were instructed to attend to the face with the frame. The time it took to disengage from faces that were displaying an emotion (happy, sad, angry) was analyzed. They found that participants with MDD took significantly longer to disengage from the emotional face when it was displaying sadness. The authors state this phenomenon may contribute to the sustained negative attitudes associated with MDD. These findings further support the theory that those with MDD seek out and attend to mood congruent stimuli and environments.

In addition to depression, eye-tracking has demonstrated value in identifying social anxiety. Liang, Tsai & Hsu (2017) compared the gaze behaviors of those who scored high on a measure of social anxiety and those who scored below the mean. The participants looked at a series of pictures displaying various emotions. They found that those with social anxiety gazed at faces showing anger for a significantly longer duration than other emotions. The control group showed no main effects of gaze duration for any of the stimuli and devoted the same amount of attention to them all. Based on this research, it is evident that those with mood disorders attend more to mood congruent stimuli. However, mood disorders differ fundamentally from each other and will show differences in gaze behavior beyond the observed emotions.

Schofield, Johnson, Inhoff, & Coles (2012) explores differences in how individuals with different mood disorders attend to emotional stimuli. They used eye-tracking to study gaze behavior with an innovative experimental method. The researchers showed participants paired photographs displaying an emotional expression and a neutral one for 1500 milliseconds while recording with an eye-tracker. To analyze participant's gaze behavior at various time points, they split each trial into three 500 millisecond epochs and analyzed them separately.

The results showed that dwell time in those scoring high on an anxiety inventory was significantly longer for angry faces across all 3 epochs. While this group also showed significant relationships with the other emotions, they found that this only occurred during the last 500 millisecond epoch. The researchers also found that those who scored high on the depression inventory dwelled significantly longer on the emotional faces but only during the middle epoch. This suggests that different individuals with mood disorders may show different patterns of gaze than neurotypical populations. In addition, this demonstrates that not all mood disorders are the same in how they attend to emotional stimuli. This experiment showed that an individual's gaze behavior may show whether a mood disorder is present and what type. Further research using eye-tracking technology with different clinical groups may reveal new insights about gaze behavior directed at different emotions.

Eye-Tracking Research Studying Traumatic Brain Injury

Due to the neurological etymology of eye movements, those who suffer a traumatic brain injury (TBI) are very likely to exhibit altered gaze behavior which can then affect tasks that depend on visual behavior. In careers, such as construction, which has a high rate of TBI, functional visual attention is vital to performing to the necessary duties. Eye tracking technology presents a method to explore effects of TBI on specific features and dimensions of gaze behavior. Research using eye tracking technology has the potential to enhance development of treatments in cases of TBI induced visual attention deficits.

Samadani et.al. (2015) explored the usefulness of eye-tracking for examining oculomotor disruptions in patients with a traumatic brain injury (TBI). The researchers had TBI patients and a healthy control group watch a music video with clear directional movement as their gaze was recorded. They found that patients who tested positive for a TBI had significantly more oculomotor disruptions and disconjugate eye movements than healthy controls. In other words, both eyes were not tracking the same target. Similar results were found in Cifu et.al. (2015) where those who suffered a TBI made significantly larger positional errors, showed lower gaze velocity, and had smaller saccadic amplitudes than healthy controls. Such problems contribute to significant interference in tasks that require precise eye movements.

Disrupted visual attention among individuals who have experienced TBI can be evaluated with eye tracking technology and these evaluations can be used in conjunction with traditional imaging techniques such as CT and MRI to fully understand an individual patient's situation. More accurate diagnoses and better treatment protocols could be the result of more complete testing. Further research may help us learn which neurological networks result in altered gaze behavior and attentional dysfunctions in stroke and TBI patients. Eye-tracking is a relatively cost-effective method to study attentional problems caused by neurological damage and offers a preliminary testing strategy to help clinicians identify how to treat the patient.

Eye-Tracking Research Studying Reading and Neurological Disorders

One of the most widely used applications of eye-tracking is in the study of reading. By studying gaze behavior, inferences can be made about a piece of text and how readers are processing it. Some processes that can be studied with eye tracking are cognitive demand, processing time of a piece of text, and how often a reader returns to previous texts (Raney, Campbell, & Bovee, 2014). Reading is a crucial part of daily life and many clinical populations struggle with it. Studying the nature of these deficits is an important step in rehabilitation for these individuals. Eye-tracking technology is a useful tool to study those who have difficulty with reading. It has shown promise in testing for dyslexia and other disorders with reading difficulties. Eye-tracking has revealed differences in gaze behavior of dyslexic individuals such as longer dwell time on text and smaller more frequent rightward saccades are shown when presented with orthographic stimuli (De Luca, Di Pace, Judica, Spinelli, & Zoccolotti 1999). Eye-tracking has also revealed higher-order categorization deficits in dyslexic children as seen in Desroches, Joanisse & Robertson, 2005.

Desroches et.al., 2005 conducted an experiment with dyslexic children and neurotypical controls engaged in an item categorization task utilizing an eye-tracker. There were four conditions in the study that showed various pictures of four different items where there is a target (e.g. candle). Condition 1 had three unrelated distractors (e.g. flower). Condition 2 had two unrelated distractors and a distractor that rhymed (e.g. sandal). Condition 3 had two unrelated distractors and an orthographically similar distractor (e.g. candy). Condition 4 had an orthographically similar distractor, rhyming distractor, and an unrelated distractor. The participants were instructed to look at the target item when asked. The researchers measured the rate of fixations to the correct target.

The control group showed significant differences in fixation rate between condition 1 and all other conditions, showing the participants were sensitive to both rhyme and orthographic interference effects. The dyslexic group showed significant differences between condition 1 and conditions 3 and 4 but no significant difference between condition 1 and 2. The dyslexic children were fixating the correct target on condition 2 at a similar rate as condition 1. The researchers suggest that this is because they may lack higher order rhyming representations present in neurotypical children. This study demonstrates that dyslexia affects more than just reading and may represent a lack of certain phonological categorizations in this population. The increasing availability of eye-tracking technology shows promise as a new tool for aiding diagnosis and further understanding dyslexic individuals.

Like mood disorders, neurological disorders can impact how affected individuals attend to the world. Two examples are Rett Syndrome and Autism Spectrum Disorder (ASD). In addition to being able to observe how these populations attend to stimuli, eye-tracking is a great tool to study these populations as many of these individuals are non-verbal. By interpreting what individuals are looking at something and how long they look at it, information about their thought processes can be determined.

Rett Syndrome is a rare neurological disorder that affects females, impacting a multitude of developmental areas such as cognitive functioning. Baptista, Mercadante, Macedo, & Schwartzman (2006) studied girls with Rett Syndrome. They designed an experiment with 3 different tasks in 3 blocks. In the first two pictures were presented on a computer screen, the task was to direct gaze to a one of the pictures ("Look at the dog"). The second task displayed 2 pictures at the bottom of the screen and a pattern at the top. The task was to direct gaze to a target that was the same as a target that matched the pictures on the bottom. The third displayed a picture and then showed two more pictures on the next display. The task was to direct gaze to the target that was in the same semantic category as the item displayed at the bottom of the screen (e.g. gazing at a baseball, when a basketball was shown).

These tasks demand the ability to categorize and distinguish target stimuli but allow the participant to do so without speech. They found the participants showed significantly longer gaze durations at the correct target in all three blocks of the experiment. This suggests that females with Rett Syndrome are capable of intentional gaze and categorization. This study utilized eye-tracking to study comprehension abilities in non-verbal individuals, further justifying these methods in studying non-verbal populations.

Individuals with ASD have consistently shown different gaze behavior compared with their neurotypical counterparts. One of the earliest studies on the topic by Pelphrey et.al. (2002) utilized corneal reflection, a precursor technique to dedicated eye-trackers, to study this population. It showed that participants with ASD spent significantly less time gazing at core features of faces than neurotypical controls. The largest group difference was the amount of gaze duration directed to the eyes with the ASD group having much lower gaze duration for this facial feature. The ASD group spent less time gazing at any of the core facial features (eyes, nose, mouth) and more time in non-features of the face. This phenomenon is congruent with the social deficits associated with ASD.

In addition to showing different facial attention from typically developing age-matched cohorts, children with ASD also differ significantly from IQ-matched cohorts as shown in Yi et.al. (2012). Utilizing an eye-tracker, their research compared the visual scanning of faces in children with ASD with both age-matched and IQ matched cohorts on a black background computer screen. They found that children with ASD made significantly fewer fixations on the face region of the screen, particularly the eyes. This demonstrates that the effects of ASD on facial attention are separate from explicable age or IQ norms. This study also showed that as children with ASD get older, they attend less to core facial areas.

In addition, eye-tracking has helped map the progression of ASD throughout childhood. Chawarska & Shic (2009) studied the effects of ASD on emotional recognition and the effects of age on this phenomenon. The participants in this study, those with ASD showed less attention to core facial features than their typically developing counterparts. In addition, the 4-year-olds in the ASD group showed less attention to core features from the 2-year-old group. This is interesting as it suggests that this aspect of ASD may manifest in the 2-4-year-old time frame. It also shows that as children with ASD get older, they attend less to facial features.

The study in this paper is intended to observe whether there is a relationship between gaze behavior and attitudes toward visual stimuli. It is hypothesized that individuals may show different gaze behavior for targets for which they have strong attitudes. During the time of this experiment, the 2016 United States presidential election was occurring, this provided a good opportunity to study attitudes. It was hypothesized that if a participant has a negative attitude about one candidate and a positive attitude toward another, they would show different levels of attention or attention to different features of the pictures of the four candidates. If a relationship could be established between gaze behavior and attitudes, it would be reasonable to say we could determine attitudes toward a visual stimulus based on how an individual attends to it.

Methods

Participants

Participants for this experiment consisted of 38 college students (32 female, 6 male) who were enrolled in psychology classes at Montclair State University. Participants fulfilled course requirements in exchange for their participation. They were given course credit for their participation. Of the original 38 students who volunteered, data from 10 were excluded due to technical failures of either the eye-tracker or the experimental software that we used. The final sample included data from 28 participants.

Apparatuses and Materials

The PC for this experiment was a Lenovo Thinkpad laptop with the eye-tracking software. The software used for the experiment was OGAMA, an open source software that was developed to design eye-tracking studies (Voßkühler, Nordmeir, Kuchinke, & Jacobs, 2008). The Eye-Tracker used was an Eye-Tribe, which sampled at 30 Hz, meaning it took 30 different samples of the participant's eye position/coordinates per second. It utilizes infrared light to track the location of a participant's pupils as they scan the computer screen. The eye-tracker was mounted on a tripod directly in front of the participant.

A 10 question Likert scale survey was created to ascertain a participant's attitude toward the candidates. Since it was a novel measure created for this experiment, reliability analysis was performed on the survey data. Four scores were calculated using the data representing each of the four candidates independently. This is because mixing the data of the candidates would compromise the reliability of the survey due to differing opinions on candidates disturbing the inter-item correlations. The reliability analysis used was Cronbach's Alpha. The reliability analysis showed excellent internal consistency for the survey we used across all four candidates (α= .949 Sanders, α= .945 Clinton, α= .903 Cruz, and α= .940 Trump). The survey attitude data were summed for each participant by block and this score was used in later analysis. In addition, a grand mean for each block's gaze data from data from individual trials. The stimuli used included 4 photographs for each of the candidates. The photographs used for all trials by block are provided in Appendices A, B, C, and D.

For the stimuli, we used 4 photographs for each of the four candidates including Donald Trump, Hillary Clinton, Ted Cruz, and Bernie Sanders. The photographs were chosen to be face centric with as little of their body shown as possible and minimal environmental distractions and maximum resolution. They were sourced via Google Images. The sound clips that were paired with the photographs were sourced from speeches the candidates gave during their campaigns. The purpose of the sound clips was to further engage participants and strengthen their emotional responses. The sound clips were neutral, they did not include any specific issues or policies. Each candidate had a dedicated block with their 4 photographs as individual trials.

We included a block of 4 geometric shapes that we intended to use to further confirm calibration, this however proved unnecessary as OGAMA has its own calibration procedure which proved sufficient. Due to this, the data from this block wasn't analyzed any further. We chose 3 gaze variables to analyze. The first was number of fixations (how many times a participant fixated on a certain point), gaze duration (how long on average they spent at a fixation), and rate (Gaze Duration divided by number of Fixations). We averaged number of fixations, gaze duration, and rate of each trial within the 4 blocks, creating a composite score for each block by participant.

Procedure

The participants were tested in a computer lab at Montclair State University. They first were given an informed consent document to read and sign in the entry room of the computer labs. The consent form used is displayed in Appendix E. They were then asked about any neurological disorders they may have (e.g. TBI, ASD, Seizure Disorder). This was to control for any variability in gaze behavior associated with those disorders. This was voluntary, the participants were under no obligation to disclose this information if they felt uncomfortable doing so, this was reinforced by the researcher. None of the participants used in the final analysis reported any neurological disorders. Next, they were brought to a computer lab where the eye-tracker and computer were located.

The participants were first calibrated on the eye-tracker. This is to ensure that the machine is accurately tracking the position of the participant's pupils. The program used, OGAMA, utilized a standard 9-point calibration. In this procedure, the participant was asked to attend to a flashing icon as it moved across 9 different positions on the screen. Once a sufficient calibration was attained (gaze within 1.5 degrees of each target), the experimental procedure began.

The experiment consisted of 5 blocks of 4 trials each. The first block consisted of 4 geometric shapes, each one contained smaller shapes within it. The participant was asked to look at each small shape and move their gaze to the next one as if they were playing connect the dots. Each block after this one displayed pictures of either Bernie Sanders, Hillary Clinton, Ted Cruz, or Donald Trump. The photographs were displayed in a fixed order. Each trial, which was one picture, had a sampled speech clip of the candidate speaking playing in the background. The speech clip did not contain any political views, only neutral statements.

Each trial lasted 15 seconds, thus, the block lasted 1 minute. The blocks were presented in a fixed order. After each block, the researcher entered the room with the participant and asked them a series of general questions about their attitudes toward the candidate displayed. The list of questions is displayed below. The researcher filled the questionnaire out himself as it was important not to break the eye-tracker's calibration. The questionnaire used is displayed in Table 1. After completion of the 4 blocks, the participant was excused and thanked for their time.

Analysis

First, the survey attitude data and eye-tracking data were summarized to be used for statistical analysis. This involved taking individual data from each trial and participant and creating means for each block the participant was shown. We took data for gaze duration, number of fixations, and rate of fixations (number of fixations divided by gaze duration). These variables (particularly gaze duration) had been used in other eye-tracking studies. Descriptive statistics were calculated for these variables

A one-way ANOVA analysis followed by a Tukey HSD post-hoc test was performed to compare the means survey results for the 4 candidates. One-way ANOVA were conducted to compare the mean gaze durations, number of fixations, and rate of fixations of the 4 blocks.

Pearson correlational analysis was conducted on the gaze data including gaze duration, number of fixations, and rate of fixations for all 4 candidates. Correlational analysis was used as it was of interest observe if there is a relationship between participant's attitudes and the different gaze variables.

Results

The order of preference in the attitude survey by candidate was: Sanders (M = 4.17, SD = 1.23), Clinton (M = 3.98, SD = 1.15), Cruz (M = 3.48, SD = .93), Trump (M = 2.77, SD = 1.25). The one-way ANOVA and analysis comparing attitudes toward the 4 candidates revealed significant differences in attitudes ($F(3,25) = 8.29$, $p<.01$). The Tukey post-hoc test indicated significant differences in attitude between Trump and Sanders ($p = <.01$) and between Trump and Clinton ($p = <.01$). The Tukey HSD revealed no significant difference between Sanders and Clinton ($p = .923$), Sanders and Cruz ($p = .117$), or Clinton and Cruz ($p = .373$). The one-way ANOVA analyses comparing gaze data revealed no significant differences between the gaze durations ($F(3,25) = .611$, $p = .609$), number of fixations ($F(3,25) = .230$, $p = .876$), or rate of fixations ($F(3,25) = .190$, $p = .903$) of any of the candidates. Table 2 displays descriptive statistics of the composite scores of the attitude measurement and gaze data across all participants.

There were no statistically significant correlations between the composite attitude score and number of fixations, gaze duration, or gaze rate for Sanders, Clinton or Cruz. There was a significant, relatively high correlation between the attitude measure and gaze duration for Trump ($r = .487$, $p = .01$). Exact correlation coefficients of each attitude scale with the gaze measurements are displayed in Table 3. A heat map of composite gaze durations of sampled trials in each block across participants is provided in Figure 1. This displays areas where participant's gaze dwelled the longest, long gaze durations are represented by hot colors. As expected of a neurotypical population, they tended to gaze longest in the eyes and nose areas.

Discussion

Based on the results, there were significant differences in attitude between Trump and Sanders and Clinton, likely due to opposing political affiliations. However, Cruz showed no significant differences from Sanders and Clinton. Sanders and Clinton showed no significant differences from each other, likely due to their similar political affiliations. This would also explain the lack of significant differences between Cruz and Trump.

There were not any significant differences between the gaze data of the candidates. This was expected and wasn't the focus of the investigation. The correlation analysis revealing the relatively high correlation between Donald Trump's attitude score and gaze duration raised a question. Why does Trump show this relationship with gaze duration but not any of the other candidates? This question warranted further investigation of the data.

When investigating the attitude data, it was noted that Trump had a very high number of 1 and 6 responses to the survey items. It was hypothesized that to observe a change in gaze behavior, an emotional salience threshold might have to be reached. Reaching this threshold would signify that participants would feel strongly about the stimuli they were observing. To analyze the possibility that attitude/emotional salience may be associated with changes in gaze behavior, a supplementary analysis of extreme survey item responses was conducted.

An extreme response was defined as a response of either 1 or 6 on the survey items. Responses of 1 or 6 indicate very strong feelings about candidates in the associated item. The number of responses that were either a 1 or a 6 across all participants were counted and converted to a percentage. To analyze statistical differences, z-tests were run comparing the proportion of 1 and 6 responses for Trump with the data of Sanders, Clinton, and Cruz. Z-tests were chosen as it was determined to be an ideal analysis for measuring count data.

It was revealed that the Trump stimuli had a disproportionately high number of 1 and 6 responses to the survey items. The number of extreme scores in the attitude survey, defined as an answer of 1 or 6 to survey items, for each candidate's pictures were tabulated. Z-tests revealed that the Trump stimuli induced significantly more extreme responses than any of the other candidates. The Trump stimuli yielded the most with 39.28 percent of responses in this category. This was significantly higher than the 30 percent of responses to Sanders in this category ($z= 2.309$, $p= .021$), 21 percent to Clinton ($z= 4.695$. $p < .01$) and 12 percent to Cruz ($z= 7.348$, $p < .01$). This data supports the hypothesis that a threshold of emotional salience that must be surpassed to influence gaze behavior.

Some limitations of this study include that the trials and blocks were presented in a fixed order. The findings would be stronger if they were randomized to control for order effects. In addition, certain variables, such as pupillometry, that are strongly tied to emotion as demonstrated in Eckstein, Guerra-Carrillo, Miller, Singley, & Bunge (2016) and Samuels & Szabadi (2008). This measurement requires an eye-tracker with a sampling rate beyond the capabilities of the Eye-Tribe.

The current study focused on the usefulness of eye-tracking to measure attitudes toward political candidates. Broadly, the study aimed to demonstrate that eye-tracking could be a confirmatory measure for an attitude scale. In addition, the goal was to further explore eye-tracking as a measure that could provide insight into specific cognitive functions such as emotion as seen in Sanchez, Romero & De Raedt, 2017 and attitude as seen in Matthews et.al., 2012. Based on the data from this study, it is possible that strong emotional salience may draw an individual's attention when they wouldn't normally be focusing as deeply.

There was a strong influence of emotional salience in the block or stimuli that included Trump. The responses on the attitude scale's items were much more extreme than those for the other candidates and this was strongly correlated with participant's gaze duration for the trials that include Trump. This suggests that Trump was able to elicit a change in participant's gaze duration. While survey data showed clear differences in participant attitudes toward the different candidates, only the Trump stimuli induced a relationship between attitudes and gaze behavior.

It would be of interest to further explore the hypothesis that a threshold of arousal must be reached to see any differences in gaze behavior. If this is the case, must the direction of the arousal be in a positive or negative emotional direction? If the threshold hypothesis proves to be viable, it can have implications about how similar research is approached. These findings could be useful across various areas of psychology.

Conclusion

This experiment explored the psychological processes associated with eye-tracking in a new way. The most interesting finding from this study is that gaze behavior may be influenced by high emotional salience of stimuli. This study also further justifies eye-tracking as a tool to measure high order psychological processes like attitudes and emotions. There are multiple fields in psychology which could benefit from future research studying subjective experiences of stimuli and the physiological effects they cause. This study warrants discussion about how gaze behavior is connected to strength of attitudes and emotions.

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Table 1

Survey of Attitudes Toward Presidential Candidates.

Item ID	Item Contents
1	The candidate is an effective public Speaker.
2	The candidate is knowledgeable about key issues in the United States.
3	The candidate reflects my personal views.
4	The United States would be safe with the candidate as our president.
5	The candidate addresses the competition effectively.
6	The candidate would bolster diplomatic relations.
7	The candidate is economically knowledgeable.
8	The candidate is sensitive to the needs of your demographic.
9	The candidate is a good role model to younger generations.
10	The candidate will make the changes they endorse.

Table 2

Descriptive Statistics for Attitude Scores and Gaze Data

Candidate	Attitude Score	Attitude SD	Count	Count SD	Duration	Duration SD	Rate	Rate SD
Bernie Sanders	4.17	1.23	5.91	3.31	710.32	504.47	.39	.22
Hillary Clinton	3.98	1.15	5.24	3.60	717.42	493.92	.35	.24
Ted Cruz	3.48	.93	5.92	3.69	597.10	322.09	.39	.25
Donald Trump	2.77	1.25	5.52	3.82	614.72	337.33	.37	.25

n= 28. Attitude Score= Mean Score from Attitude Survey, SD= Standard Deviation, Count= Number of Fixations, Duration= Gaze Duration,

Rate= Fixations per Second

Table 3.

Correlation of Candidate's Attitude Scores with Their Gaze Data

Attitudes	Count	Duration	Rate
Bernie Sanders	-.126	.223	-.133
Hillary Clinton	-.151	-.015	-.155
Ted Cruz	.061	-.014	.060
Donald Trump	273	*.487	.271

n= 28. Note, BS= Bernie Sanders, HC= Hillary Clinton, TC= Ted Cruz, DT= Donald Trump, Count= Number of Fixations, Duration= Gaze Duration, Rate= Fixations per Second, *=Significant.

Figure 1. Heat Maps Displaying Areas of High Gaze Duration with Hot Colors.

Heat maps displaying areas with longest gaze duration from sampled trials in hot colors. This is a compiled version with data from all participants.

Appendix A

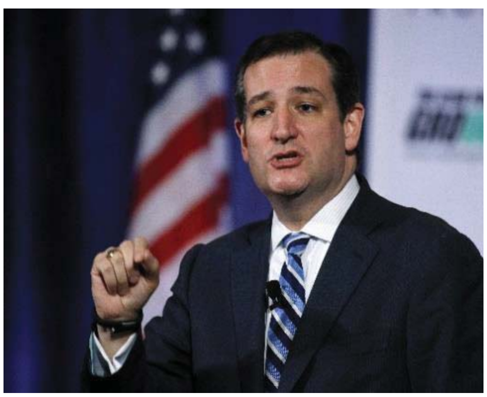
Photographs Used in Block 1: Bernie Sanders.

Appendix B

Photographs used in Block 2: Hillary Clinton.

Appendix C

Photographs Used in Block 3: Ted Cruz



Appendix D

Photographs Used in Block 4: Donald Trump.

Appendix E

Consent Form

CONSENT FORM FOR ADULTS

Please read below with care. You can ask questions at any time, now or later. You can talk to other people before you sign this form.

Study's Title: Gaze Behavior and Political Disposition.

Why is this study being done?

The purpose of this study is to investigate your gaze fixations of political candidates in relation to political dispositions. Utilizing the latest eye-tracking technology, our goal is to see if there is a relationship between these variables and if your political disposition can be predicted by gaze behavior.

What will happen while you are in the study?

First you will be given a form related to any present neurological conditions. You will then be taken into the interview room where you will watch video clips of current presidential candidates while having your eyes tracked. You will then be given a series of statements to rate your level of agreement with the statement. The whole process should take no more than an hour of your time.

Time:

This study will take about 60 minutes.

Risks:

Though this is a minimum risk study with no invasive procedures, it does involve politics and may cause some discomfort. Though this involves minimal benefit to you, it will assist the field of psychology in furthering knowledge of gaze behavior and political attitudes. You have the right to skip any items you don't feel comfortable answering and may stop participation at any time.

Although we will keep your identity confidential as it relates to this research project, if we learn of any suspected child abuse we are required by NJ state law to report that to the proper authorities immediately.

Benefits:

Though this involves no benefit to you, it may benefit the field of psychology in furthering knowledge of gaze behavior and political attitudes. You have the right to skip any items you don't feel comfortable answering and may stop participation at any time.

Compensation

To compensate you for the time you spend in this study, you will receive 2 SONA Credits. If you are unable to complete the study for any reason, you will still be fully compensated.

Who will know that you are in this study? You will not be linked to any presentations. We will keep who you are confidential.

The data obtained from you will remain absolutely confidential. Any identifying information will be kept in a secure place and destroyed when the study is over. Only staff assigned to this study will have access to these data. If data are presented, your name will not be used.

Do you have to be in the study?

You do not have to be in this study. You are a volunteer! It is okay if you want to stop at any time and not be in the study. You do not have to answer any questions you do not want to answer. Nothing will happen to you.

You will still get what you were promised. Your payment is 2 SONA Credits and your treatment at Montclair State University will not be affected.

Do you have any questions about this study? Phone or email the (Joseph Melon, 53 Bernice Road, Belleville, NJ, 07109 732-239-0612, melonj2@montclair.edu and Peter Vietze, 957 Cedarbrook Rd., Plainfield, NJ, 07060, 347-668-4992, vietzep@montclair.edu.)

Do you have any questions about your rights as a research participant? Phone or email the IRB Chair, Dr. Katrina Bulkley, at 973-655-5189 or reviewboard@mail.montclair.edu.

Future Studies

It is okay to use my data in other studies:

Please initial: _______ Yes _______ No

As part of this study, it is okay to videotape me performing the task for possible presentation purposes. My identity will still remain confidential:

Please initial: _______ Yes _______ No

One copy of this consent form is for you to keep.

Statement of Consent

I have read this form and decided that I will participate in the project described above. Its general purposes, the particulars of involvement, and possible risks and inconveniences have been explained to my satisfaction. I understand that I can withdraw at any time. My signature also indicates that I am 18 years of age or older and have received a copy of this consent form.

______________________	______________________	__________
Print your name here	Sign your name here	Date
Joseph Melon	______________________	__________
Name of Principal Investigator	Signature	Date
Dr. Peter Vietze	______________________	__________
Name of Faculty Sponsor	Signature	Date