Master Thesis

How gaze affects time perception:

Direct gaze leads to duration underestimation

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Plagiarism statement

I declare that, apart from properly referenced quotations, this report is my own work and contains no plagiarism; it has not been submitted previously for any other assessed unit on this or other degree courses.

Acknowledgements

“Let me look into a human eye;

it is better than to gaze into sea or sky;

better than to gaze upon God.”

– Herman Melville

To my wife, Rania, and to my feline companion, Banker.

Abstract

Studies have shown that direct gaze engages attention more efficiently compared to averted gaze, leading to greater interference with concurrent or immediately-following cognitive processing. Moreover, this attentional effect is in some cases reported to be rather short-lived, manifesting clearly at short stimulus durations while subsiding significantly or disappearing completely at longer ones. The attentional-gate model, the dominant model in human temporal perception, holds a central role for attention in duration estimation. The model predicts that attentional engagement in non temporal information processing will lead to interval underestimation. We hypothesized that a direct gaze would lead to greater interval underestimation via more efficient attentional engagement compared to an averted gaze, and that this would be a transient effect, manifesting only in the shorter intervals. Our results verified our hypotheses and they are interpreted based on the attentional-gate model framework.

Keywords: gaze perception, time perception, visual cognition, nonverbal communication, attentional-gate model.

Introduction

Direct gaze in humans conveys valuable information about the intentions of conspecifics regarding communication and social interaction (Emery, 2000). Given the adaptive value of sociability for our species, direct gaze is considered a critical social stimulus, so it comes as no surprise that it has been shown to be processed preferentially compared to averted gaze (e.g., Conty, Gimmig, Belletier, George, & Huguet, 2010; Doi, Ueda, & Shinohara, 2009; Farroni, Csibra, Simion, & Johnson, 2002; Palanica & Itier, 2012; Senju & Hasegawa, 2005; Ueda, Takahashi, & Watanabe, 2014; Xu, Zhang, & Geng, 2011; Yokoyama, Ishibashi, Hongoh, & Kita, 2011; Yokoyama, Sakai, Noguchi, & Kita, 2014). For example, Senju and Hasegawa (2005) showed that peripheral targets are detected more slowly when participants fixate on a face with a direct gaze compared to a face with an averted gaze. They concluded that direct gaze interferes more drastically with the concurrent or immediately-following processing of other stimuli, by engaging the attention of the perceiver more efficiently. When, however, a temporal gap was inserted between the presentation of the face with the direct gaze and the target, the effect of gaze direction on target detection latency disappeared altogether. This was, presumably, due to the sufficiency of that temporal gap to facilitate attentional disengagement from the direct gaze and reallocation of attentional resources to the target detection task, leading researchers to report that this most likely is a transient effect in nature.

Apart from target detection, attentional engagement has been found to affect duration estimation as well (e.g., Block, Hancock, & Zakay, 2010; Chaston & Kingstone, 2004). For instance, Chaston and Kingstone (2004) manipulated attention in a visual search paradigm and reported that participants underestimated time more in the attentionally demanding condition (i.e., conjunction search) as compared to the less demanding condition (i.e., simple feature search). According to the attentional-gate model, attention is a key factor that affects time estimation under prospective conditions (Zakay & Block, 1996). The model proposes that humans' temporal perception is regulated by an internal clock, which includes a pacemaker, a gate, and an accumulator. The accumulator collects the pulses that the pacemaker emits at a constant rate. Pulse accumulation is dependent on attention, where an increased number of pulses are collected when more attentional resources are allocated to the elapsed time, as a result of the attentional gate flickering more and thus allowing more pulses to be transferred to the accumulator. Then, the total count is transferred to a short-term memory system, which maintains the just-presented time interval, and to a reference memory system, which holds information regarding past pulse accumulations under similar contextual conditions. Lastly, a comparison is made between the just-presented time interval and the remembered time interval in order to produce a temporal judgment.

The attentional-gate model predicts that interval underestimation should be greater when attention is diverted from temporal information processing to any non-temporal information processing that humans perform during the to-be-estimated interval (Zakay & Block, 1996). Accordingly, based on what has already been mentioned (Chaston & Kingstone, 2004; Emery, 2000; Senju & Hasegawa, 2005; Zakay & Block, 1996), it seems reasonable to expect that a direct gaze would lead to greater underestimation of time duration via attentional engagement, compared to an averted gaze. In our study, therefore, using a temporal reproduction task, we sought to investigate whether the direct gaze of a centrally presented face would lead to greater interval underestimation compared to a centrally presented face with an averted gaze.

If direct gaze engages attention more efficiently compared to averted gaze, the to-be-estimated interval should be relatively underestimated as a result of more attentional resources being diverted to the processing of non temporal information. Additionally, if this truly is a transient effect, duration underestimation will be manifested only in shorter intervals (1200 and 2400ms) and subside significantly or disappear completely in longer intervals (3600 and 4200ms). The durations were selected so as to tap into attentional resources given that it has been shown that attentional effects manifest for durations of approximately 1 second and over (Wearden & Lejeune, 2008). To the best of our knowledge, this is the first time that the effect of gaze on temporal perception has been studied.

Methods

Participants

Twenty five undergraduate psychology students (M = 20 years of age, age range = 19 to 28 years, 24 females) of the University of Athens participated in this experiment for course credit. All were naive to the purposes of the experiment, and their visual acuity was reported to be normal or corrected-to-normal.

Apparatus and stimuli

The experiment was programmed in Presentation (Version 16.4, Neurobehavioral Systems, Inc.) and conducted in a desktop computer. Participants were asked to fixate at the center of the monitor. Participants' time estimates were obtained from their keyboard-pressing responses. The response key utilized was the ENTER on a conventional computer keyboard. A central cross subtended by 0.35 was used as the fixation point. The target stimuli were three rectangular color images of a woman's face (Caucasian) displaying a neutral facial expression, with either a direct gaze (front-looking) or an averted gaze (left-looking or right-looking).The images were in color, 1024 x 681 px, obtained from the standardized Radboud Faces Database (Langner, Dotsch, Bijlstra, Wigboldus, Hawk, & van Knippenberg, 2010), cropped so as to focus on the face from the chin to the tip of the head, and displayed in 375 x 499 px (see Figure 1). This database was utilized due to its thorough standardization on the: depicted expression, valence of the image, and intensity, clarity, and genuineness of the expression. Additionally, the images were standardized in all other aspects (e.g., illumination, gaze-axis, image processing).

Figure 1. The images of direct, left-wards, and right-wards looking gaze of the stimulus presented in the experiment.

Design

There were two within-participant factors: Gaze, which had 3 levels (direct, left-averted, and right-averted) and Duration, which had 4 levels (1200, 2400, 3600, and 4200 ms), resulting in 12 experimental conditions. The order of stimulus and condition presentation was randomized.

Experimental procedure

Participants were seated approximately 57 cm from the screen in a dedicated dimly-lit room. The initiation of the experiment was self-paced. A ‘Ready’ screen was presented and participants were instructed to press ‘enter’ for the experiment to start. In every trial participants were presented with one of the three images at the center of the screen for a duration of 1200, 2400, 3600, or 4200ms. Immediately afterwards a blue square (300 x 300 px) replaced the image. Participants were instructed to press the ‘enter’ key when they deemed that the same amount of time had elapsed as the time-interval that the image had appeared on the screen. There were 5 blocks of 24 trials each, plus a practice block in the beginning of the experiment, consisting of 4 trials to familiarize participants with the procedure. In the practice block, a color drawing of a house was used as the target stimulus, thus the experimental stimuli were presented only during the main experiment. The data from all 5 blocks were included in the subsequent analyses. All participants were kindly requested to avoid keeping track of the passage of time by tapping or verbally counting for the time the image or the blue square appeared on the screen. The experiment lasted approximately 30minutes.

Analysis

Two psychometric measures were derived from the raw participant data, the accuracy (i.e., estimated time divided by the original duration in each condition) and the coefficient of variation (CV; i.e., the standard deviation divided by the mean duration judgment). Accuracy indicates whether participants had underestimated (<1) or overestimated (>1) the actual duration of a given interval. CV is a measure of the participants’ response variability, with higher CV indicating greater response variability. We ran repeated measures ANOVA with two factors: Gaze, which had 3 levels (direct, left averted, and right averted) and Duration, which had 4 levels (1200, 2400, 3600, and 4200 ms). Bonferroni corrected t-tests were used for all post-hoc comparisons ($p < 0.5$). Two participants were excluded from the analyses due to very high CV values.

Results

The accuracy (see Figure 2) analysis showed a significant main effect for Gaze [$F (2.44) =13.680$, $p=.0001$]. The direct gaze ($M=.849$) was significantly underestimated compared to both left and right gaze ($M=.915$ and $.987$, respectively). Additionally, the left averted gaze was underestimated significantly compared to the right averted gaze. We also obtained a significant main effect for Duration [$F (3.66) =18.824$, $p=.0001$], with all durations being significantly different from each other except for the durations of 3600 and 4200ms. The duration of 1200 was overestimated ($M=1.118$) and the durations of 2400, 3600, and 4200 ms were underestimated ($M=.914$, $.836$, and $.799$, respectively). Lastly, we report a significant interaction of Gaze by Duration [$F(6,132)=3.318$, $p=.004$], where for the duration of 1200 ms, the direct and left averted gaze were not different ($M = .985$ and 1.099, respectively), but they were both significantly different from the right averted gaze ($M=1.269$). For the duration of 2400 ms, direct gaze was underestimated ($M=.837$) significantly in comparison to both left averted and right averted gazes ($M= .932$ and $.974$, respectively).For the durations of 3600 and 4200 ms, all effects disappeared with no gaze difference ($M=.817$, $.826$, and $.865$ at 3600 ms for direct, left averted, and right averted gaze, respectively, and M= .758, .801, and .838 at 4200 ms for direct, left averted, and right averted gaze, respectively).

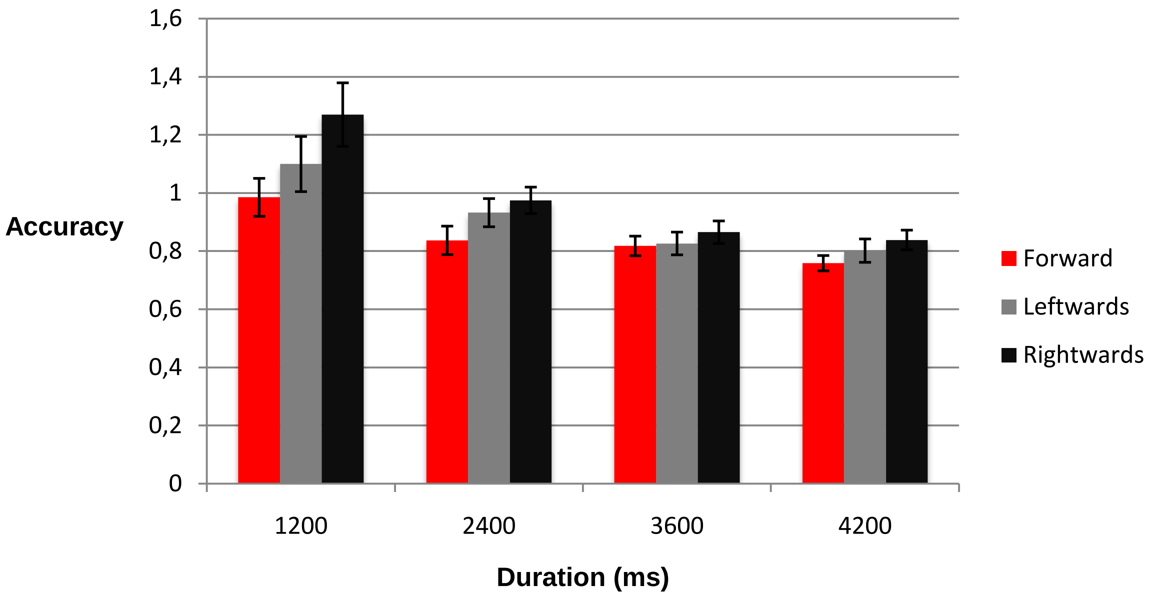

Figure 2. Participants' accuracy for the different gaze conditions and durations. Error bars represent the standard error of the mean.

The CV (see Figure 3) analysis showed a main effect of Duration [F (3, 66) = 20.501, p = .0001] with judgments of short duration being more variable than longer durations (M = .386, .303, .252, and .245, for 1200, 2400, 3600, and 4200 ms, respectively), a finding reported in many time estimation studies utilizing a reproduction task (e.g., Wearden& Lejeune, 2008). No main effect for Gaze and no interaction of Gaze by Duration was obtained (Gaze: [F (2, 44) = .897, p = .415]; Interaction: [F (6, 132) = .331, p = .920]).

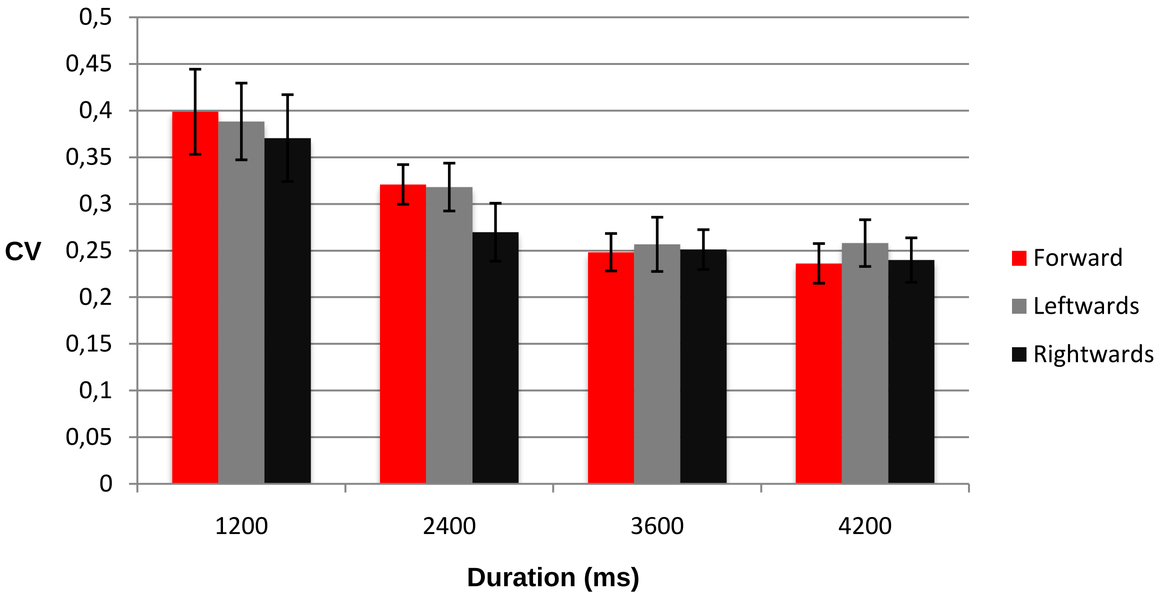

Figure 3. Participants' CVs for the conditions of gaze as a function of duration.

Discussion

Based on the relevant literature and previous findings, we hypothesized that direct gaze, as a highly attentionally engaging stimulus (e.g., Conty, Gimmig, Belletier, George, & Huguet, 2010; Doi, Ueda, & Shinohara, 2009; Farroni, Csibra, Simion, & Johnson, 2002; Palanica & Itier, 2012; Senju & Hasegawa, 2005; Ueda, Takahashi, & Watanabe, 2014; Xu, Zhang, & Geng, 2011; Yokoyama, Ishibashi, Hongoh, & Kita, 2011; Yokoyama, Sakai, Noguchi, & Kita, 2014), would lead to greater time underestimation via attention modulation (Chaston & Kingstone, 2004) compared to an averted gaze, and that this would be a transient attentional effect (Senju & Hasegawa, 2005). Our hypotheses were confirmed for all intervals tested. In the 1200 ms condition, interval underestimation was greater for the direct gaze compared to both averted gazes, though not significantly different from the left-wards gaze. In the 2400 ms condition, the expected attentional effect became more pronounced, and we report a statistically significant underestimation in the direct gaze condition compared to both the averted gaze conditions. For the two longer intervals (3600 and 4200 ms) the effect disappeared as was expected based on its most probably transient nature. To the best of our knowledge, this is the first time that the effect of gaze on temporal perception has been studied, reporting a short-lived effect of duration underestimation via attention modulation caused by a direct gaze.

Although we believe the effect we report here to be a genuine effect of a critical social stimulus on an attentionally demanding cognitive process such as temporal estimation, other explanations could hold as well. Differences in low-level visual properties of direct gaze compared to averted gaze, such as contrast or luminance, the mere presence of open eyes, or the perception of iris' displacement as a spatial and not a social cue, could provide sufficient explanation for our data. However, studies have shown that the modification of earlier-stage perceptual features of the eye region eliminates all effects of direct gaze perception on concurrent or immediately-following cognitive processing (Conty, Gimmig, Belletier, George, & Huguet, 2010; Senju & Hasegawa, 2005; Yokoyama, Ishibashi, Hongoh, & Kita, 2011; Yokoyama, Sakai, Noguchi, & Kita, 2014). Furthermore, Conty et al. (2010) have reported that only direct gaze perception interferes drastically with non temporal information processing, and that the mere presence of open eyes with an averted gaze does not elicit the same effect. Lastly, it has been shown that iris-like stimuli need to be perceived as a gaze in order to elicit an attentional engagement effect (Yokoyama, Ishibashi, Hongoh, & Kita, 2011). Based on these findings, we are confident that we report a genuine direct gaze effect on duration estimation.

The significance of our findings rests on the confirmation of the central role of attention in human temporal perception, as proposed by the attentional-gate model in timing. The model predicts that diversion of attentional resources from temporal information processing to any non temporal information processing that humans perform during a to-be-estimated interval, will lead to greater time underestimation due to less pulses being accumulated compared to a condition where all attentional resources are deployed for the duration estimation process and no pulse is lost (Zakay & Block, 1996). Direct gaze provides valuable social information compared to an averted gaze, and, therefore, due to attentional capture leads to greater underestimation of duration compared to an averted gaze, as was predicted by the model. However, the attentional-gate model does not predict that this effect of attention on temporal perception will be transient, disappearing in the longer internals of 3600 and 4200 ms we tested. It could, thus, be the case that attention does not affect duration estimation through faulty pulse accumulation but at the “site” of time interval comparison, distracting from the cognitive process of producing an accurate temporal estimate based on an already stored temporal representation of analogous intervals. According to this line of reasoning, pulses are never lost; they are accumulated normally and as soon as the detrimental effect of direct gaze subsides or disappears they are used to produce an accurate temporal estimate, hence the unexpected accuracy in the longer internals of 3600 and 4200 ms, which cannot be explained by the model as it now stands. Further experimentation is required to thoroughly test this hypothesis.

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