Title
Attentional Bias for Self-Face: Investigation using Drift Diffusion Modelling

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 44(44)

Authors
Jublie, Aditi
Kumar, Devpriya

Publication Date
2022

Peer reviewed

Attentional Bias for Self-Face: Investigation using Drift Diffusion Modelling

Aditi Jublie (aditijub@iitk.ac.in)
Department of Humanities and Social Sciences, Indian Institute of Technology
Kanpur, India

Devpriya Kumar (devpriya@iitk.ac.in)
Department of Cognitive Science, Indian Institute of Technology
Kanpur, India

Abstract

Literature has suggested that self-faces are processed differently at various stages of information processing. Although mechanisms like familiarity, implicit positive attitude, emotional arousal, dual-coding, and dopamine reward pathway have been theorized to explain this effect, it may share a fundamental basis in the attentional mechanism resulting in perceptual prioritization for self-face. In this study, we have assessed the attentional bias resulting from the self-face (over other familiar and unfamiliar faces), by using face pairs as cues before a dot-probe task. We looked at reaction time and its underlying latent variables as a function of face pairs used as cues. We find that both self-face and familiar face result in a faster reaction time for subsequent stimuli at cued locations. Though self-face shows this advantage for both short and long cue-time, a familiar face shows the advantage only for longer cue-time. We also found that drift rate bias is found for the location where self-face is presented. Familiar faces show a prior bias (z) as the reason for underlying advantage. We conclude that although, self-face, as well as familiar faces, might bias the processing of subsequent stimuli the underlying latent factor might differ.

Keywords: self-face; attentional bias; DDM

Introduction

There is huge literature demonstrating that our cognition is biased toward the self. This self-bias has been originally called the self-reference effect (Rogers et al., 1977). Trait adjectives paradigm and ownership tasks have been used to measure self-reference effects in the domain of memory. It is found that our memory for the objects or adjectives related to us is better than for the ones related to others (Bredart, 2016). This self-reference effect for memory has also been observed in adults as well as children (Cunningham et al., 2013). Shape label matching tasks have been used to test the effect of newly established self-association with arbitrary shapes on perception (Sui et al., 2012). Results showed an advantage in terms of reaction time and accuracy for self-associated pairs, despite contrast reduction, depicting the effect of self-reference on the low-level perceptual processing. A similar advantage has been observed by some studies when self-face is taken as a stimulus. Perceptual judgment for orientation (head facing leftward or rightward) is faster for our face than for the other faces (Liu et al., 2016). Memory-based (familiarity judgment) and perception-based (head orientation task) identification tasks for faces have supported self-face advantage over other faces (Bortolon & Raffard, 2018). A prior-entry effect for self-face has been observed for both direct temporal order judgment as well as orthogonal emotion identification tasks (Jublie & Kumar, 2021).

The mechanisms behind the self-face advantage may include familiarity, increased emotional arousal, implicit positive attitudes towards the self, dual encoding (configural and featural) of self-face, multisensory information, and integrative self-hypothesis, the dopamine reward pathway (Bortolon & Raffard, 2018; Ota & Nakano, 2021). Another mechanism is an automatic capture of attention by self-face (Wojcik et al., 2018). However, other studies have claimed that controlled attentional resources are required to process self-face (Keyes & Dlugokencka, 2014). Studies have shown that self-faces can influence processing due to problems in disengagement of attention from the self-face once attended to (Devue et al., 2009).

One way to tease apart the effect related to attentional capture versus disengagement is to use a dot-probe task, before which self-face is presented either congruent or incongruent to the subsequent dot-probe. If automatic attentional processing is the primary mechanism via which self-face processing advantage occurs, one would expect self-face to grab attention resulting in self-faces influencing the processing of the probe. Similarly, using a dot-probe task, researchers have shown a difference in dot-detection sensitivity using EEG measures (Wojcik et al., 2018). Liu and colleagues (2016) found that the dynamic orientation of the self-face can act as a strong ecological cue for attention and in reducing the uncertainty of the decision-making. However, in a digit parity task conducted by Devue & Bredart (2008), the self-face seemed to have a temporary distraction but that was not different from the distraction created by any other familiar face.

To investigate whether the deployment of attentional bias occurs for self-face, we used a dot-probe task cued by face-pairs differing in identity to understand how performance on the dot-probe detection task is mediated by the processing of self-faces. To understand what components of attentional processing are affected by self-face cues, faces were presented as cues at left or right visual angles before the target (an asterisk), and the participants had to respond to the

In J. Culbertson, A. Perfors, H. Rabagliati & V. Ramenzoni (Eds.), *Proceedings of the 44th Annual Conference of the Cognitive Science Society*.

location of the target (see Figure 1 for trial structure). Cue presentation time was manipulated as it reflects different stages of processing. We performed DDM on the RT/accuracy data. We expected that a congruent self-face cue will result in an enhanced attentional bias towards the dot-probe (compared to other faces).

Method

Participants

We earlier planned the experiment to obtain a moderate effect size of 0.75 (Cohen's d) and a power (1- Beta) of 0.8, and alpha =0.05. We calculated power for multiple-way ANOVA. The sample size of 31 was calculated in '*R v4.1.1*' using function *wp.kanova*() in the package '*WebPower*'.

In total, 32 students (16 females, 16 males) of IITK within the age range of 18-28 with normal or corrected-to-normal vision participated in the study. Each participant was compensated with an amount of Rs. 50 for participating in the experiment. The study was approved by the Institute's Ethics Committee of IIT Kanpur (IEC Communication No: IITK/IEC/2018-19/I/11).

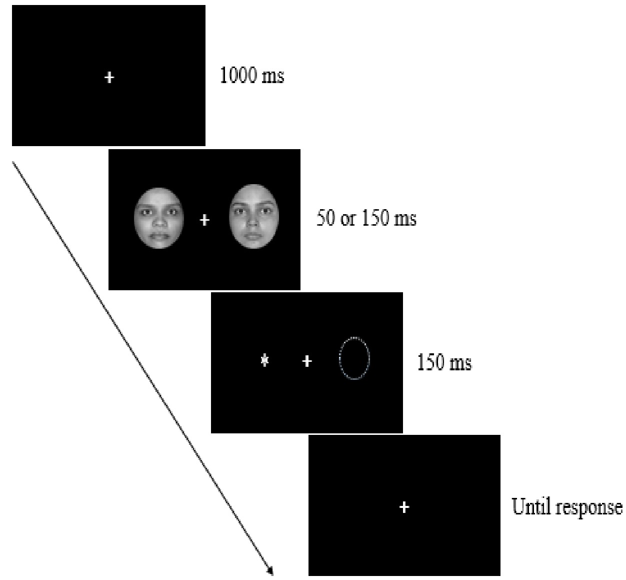

Figure 1: Trial structure for the experiment. *The dotted circle in the right visual field in the third slide indicates that the probe can appear in the right position too.*

Apparatus

The experiment was conducted on a standard IBM PC at a refresh rate of 60 Hz and a resolution of 1,024 × 768 on a 24" LED display. Participants were seated at a distance of 60 cm from the monitor screen and gave their responses through a standard QWERTY keyboard. The experiment was designed using PsychoPy.

Stimulus

Stimuli consisted of grayscale photographs of participants, their friends, and strangers as the ones used in experiments 1 and 2. The face (as cue) was presented at an angle of 4*4 degrees at an eccentricity of approximately 6 degrees from the center. The target appeared after the stimulus and was presented at an angle of 4*4 degrees at an eccentricity of approximately 6 degrees from the center or at the center.

Procedure

In the first phase, participants were requested to get their friends along with them at Media Lab, IIT Kanpur. Consent for taking photographs was obtained from both the participants and their friends, along with the consent to take part in the experiment. In most cases, both the participant and their friend took part in the main experiment. A professional photographer took pictures (exhibiting happy or neutral expressions) in controlled settings. The photographs were clicked and collected for a gender-neutral unfamiliar face (volunteers were not a part of the campus) beforehand for female and male participants. These photographs were cropped to an oval frame to remove facial hair and any other identifications then converted to grayscale and matched for contrast using MATLAB.

Fifteen other participants (who did not take part in the experiment and were not photographed) categorized the facial expression as 'sad', 'happy', or 'neutral', and rated these photographs on a five-point rating scale for valence, intensity, arousal, and genuineness. The photographs were presented in randomized order, and each participant rated each picture five times for every domain. We did not find any difference in the rating between self-faces, friends face, and an unfamiliar face on any of the rating parameters.

The participants performed a dot-probe task where each trial began with a fixation cross, after which a face cue appeared on left and right, which was followed by an asterisk (*) target at the left or right. It was followed by a blank screen and the participants had to respond as quickly as possible whether the target appeared on the left or right by pressing 'z' and 'm' keys respectively.

Each participant completed a practice block of 24 trials, followed by the main experiment having 384 trials. The order of presentation and location was randomized. The main experiment was divided into four blocks with compulsory breaks in between. The interaction between cue by the preferred face (congruent, incongruent) * cue-time (50 ms, 150 ms) = 2*2 was analyzed for three pairs of faces (self-friend, self-unfamiliar, and friend-unfamiliar).

Results & Discussion

Reaction Time Analysis

Every participant's data was accepted for having >70% accuracy. To make the analysis' understanding clear, three 2 x 2 repeated measures ANOVA were conducted for three face pairs. The significant effects are briefed below.

For ***the Self-Friend*** pair, the main effect of **cue-time**, ($F(1,31)=20.81$, $p=.000$, $\eta^2=.40$) was found significant. Tukey's post hoc analysis indicates ($t(31)=4.56$, p=.000) that the reaction time was faster for 150 ms cue-time (Mean RT = 445 ms) as compared to that of 50 ms (Mean RT = 466 ms).

For the ***Self-Unfamiliar*** pair, the main effect of **cueing** ($F(1,31)=6.27$, $p=.018$, $\eta^2=.19$) was found significant, and post hoc analysis indicates ($t(31)=2.5$, p=.018) the reaction time faster for the case when self-face (as cue) and target (*) were congruent (Mean RT= 446 ms) as compared to when they were incongruent (Mean RT= 454 ms).

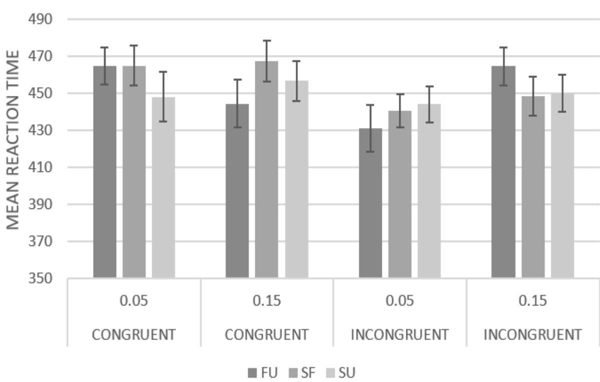

Figure 2: Mean Reaction Time for preferred face in each pair.

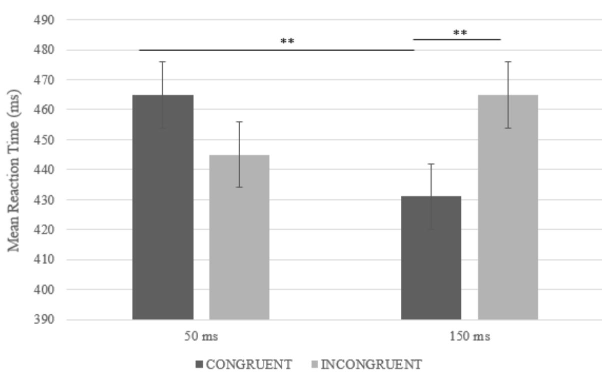

Figure 3: Interaction between cueing and cue-time for FU pair.

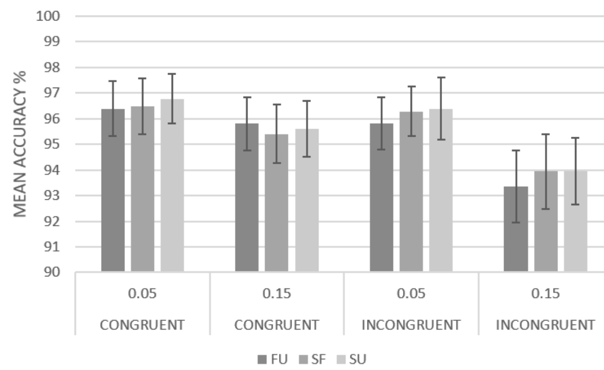

Figure 4: Mean accuracy percentage.

The interaction effect **Cue*Cue-Time** for ***Friend-Unfamiliar*** pair was found significant ($F(2,62)=14.15$, p=.001, $\eta^2=0.31$) (see figure 3). We found that for 150 ms cue time reaction time for the congruent condition was faster than the incongruent condition (Mean Difference=33.5 ms, p=0.034) and the difference between (Mean Difference=33.68, p=0.033) 50 ms and 150 ms cue-time was significant for congruent condition.

Based on the above results we can conclude that both familiar, as well as self-face, can bias attention when presented against an unfamiliar face. For self-face, this bias occurs early (50ms cue duration as well as late 150ms cue duration). However, for a friend's face, the bias is seen only at longer cue durations. When a self-face is paired with a familiar face, no differential attentional bias is observed towards either of the two faces.

Accuracy Analysis

Similar to RT analysis, three 2 x 2 repeated measures ANOVA were conducted for three face pairs. None of the main effects or interaction effects were significant for accuracy for any face-pair, making the self-face advantage questionable. To understand the underlying mechanism of parameters determining the inconclusive behavioral results in the RT analysis and non-significant effects in accuracy data, we conducted the DDM for all face pairs in the next section which will provide information about the prior bias that faces as cues are supposed to create.

DDM analysis

Drift diffusion model (DDM) analysis has been used to analyze the specific model (or models) through which the self-reference effect has affected the task performance (Golubickis et al., 2019). In any task, there are two distinct ways in which decisional processing can be biased. Firstly, how a stimulus is processed; secondly, how a response is generated; with each source of bias reflecting a different underlying component of decisional processing (Voss et al., 2013). While variability in stimulus processing affects the quality of information gathering during decision-making

Table 1: DIC values for Cue*Cue-time for different models. *The models with the least DIC are highlighted in bold.*

Varying Parameter	SF	SU	FU
v	-9547	**-9580**	-9612
z	**-9587**	-9573	**-9657**
v, z	-9567	-9552	-9638
Null	-9366	-9391	-9541

(i.e., stimulus bias), adjustments in response preparation influence how much evidence are required before a specific response is made. Another bias is caused by starting point, which indicates bias that people might have even before they process the stimuli.

The DDM assumes that during two alternative forced-choice tasks (e.g., respond to the location of the probe whether left or right), noisy information is continuously sampled until sufficient evidence is acquired to initiate a response. The parameter drift rate (v) estimates the speed of information gathering (i.e., larger drift rate = faster information uptake), and is interpreted as a measure of the quality of visual processing during decision-making. Boundary separation (a) estimates the distance between the two decision thresholds (i.e., whether the response is in favor of self-face or friend's face), hence indicating how much evidence is required before a response is made (i.e., larger values indicate more conservative responding). Another parameter of interest, the starting point (z) defines the position between the decision thresholds at which evidence accumulation begins. If z is not centered between the thresholds (i.e., if z is 0.5), this denotes a prior bias in favor of the response that is closer to the starting point, that is, less evidence is required to reach the threshold. Non-decision time (t) indicates the time taken for stimulus encoding and motor processes.

We used HDDM which is an open-source software package written in Python for the hierarchical Bayesian estimation of drift diffusion model parameters (Wieki et al., 2013). Models were response coded, such that the upper threshold corresponded to the response congruent to the preferred face (S in SF and SU; F in FU) and the lower threshold to the non-preferred face (U in FU and SU; F in SF). To identify the mechanism by which self-face biases information processing, we calculated Deviance Information Criterion (DIC) values for models with v: dynamic bias model, z: prior bias model, and vz: multi-stage model (based on Golubickis et al., 2019) when being allowed to vary as a function of cue congruency and cue-probe ISI. Bayesian posterior distributions were modeled using a Markov Chain Monte Carlo (MCMC) with 5000 samples (following 200 burns in samples).

The DIC value for a model reflects the overall fit to the data at the participant and group levels. The model with the least DIC is considered the best for defining the performance. By comparing DIC values of cue-time*cue with the null model for all face pairs (see Table 1), we found that the value for all models is smaller as compared to the respective null models.

For SU face-pair, we observed the lowest DIC values for the dynamic bias model where the parameter drift rate (v) was allowed to vary freely while other parameters were kept fixed (DIC_v-DIC_{null}=-189), indicating that presentation of self-face (against an unfamiliar face) increase sampling rate for subsequent stimuli both especially for higher cue-time (For details, see Table 2).

For SF and FU face-pair, we observed the lowest DIC values for the prior bias model where parameter z was allowed to vary freely with cue-time*cue while other parameters were kept fixed. For details of SU pair (DIC_z-DIC_{null}=-221), and FU pair (DIC_z-DIC_{null}=-116). Results suggest that RT benefits that we see earlier for a friend's face (compared to an unfamiliar face) are due to an increase in bias towards the friend's face for greater cue-time (see Table 3 and 4). Similarly, we see a greater starting point bias for self-face (compared to friend's face).

The overall results indicate that although self-face and friend's face both show a cueing advantage in a dot-probe task (over unfamiliar faces), latent factors suggest that the advantage might stem from different biases. While the advantage for a friend's face (familiarity) results from a prior bias, the advantage to self-face results in an increased sampling rate for subsequent stimuli. When self-face and friend's face are compared with each other, we still observe some processing advantage for self-face (although in form of a starting point bias).

When we compared the values of prior bias (z) for different cue-time in congruent conditions, we found $p_{Bayes} < .001$ for both SF and FU pairs. This again supports the disengagement from the face as the major source of advantage for these two pairs. However, when we compared the values of z for different cue-time in incongruent conditions, we found $p_{Bayes} < .05$ for the FU pair only, establishing that here self-face is not engaging against a friend's face.

Table 2: Values for drift rate (v) for SU pair *(z=0.61)*.

Cue-time (ms)	Cue	v
50	Congruent	7.31
50	Incongruent	7.34
150	Congruent	8.21
150	Incongruent	6.92

Table 3: Values for starting point (z) for SF pair. *The bold row indicates p_{Bayes} (bias > 0.5) < .001.*

Cue-time (ms)	Cue	z
50	Congruent	0.58
50	Incongruent	0.58
150	**Congruent**	**0.63**
150	Incongruent	0.58

Table 4: Values for starting point (z) for FU pair. *The bold row indicates p_{Bayes} (bias > 0.5) < .001.*

Cue-time (ms)	Cue	z
50	Congruent	0.52
50	Incongruent	0.52
150	**Congruent**	**0.57**
150	Incongruent	0.5

The results, hence, support that presentation of self-face results in an attentional bias towards itself. A similar advantage is also seen for familiar faces. However, it might be wrong to reduce the self-face processing related interactions with attention to familiarity. Our results show that the kind of biases that familiarity creates and the kind of biases that self-referentiality creates might be different. While familiarity results in a bias for initial selection bias toward the familiar face. Processing a self-face might result in a subsequent increase in the rate at which information is sampled from the region in which the self-face was processed. However, results are not completely conclusive about other aspects of self-face processing. For example, we did not find an increased sampling for self-face when it was compared with a friend's face directly. Similarly, we did not find any self-face advantage (against a friend) in the processing of incongruent trials, where the self-face and probe were at different locations. To summarize, both self-face and other familiar faces show an advantage in terms of reaction time for subsequent stimuli, the underlying psychological process might be different. While self-face shows a subsequent increase in drift rate for processing of stimuli, friends face shows a starting bias.

References

Alzueta, E., Melcón, M., Poch, C., & Capilla, A. (2019). Is your own face more than a highly familiar face?. *Biological psychology*, *142*, 100-107.

Bantin, T., Stevens, S., Gerlach, A. L., & Hermann, C. (2016). What does the facial dot-probe task tell us about attentional processes in social anxiety? A systematic review. *Journal of behavior therapy and experimental psychiatry*, *50*, 40-51.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & Van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. *Psychological bulletin*, *133*(1), 1.

Bortolon, C., & Raffard, S. (2018). Self-face advantage over familiar and unfamiliar faces: a three-level meta-analytic approach. *Psychonomic bulletin & review*, *25*(4), 1287-1300.

Brédart, S. (2016). A self-reference effect on memory for people: We are particularly good at retrieving people named like us. *Frontiers in psychology*, *7*, 1751.

Brédart, S., Delchambre, M., & Laureys, S. (2006). Short article: One's own face is hard to ignore. *Quarterly Journal of Experimental Psychology*, *59*(1), 46-52.

Cunningham, S. J., Vergunst, F., Macrae, C. N., & Turk, D. J. (2013). Exploring early self-referential memory effects through ownership. *British Journal of Developmental Psychology*, *31*(3), 289-301.

Cooper, R. M., & Langton, S. R. (2006). Attentional bias to angry faces using the dot-probe task? It depends when you look for it. *Behaviour research and therapy*, *44*(9), 1321-1329.

Cunningham, S. J., Turk, D. J., Macdonald, L. M., & Macrae, C. N. (2008). Yours or mine? Ownership and memory. *Consciousness and Cognition, 17*, 312–318.

Devue, C., & Brédart, S. (2008). Attention to self-referential stimuli: Can I ignore my own face? *Acta Psychologica, 128*(2), 290–297.

Devue, C., Van der Stigchel, S., Brédart, S., & Theeuwes, J. (2009). You do not find your own face faster; you just look at it longer. *Cognition, 111* (1), 114-122.

Golubickis, M., Ho, N. S., Falbén, J. K., Mackenzie, K. M., Boschetti, A., Cunningham, W. A., & Macrae, C. N. (2019). Mine or mother's? Exploring the self-ownership effect across cultures. *Culture and Brain, 7*(1), 1-25.

Jublie, A., & Kumar, D. (2021). Early Capture of Attention by Self-Face: Investigation Using a Temporal Order Judgment Task. *i-Perception*, *12*(4), 20416695211032993.

Kappenman, E. S., Farrens, J. L., Luck, S. J., & Proudfit, G. H. (2014). Behavioral and ERP measures of attentional bias to threat in the dot-probe task: Poor reliability and lack of correlation with anxiety. *Frontiers in psychology*, *5*, 1368.

Keyes, H., & Dlugokencka, A. (2014). Do I Have My Attention? Speed of Processing Advantages for the Self-Face Are Not Driven by Automatic Attention Capture. *PLOS ONE*, *9*(10), e110792.

Liu, M., He, X., Rotsthein, P., & Sui, J. (2016). Dynamically orienting your own face facilitates the automatic attraction of attention. *Cognitive neuroscience*, *7*(1-4), 37-44.

Ma, Y., & Han, S. (2010). Why we respond faster to the self than to others? An implicit positive association theory of self-advantage during implicit face processing. *Journal of Experimental Psychology: Human Perception and Performance*, *36*, 619–633.

Nijhof, A. D., Shapiro, K. L., Catmur, C., & Bird, G. (2020). No evidence for a common self-bias across cognitive domains. *Cognition*, *197*, 104186.

Ota, C., & Nakano, T. (2021). Self-Face Activates the Dopamine Reward Pathway without Awareness. *Cerebral Cortex*.

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of personality and social psychology*, *35*(9), 677.

Schoth, D. E., Nunes, V. D., & Liossi, C. (2012). Attentional bias towards pain-related information in chronic pain; a meta-analysis of visual-probe investigations. *Clinical psychology review*, *32*(1), 13-25.

Sui, J., He, X., & Humphreys, G. W. (2012). Perceptual effects of social salience: evidence from self-prioritization effects on perceptual matching. *Journal of Experimental Psychology: Human perception and performance*, *38*(5), 1105.Thigpen, N. N., Gruss, L. F., Garcia, S., Herring, D. R., & Keil, A. (2018). What does the dot-probe task measure? A reverse correlation analysis of electrocortical activity. *Psychophysiology*, *55*(6), e13058.

Voss, A., Nagler, M., & Lerche, V. (2013). Diffusion models in experimental psychology. *Experimental Psychology, 60,* 385–402.

Waechter, S., Nelson, A. L., Wright, C., Hyatt, A., & Oakman, J. (2014). Measuring attentional bias to threat: Reliability of dot probe and eye movement indices. *Cognitive therapy and research*, *38*(3), 313-333.

Wilson, D. A., & Tomonaga, M. (2018). Exploring attentional bias towards threatening faces in chimpanzees using the dot probe task. *Plos one*, *13*(11), e0207378.

Wieki, T. V., Sofer, I., & Frank, M. J. (2013). HDDM: Hierarchical Bayesian estimation of the drift- diffusion model in python. *Frontiers in Neuroinformatics, 7,* 14.

Wójcik, M. J., Nowicka, M. M., Kotlewska, I., & Nowicka, A. (2018). Self-face captures, holds, and biases attention. *Frontiers in psychology*, *8*, 2371.