Title: Does Men's Facial Sexual Dimorphism Affect Male Observers' Selective Attention?

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Abstract

Facial sexual dimorphism affects observers' physical dominance ratings. Here, we test whether such perceived dominance influences selective attention. To minimize demand characteristics, we examined whether task-irrelevant masculinized men's faces would show an attentional bias in several experimental paradigms. Experiment 1 employed a Posner Cueing Paradigm in which participants classified shapes after a masculinized or feminized man's face was presented. We could not find a difference in participants' classification speeds when either feminized or masculinized face cued target position. Experiment 2 employed a Flanker Task in which participants judged letter orientation, while ignoring flanking faces. There was no observed difference in participants' reaction time (RT) when masculinized faces flanked the target. Experiment 3 employed a Dot Probe Task, where participants were presented with a masculinized face and a feminized face to the left and right of center screen, and a target shape was presented in the location of one face. Participants' task was to classify shape orientation. We observe a small effect of facial sexual dimorphism on participants' classification speed. In Experiment 4, we primed participants with images meant to induce fear or arousal before each trial of a Dot Probe Task. Following the presentation of a fear inducing picture, participants RT to classify shapes when a masculinized face cued target position did not differ from when a feminized face cued target position. The two different presentation times did not create different patterns of results, indicating that masculinized faces did not induce either a cueing or inhibitory affect. Overall, we failed to support the hypothesis that people selectively attend to masculinized faces when they are presented as irrelevant information.

Keywords: Facial sexual dimorphism; Masculinity; Threat; Selective attention

Does Men's Facial Sexual Dimorphism Affect Male Observers' Selective Attention?

1. Introduction

Individuals use faces to assess others' interpersonal dimensions, which then guides their social interactions (Carré et al., 2009; Thornhill & Gangestad, 2006; Jones et al., 2001; Sell et al., 2008; see Van Vugt & Grabo, 2015 for review). One aspect of facial appearance that has received substantial attention is sexual dimorphism, which ranges along a continuum from highly feminine to highly masculine (Little, Burriss, & Jones, 2007; Little, Roberts, Jones & DeBruine, 2012; Todorov et al., 2015; Watkins et al., 2010).

Increased testosterone production with the onset of puberty masculinizes male faces (Enlow, Han, & McGrew, 1996; Marečková et al., 2011; Whitehouse et al., 2015; see Verdonck et al., 1999 for a quasi-experiment using T-administration). Masculine faces are those with broader jaws, thicker brow ridges and longer lower face halves (Thornhill & Gangestad, 2006). Facial masculinity is associated with aspects of men's physical dominance and under certain contexts threat potential (i.e., their capacity to inflict harm on others), such as their upper-body strength (Sell, et al., 2008; Toscano, Schubert, & Sell, 2014; Van Dongen & Sprengers, 2014). Observers are accurate at judging men's physical strength when presented with their facial photographs (Sell, et al., 2008; Toscano, et al., 2014), suggesting that they can make upper body strength judgements solely from the face.

The ability to assess threat potential from the face might extend beyond physical dominance assessments. People appear to have the capacity to accurately assess men's ability to win an aggressive competition from their facial photographs (i.e., Mixed Martial Arts (MMA) matches; Little, Trebicky, Havlicek, Roberts, & Kleisner, 2015). Because competitors of MMA matches are closely matched in height, weight and upper body strength, observers' above-chance accuracy at selecting winners may reflect their ability to assess other qualities which aid in aggressive dyadic competition, such as trait aggression. Observers' possess stereotypes of people with masculine faces. They perceive them as belonging to individuals who are more likely to engage in antisocial and aggressive behavior (Han et al., 2017). In an experiment evaluating observers' judgement of guilt, individuals with higher levels of masculine facial appearance were more likely to be perceived as guilty, especially for stereotypically male crimes, such as burglary (Ward, Flowe, & Humphries, 2012). They were more likely to be selected as the perpetrator of a crime in a suspect lineup, especially when those crimes were violent (Estrada-Reynolds, Reynolds, McCrea, & Freng, 2017), and to be judged as guilty of a violent crime (Ford, Penton-Voak, & Pound, 2020).

These studies provide correlational evidence that men's facial masculinity cues their threat potential and observers may use these cues to inform their threat perceptions. Experiments investigating observers' dominance perceptions have found that experimentally masculinizing men's faces using computer graphic software makes them appear more formidable and causes observers to rate them as more dominant (Han et al 2017; Perrett et al., 1998; Watkins et al., 2010), threatening (Han et al., 2017) and less trustworthy (Little, Roberts, Jones & DeBruine, 2012).

1.1, Gap in the Current Research

Force-choice paradigms are the most common method to evaluate observers' dominance perceptions of masculinized and feminized faces (e.g., Watkins, Debruine, Feinberg, & Jones, 2013; Watkins, Fraccaro, Smith, Vukovic, Feinberg, DeBruine, & Jones, 2010; Watkins, Jones, & DeBruine, 2010). Participants are presented with a masculinized and feminized version of the same man's face and asked to indicate which individual is higher on a certain dimension. These studies have consistently demonstrated that masculinized men’s faces are more likely to be selected as physically dominant when appearing next to the feminized version (e.g., Watkins, et al., 2013; Watkins, et al., 2010a; Watkins, et al.,2010b). Forced-choice paradigms cause participants attention to be directed towards the traits of interest (e.g., Sherlock et al., 2017; Whitehouse et al., 2002), which ultimately can bias the experiments’ results (cf., Albert et al., 2021; Sherlock et al., 2017). By providing participants with unlimited time to make their responses, researchers are increasing the likelihood that participants will attend to the manipulated facial traits and determine that they should make their assessments using them.

If masculine faces reliably cue individuals’ threat potential, we expect that observers should demonstrate an attentional bias, such that they would rapidly and automatically allocate their attention to the processing of these masculinized faces at the cost of competing information. This would aid observers by prioritizing the processing of potentially dangerous individuals and enable them to engage in steps necessary to mitigate the threat. If masculinized men’s faces are indicative of threat, then observers should demonstrate an effect which is akin to the Threat Superiority Effect (TSE), whereby they automatically allocate their spatial attention to these faces (over unmodified or feminized ones) even when not instructed (Eastwood, Smilek, & Merikle, 2001; Fox, 1996; Hansen & Hansen, 1988; Mogg & Bradley, 1999; Öhman, Flykt, & Esteves, 2001). The purpose of the current experiments is to determine if masculinized men’s faces are more effective at capturing observers’ attention than feminized or unmodified ones, even when these faces are presented as irrelevant information (i.e., stimuli which are not central to task completion). Apart from avoiding the demand characteristics that could be associated with the task if the information is made relevant, we chose to present the faces as task irrelevant information because it allowed us to study whether masculinized faces were effective at capturing observers' attention.

1.2, Threat Advantage Hypothesis

Attention's primary function is to direct limited cognitive resources toward features that are most relevant to the organism (Fox, 2002). Because information selected for further processing guides individuals' actions, it is essential that attention is allocated to survival relevant information (Fenske & Eastwood, 2003). When it is directed towards a specific object or location, it acts like a spotlight increasing cognitive processing for the object or spatial location (Carlson & Reinke, 2008; O'Craven et al., 1999). Spatial selective attention is the direction of cognitive resources and amplification of cognitive processing at specific areas of visual space (Carlson & Reinke, 2008).

Socially relevant cues, such as angry or fearful facial expressions elicit a TSE. Observers are faster to orient their attention to fearful rather than neutral or happy faces (Carlson & Reinke, 2008; Fox, 2002), and to find angry faces within neutral and happy faced crowds (Ceccarini & Caudek, 2013; Hansen & Hansen, 1988). Together, these results provide evidence that individuals have an attentional bias for social threat (e.g., Fox et al., 2002). Individuals with high trait anxiety (i.e., those who should be hypersensitive to cues of threat) fixate longer on angry faces than happy or neutral ones, indicating that these individuals have a greater attentional bias to social threat cues (Fox, Russo, & Dutton 2002).

Here, we test if masculinized faces elicit an effect akin to the TSE (e.g., Mogg, et al., 1993). Our experiments have the potential to extend the results of force-choice paradigms because we examine whether masculinized faces are highly salient to observers' even when they are presented as task-irrelevant information. We predict a similar bias for characteristics towards masculinized men's faces relative to feminized ones, because physically dominant men represent a threat to individuals' survival (Little et al., 2015; Sell et al., 2008; Toscano et al., 2014; Van Dongen & Sprengers, 2012). Recent research has demonstrated that facial sexual dimorphism affects the amplitude and latency of event related potentials (ERPs) involved in face processing (Cellerino et al., 2007; Welling, Bestelmeyer, Jones, DeBruine, & Allan 2017) and that masculinized faces' gaze direction affects participants letter classification speed, suggesting that facial sexual dimorphism effects selective attention. Albert and colleagues (2021) showed that men had the capacity to judge the physical dominance of men when their faces were presented individually and for a brief duration (i.e., 100 *ms*). Although this study relied on explicit ratings, it went beyond forced-choice designs because observers were not given an unlimited amount of time to inspect each face. Rather, the time of presentation was just within the limits of the ability to make an accurate assessment (cf., Todorov, Pakrashi, & Oosterhof, 2009). This investigation provided evidence that observers can make dominance assessments following brief visual exposure and provided a basis for the current investigation.

1.3, Current Study

In the current series of experiments, we present faces manipulated on their sexual dimorphism for a brief duration to assess if their presentation affected observers' selective attention.

Informed by the research on the TSE, we test if faces varying on sexual dimorphism affect observers' selective attention when presented as irrelevant information. To measure the effect of facial sexual dimorphism on selective attention, we conducted three experiments using experimental paradigms common in TSE research; the Posner Cueing Paradigm (Sui & Liu, 2009; Posner, Snyder, & Davidson, 1980), the Flanker Task (Chen, Yoa, Qian, & Lin 2016;

Grose-Fifer, Rodrigues, Hoover, & Zottoli, 2013) and the Dot Probe Task (Carlson & Reinke, 2008; Koster, Crombez, Verschuere, & De Houwer, 2004; MacLeod & Mathews, 1988). Since masculinized men's faces are indicative of threat (Han et al., 2017), we predict observers should demonstrate a TSE whereby they automatically attend to masculinized men's faces. Furthermore, we sought to account for individual difference variables that could affect the degree of TSE participants experienced, including their trait anxiety (Beall & Herbert 2008; Fox, et al., 2002) and self-perceptions of their physical dominance (Watkins et al., 2010). In the last experiment we also added contextual factors of a threatening situation, to determine if priming participants with fear could make them more sensitive to masculinized faces.

2 General Methods

2.1, Ethics Statement

The four experiments were approved by [*Institution Blinded for Review]* in accordance with the declaration of Helsinki for the ethical treatment of human subjects. Participants provided informed consent prior to beginning each experiment.

2.2, Materials

2.2.1, Stimulus Creation

For Experiments 1-3, we used 109 photographs from the *[Institution Blinded for Review]* Face Set. The methodology used closely followed *Authors Blinded for Review* et al. (2017). As a part of a study on health and human mating, 167 men between 18 and 39 (M_{age} = 22.71 SD_{age} = 4.71) were photographed with a neutral facial expression. To take facial photographs, the researchers used a 16-megapixel Nikon CoolPix L830 digital camera. Men in the study were photographed from a standardized distance of two meters, using standardized lighting and against a neutral backdrop. One-hundred nine facial photographs were selected for use. Selection criteria were that the photographs were of White men with no facial scars, jewelry, and minimal to no facial hair. Photographs were originally 4608 × 3456 pixels in size. These were cropped and resized to be 1350×1350 pixels in size to match the London Face Set photographs. We selected 33 neutral frontal facial photographs of White men from the London Face Set, giving us a total of 142 facial photographs (i.e., 109 photographs from the *[Institution Blinded for Review]* and 33 London Face Set photographs) for transformation (DeBruine & Jones, 2017). The London Face Set contains 102 adult faces 1350×1350 pixels in full color. For a detailed description of methods used to obtain facial photographs for this face set please see DeBruine and Jones (2017).

We used Psychomorph (version 6; Tiddeman et al., 2001) to delineate face shape by placing 189 landmark points along contours of major facial features. Next, we aligned pupil position for each photographed face on the same *x-y* plane. We used prototype-based image transformations to manipulate facial photograph sexual dimorphism. To create the masculinized and feminized versions 75% of the linear differences in the 2D shape between symmetrized versions of the male and female prototype faces were added to or subtracted from each original photograph (e.g., Jones, DeBruine, Main, Little, Welling, Feinberg, & Tiddeman, 2010). The prototype faces were obtained from DeBruine (2017); technical details for the computer graphic methods used to transform two-dimensional face shape in this way are given in Tiddeman et al. (2001) and Perrett et al. (1998). This process generated two faces per original facial photograph, resulting in 284 morphed faces (i.e., 142 masculinized and 142 feminized men's faces). We placed a mask around the face outline so that hair and clothing cues were not visible. Please see Figure 1 for a schematic of the face transformation process and Figure 2 for an example of the facial photographs used in the experiments.

[Insert Figure 1 Here]
[Insert Figure 2 Here]

2.2.3, Apparatus.

Participants were tested individually. All testing took place at a single computer station (Lenovo ideacentre). We used a chin rest to ensure that all participants sat 57 cm from the computer monitor. Participants viewed the facial photographs on a Lenovo 24-inch LED FHD computer monitor, with a 60Hz refresh rate and 1920 × 1080 screen resolution. Psychopy (version 3.2.3; Peirce, et al., 2019) was used to present stimuli and record participants' responses for all experiments. Participants made their timed responses with a Cedrus RB-740 response pad (Experiment 1 to 3) or the keypad (Experiment 4).

2.2.4, Questionnaires.

For Experiment 1 to Experiment 3 participants completed the State Trait Anxiety Inventory (STAI; Speilberger, 1983; Spielberger, 1989) and the International Personality Item Pool (IPIP; Golberg 1999). For internal consistencies see the Supplement (S1.1).

2.3, Sample Size Determination

Sample size was determined before any analysis was made. A power analysis using G*Power 3.1.9.7 (Faul, Erdfelder, Buchner, & Lang, 2009; d =.49, α = .05, and Power 1 - β = .80), using the results of participants' reaction time (RT) from Jones et al. (2010) revealed that a minimum sample of 28 participants were needed for each experiment. For all experiments we exceeded the minimum sample size by collecting data from between 41 and 57 university students. For Experiment 1 to Experiment 3, all participants were male. In Experiment 4, we collected data from 31 females to test if participants' sex affected attention to morphed facial photographs.

2.4, Data Screening

For all four experiments, we removed incorrect trials from the datasets. Next, we winsorized the data by removing all RTs that fell outside of ± 2 SD from participants' mean RT.

2.5, Distribution Estimation of RT

To increase the generalizability of our findings, we did not transform RT data despite high kurtosis (cf., Lo & Andrews). Rather, we used the *descdist* function from the *fitdistrplus* in R (Muller & Dutang, 2015) to estimate which distribution participants' RT best conformed to, and which family to specify our generalized mixed-effects linear models (GLM). More information on the process of determining the correct distribution to specify for our GLMs is given in the supplement. In all 4 experiments, we specified the family type as Gamma in our generalized linear mixed effect model, which is common and widely accepted in GLMs conducted on RT data (cf., Lo & Andrews 2015; Ng & Cribble 2017). For more on the distribution estimation of RT please see the Supplement (S1.2).

2.6, Analytic Plan

We conducted all analyses using R (either version 3.6.2 or 4.02; R core team). For all four experiments, we conducted multilevel GLM with Maximum Likelihood estimation using *glmer* function from the package, *lme4* (Bates, Maechler, Bolker, & Walker 2015). We specified our random effects as Subject (level 2) and Cue Image (level 1) in our multilevel GLMs in all four experiments. Our models were a 2-level random intercepts model in which the image for the trial (i.e., cue image) is nested within subjects. RT was the dependent variable in all four experiments. For a detailed description for our analytic plan of the four experiments please see the Supplement (S1.3).

3 Experiment 1: Posner Cueing Paradigm

3.1, Hypothesis

Targets were the focal information, either shapes or letters, participants must make a classification during the cognitive task. Participants were told to judge whether a square or a diamond was presented on the screen. The shape participants were required to judge was called the target shape. We predicted that observers would be faster to classify target shapes when a masculinized face cued target location and slower when a masculinized face cued the opposite location.

3.2, Methods

3.2.1, Participants.

Participants were 45 right-handed male students from [*Institution Blinded for Review]* between the ages of 18 and 26 (M_{age} = 19.67, *SD* = 1.77). Participants were primarily recruited through the institution's research participation pool (SONA). The remaining participants were recruited via advertisements placed throughout *the Blinded Institution* campus, and through online job ads for *Blinded Institution* students. Remuneration was either 20.00 USD, or 1 credit hour. For experiment Design and Stimulus Presentation please see the Supplement (S2.1 and S2.2).

3.2.2, Procedure.

Figure 3 provides a trial schematic for the Posner Cueing Paradigm. Each trial began with a central fixation cross (subtending 0.75˚of visual angle) for 500 *ms*. This was followed by the 100 *ms* presentation of either a masculinized or feminized man's face (4.52˚ horizontally and 6.03˚ vertically), right or left of center screen. A 33 *ms* inter-stimulus interval (ISI) separated the face and target shape. The target shape, either a diamond or a square (1.00˚of horizontally and vertically), was presented in the same screen position as the presented face, or the opposite position. Participants' objective was to classify the shape as either a diamond or a square as quickly and accurately as possible by pressing the corresponding key on a Cedrus RB-740 response pad. The keys to classify diamonds and squares were counterbalanced. By presenting the target shape in the exact same spatial location as the face in half of the trials, we were assuming that the masculinized face would facilitate attentional capture more effectively, resulting in either facilitated performance when the shape was presented in the exact same location or inhibited performance when it was presented in the opposite location. Target shape (i.e., diamond or square), Trial Type (i.e., whether the shape was in the same or opposite location of the face) and Morph Type were randomized. The next trial began after a 500 *ms* inter trial interval. Following ten practice trials, participants completed eight blocks of 71 trials (i.e.,568 trials) of the Posner Cueing Paradigm. Participant accuracy was 90.50%. For a rational for our specific Posner Cueing Paradigm Design, Data Screening, and our Analytic Plan see the Supplement (S2.3, S2.4, S2.5).

[Insert Figure 3 Here]

3.3, Results

Table 1 shows means and standard deviations of observers' RT by Morph Type and Target cue, and Table 2 shows the fixed effects and interactions of the GLM. Table S1 shows the random effects of the GLM (Supplement). The main effect of Morph Type was outside the cut-off for conventional levels of statistical significance. There was a significant difference in classification speed as a function of Trial Type and Target Cue. Observers were faster to classify the shape when it appeared in the congruent position and were also faster to classify the shape when it appeared in the right visual field. None of the interactions between Morph Type, Trial Type and Target Cue were significant.

[Insert Table 1 Here]

[Insert Table 2 Here]

3.4, Experiment 1: Discussion

We were unable to find an effect of facial sexual dimorphism on participants RT. Facial sexual dimorphism did not produce an observed difference in participants RT to classify shapes. Participants with high-trait anxiety were slower to classify shapes. Observers who scored higher on self-reported physical dominance were also slower to classify shapes. We made no specific predictions about the direction of the relationship between dominance, anxiety, and participants RT during the Posner Cueing Paradigm. Instead, these variables were entered into our regression to control for them when accounting for participants' responses to masculinized faces.

4, Experiment 2: Flanker Task

In Experiment 2, The Flanker Task, we used a simplified design to test how facial sexual dimorphism affected participants' selective attention. We conducted a modified Flanker Task in which participants had to classify the orientation of a centrally presented letter, as either upright or upside down, while it was being flanked by two faces of the same Morph Type. We use a Flanker Task to reduce the number of fixed factors in our analysis and ease the interpretability of our findings. By presenting the same version of men's faces on both sides of the target letter we eliminated the need to account for the position of the target relative to the presented faces.

A limitation of Experiment 1 was the face was only presented for 100 *ms*, meaning that participants may not have directed their gaze quickly enough to the face. In contrast, in Experiment 2 we chose to have both the target letter and the faces remain on the screen until the participants made their classification. Because the faces were at the periphery and not the center of attention any slowed reaction time to classify letters would reflect attentional capture. Moreover, our design in Experiment 1 did not permit us to determine if masculinized faces facilitated attention or feminized faces inhibited attention. In Experiment 2, we included pairs of unmodified faces as a control condition which we could use to contrast observers' RTs in the masculinized and feminized face conditions.

4.1, Hypothesis

If masculinized men's faces are more effective at capturing selective attention, we expected that observers would be slower to direct their attention away from masculinized flanking faces while classifying a centrally presented target letter, than when either feminized or unmodified faces flank the target letter.

4.2, Methods

4.2.1, Participants.

Participants were 44 right-handed male students from *Institution Blinded for Review* ages 18 to 27 (M_{age} = 19.81, *SD* = 2.28). Participants were recruited in the same manner as Experiment 1. Remuneration was either 30.00 USD, or 1 credit hour. For a description of stimulus presentation and experimental design see the Supplement (S3.2, S3.3).

4.2.2, Procedure.

Figure 4 provides a trial schematic for the Flanker Task. Each trial began with a centrally presented fixation cross (subtending 0.75˚of visual angle) for 500 *ms*. A letter (i.e., a capital L or T) was presented at center screen with identical face images (0.50˚ horizontally and vertically), on both sides of the target letter. Participants' objective was to classify letter orientation as either upright or upside-down as quickly and accurately as possible with a key press. Our rational for using a capital 'L' and 'T' was to increase task complexity since each letter resembles the other when upside down. The faces and the target letter remained on the screen until the participant made his classification. The presentation of an L or T, Letter Orientation (i.e., whether the letter was presented at 0˚ or 180˚) and Morph Type were randomized. A 500 *ms* inter-trial interval separated trials. After completing ten practice trials, participants completed 12 blocks of 71 trials (i.e., 852 trials). Participant accuracy was 94.64%. For Data Screening and the Analytic Plan of Experiment 2 please see the Supplement (S3.4, S3.5).

[Insert Figure 4 Here]

4.3, Results

Table 3 shows the means and standard deviations of observers' RT by Morph Type, Table 4 for the fixed effects and interactions of the GLM and Table S2 for the random effects of the GLM in the Supplement. The main effect of Morph Type was not significant. Observers' RT did not differ whether masculinized, feminized, or unmodified faces flanked the target.

[Insert Table 3 Here]

[Insert Table 4 Here]

4.4, Discussion

The results of Experiment 2 fail to show an effect of facial sexual dimorphism on observers' RT. It could be that observers were able to successfully attend to the centrally presented letter and ignore the flanking faces, or alternatively that all types of faces were equally distracting when presented peripherally. Therefore, in Experiment 3 we sought to make the faces more difficult to ignore by presenting them in the same location as the target.

5, Experiment 3: Dot Probe Task

5.1, Hypothesis

We elected to use a Dot Probe Task in which participants were presented with two faces, one of which would cue the target shape's location. In the past two experiments, we only presented observers with faces from one Morph Type. To provide evidence that masculinized faces are processed at the cost of competing information, it is important to test whether masculinized men's faces are more effective when competing facial images of other Morph Types are also presented. This would demonstrate that masculinized facial features capture attention when all other factors are held constant. In Experiment 3, we sought to assess whether masculinized faces are more effective at capturing observers' attention when competing with either a simultaneously presented unmodified or feminized face.

By presenting the target shape in the exact same spatial location as one of the faces, we were assuming that the face in the pair that has a higher degree of facial masculinity will facilitate attentional capture more effectively (i.e., masculinized relative to unmodified or feminized, and unmodified relative to feminized), resulting either in facilitated performance when the shape is presented in the same location or inhibited performance when it is presented in the opposite location. We predicted that participants will be fastest to classify the target shape when it has been cued by the more masculine face in the pair.

5.2, Methods

5.2.1, Participants.

Participants were 41 right-handed male students from *Institution Blinded for Review* between the ages of 18 and 27 (M_{age} = 20.00, *SD* = 2.13). Participants were recruited in the same way as the above experiments. Remuneration was either 30.00 USD, or 1 credit hour. For a description of Stimulus Presentation and Design see the Supplement (S4.1, S4.2).

5.2.2, Procedure.

Figure 5 provides a trial schematic for the Dot Probe Task. Each trial began with a centrally presented fixation cross (subtending 0.50˚of visual angle) for 500*ms*. Then participants were presented with both masculinized and feminized versions of the same man's face to the left and right of center screen for 100 *ms*. The face and the target shape were separated by a 33 *ms* ISI. Next, the target shape (either a diamond or a square; 0.50˚ horizontally and vertically) was presented in the same screen position as one of the faces. The shape remained on the screen until the participant made his classification. Participants' objective was to classify the shape as quickly and accurately as possible. The Target Shape (i.e., diamond or square), Target Cue (i.e., appeared under the more masculine or feminine face) and Target Position (i.e., left, or right) were randomized. After completing the trial, the next trial began following a 500 *ms* inter-trial interval. Following 10 practice trials, participants completed 12 blocks of 71 trials (i.e., 852 trials). Participant accuracy was 95.00%. For Data Screening and the Analytic Plan of Experiment 3 please see the Supplement (S4.3, S4.4).

[Insert Figure 5 Here]

5.3, Results

Table 5 shows means and standard deviations of observers' RT by Target Cue and Target Position, Table 6 shows the fixed effects and interactions, and Table S3 shows the model's random effects. The main effect of Trial Type was significant. Observers were slower to classify shapes in the masculinized face vs. unmodified face condition relative to the feminized face vs. unmodified face (Table 6). There was as a significant, albeit very slight (i.e., approximately 1 *ms*) effect of Target Cue. Participants RT was faster when the more masculine face in the pair cued target position (Table 5).

Regarding the level 2 fixed effects, trait anxiety was a significant negative predictor of participants RT, indicating that observers who reported higher trait anxiety were slower at classifying target shapes. The Target Cue × Target Position interaction was significant. To explore the significant Target Cue × Target Position interaction we used the *lsmeans* function of the *lsmeans* package (Lenth, 2016). Observers were faster to classify shapes when they were cued by the more masculine face in the right visual field, than when they were cued by the more masculine face in the left visual field ($z = -4.15$, $p < .001$). Participants were faster to classify shapes when the more masculine face in the pair cued the target and was presented in the right visual field contrasted to when the less masculine face in the pair cued the target shape and was presented in the left visual field ($z = -3.00$, $p = .01$). Participants were faster to classify shapes when the less masculine face in the pair cued the shape and was presented in the right visual field contrasted to when the more masculine face in the pair cued the shape and was presented in the left visual field ($z = -3.43$, $p = .003$).

[Insert Table 5 Here]

[Insert Table 6 Here]

5.4, Discussion

Although observers were faster to classify shapes when a more masculinized face cued target position this difference was minimal (i.e., approximately 1 *ms*). When inspecting the Target Cue × Target Position interaction observers were faster to classify shapes when they appeared in the right visual field, but this occurred regardless of Target Cue. In Experiment 4 we elected to repeat the Dot Probe Task and prime participants with images meant to induce fear or arousal before each trial.

6, Experiment 4: Modified Dot Probe Task with IAPS Priming

In the previous three experiments we were unable to find an obvious affect that highly masculine faces biased observers' selective attention. When considered with findings that masculinized faces are rated as more dominant (Todorov et al., 2015; Watkins et al., 2010) and threatening (Han et al., 2017) and with studies documenting relationships between facial masculinity and formidability (e.g., Little et al., 2015; Sell, et al., 2008; Toscano, et al., 2014; Van Dongen & Sprengers, 2012), observers should show an attentional bias towards masculinized faces because these faces cue threat. Our results were at odds with the hypothesis because we did not find evidence for enhanced selective attention to masculinized faces. Based on these null findings, we sought to improve upon our previous experimental design. We reasoned those masculinized faces on their own may not have been sufficient to elicit a threat response. Without contextual factors of a threatening situation, it could be that masculinized faces were not salient to observers.

Therefore, in Experiment 4 we repeated our Dot Probe task, but improved upon it by priming participants with images meant to induce threat or feeling of arousal at the beginning of each trial. We presented images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) to induce fear (experimental condition) and arousal (control condition) to see if priming participants with fear-inducing images made them more attentive to potential threat in their environment (i.e., the masculinized men's faces). The arousal condition was the control condition because threatening images cause heightened arousal in addition to a fear response. We also varied the presentation time of the faces during the Dot Probe Task such that half of the participants viewed the face pairs for 100 *ms* and the other half viewed the face pairs for 250 *ms*. We varied the presentation time of the faces, such that half of the participants viewed the facial photographs for 100 *ms*, which we expected would produce a cueing effect for congruent targets (Carlson & Reinke, 2008; Koster, et al., 2004; MacLeod & Mathews, 1988). The remaining participants viewed facial photographs were 250 *ms*, which we expected would produce an inhibition of return response for congruent target shapes (Posner, Rafal, Choate, & Vaughan, 1985). We expected participants to be slower to classify target shapes when masculinized faces cued the target shape and were presented for 250 *ms* because they would initially fixate on the masculinized face and then shift their attention. Additionally, we used a mixed-sex sample to evaluate how participant sex affected their selective attention to masculinized faces.

6.1, Hypothesis

We expected that all participants should show a bias to selectively attend to masculinized faces, and we expected this effect to be greatest when primed with images meant to elicit threat. For participants viewing faces for 100 *ms*, this would be demonstrated by participants faster classification of target shapes when they appeared in the position congruent with the more masculinized face. Whereas, when facial photographs were presented for 250 *ms* we expected that participants would show an inhibition of return effect and be slower to classify the target shapes when they appeared in the position congruent with the more masculinized face. Because women have lower levels of upper body strength relative to men, we expected them to demonstrate greater selective attention to masculinized faces (Lassek & Gaulin, 2009).

6.2, Materials

6.2.1, Facial Photographs and Stimulus Creation.

For this experiment we selected 33 neutral frontal facial photographs of White men from the London Face Set (DeBruine & Jones, 2017). The process for morphing faces was the same as that described in the General Methods section; however, because we only used the 33 neutral frontal facial photographs of White men from the London Face Set (DeBruine & Jones, 2017), to reduce the number of trials in Experiment 4, the resulting number of morphed faces was 66 (i.e., 33 masculinized and 33 feminized men's faces). Images were then masked around the outline of the face so that hair and clothing cues were not visible**.**

6.2.2, International Effective Picture System.

For the two prime conditions, threat, and arousal, we selected photographs from the International Affective Picture System (IAPS; Lang, et al., 2008). The IAPS was developed to provide a normed set of emotional stimuli to be used by researchers studying emotion, attention, and perception. It contains 2364 images designed to elicit emotions. All images in the IAPS have been pre-rated by a large sample of men and women on arousal, valence, and dominance. For the threat condition we selected images 3530, 6244, 6250, 6312, 6314, 6315, 6350, 6520, 6540, 6571, and for the arousal condition 8001, 8021, 8031, 8040, 8090, 8179, 8185, 8186, 8193, 8208, and 8220. The threat condition contained images designed to prime individuals with fear of aggression from men ($Mean_{arousal} = 6.33$, $SD_{arousal} = 0.73$). Each of the images depicted either a man with a weapon or a man attacking someone else. The arousal condition was designed to control for the heightened arousal caused by the threatening images. It contained images of people engaging in extreme sports which function to prime arousal while not priming threat ($Mean_{arousal}= 5.97$, $SD_{arousal}= 0.70$). For Data Screening and Analytic Plan of Experiment 4 please see the Supplement (S5.1, S5.2).

6.2.3, Apparatus.

The apparatus was the same as the previous experiments; however, participants made their timed responses on the keyboard rather than the Cedrus RB-740 response pad.

6.3, Participants.

Participants were fifty-seven right-handed students (25 male, 1 Prefer not to answer) from *Institution Blinded for Review* between the ages of 18 and 29 (M_{age} = 20.86, *SD* = 2.66). Participants were recruited in the same manner as the other experiments. Remuneration was 30.00 USD.

6.6, Procedure

Figure 6 provides a trial schematic for the task. As per Ohlsen, van Zoest, and van Vugt (2013), IAPS pictures (18.00˚ horizontally and 12.00˚ vertically) were presented at the beginning of each trial for 3000 *ms*. Following a 33*ms* ISI, participants were presented with two versions of the same man's face for either 100 *ms (n=28)* or 250 *ms (n=29)*. These faces were presented to the left and right of center screen. Participants were randomly assigned to a condition either the 100 *ms* or 250 *ms* presentation condition. The face images (4.52˚ horizontally and 6.03 ˚ vertically) and the target shape were separated by another 33 *ms* ISI. Next, the target shape (0.50˚ horizontally and vertically) was presented in the same screen position as one of the faces. The shape remained on the screen until the participant made their classification. Participants' objective was to classify the shape as either a diamond or a square as quickly and accurately as possible. The presentation of a diamond or a square, Target Cue and Target Position were randomized. After a 500 *ms* inter trial interval the next trial began. Following 10 practice trials, participants completed 12 blocks of 66 trials (i.e., 792 trials). Participant accuracy was 94.11%. For Data Screening and Analytic Plan of Experiment 4 please see the Supplement (S5.3, S5.4).

[Insert Figure 6 Here]

6.7, Results

Table 7 shows means and standard deviations of observers' RT by Target Cue and Target Position. Only the main effect of Sex was significant. Women showed slower RT relative to men. However, none of the other fixed effects or the interactions were significant (Table S5 in the Supplement).

[Table 7]

6.8, Discussion

There was no evidence of participants demonstrating greater sensitivity to masculinized faces even after they were primed with images meant to induce fear. Women did not show greater sensitivity to masculinized faces than did men. Despite using well validated stimuli to induce fear in our participants, we did not find that they showed a bias to selectively attend to more masculine faces regardless of face presentation time or sex.

[Insert Table 7 Here]

7, General Discussion

The purpose of the current investigation was to test the effect of facial sexual dimorphism on observers' perceptions in a way that limited the effects of demand characteristics. If facial sexual dimorphism is a salient factor which informs observers' assessments of dominance, and men with more masculinized faces are perceived as more dominant and threatening, then observers should selectively attend to masculinized faces. Based on the results of the above four experiments, we fail to reject our null hypothesis, individuals show no difference in their processing of masculinized and feminized faces. In Experiment 1, observers were not faster to classify shapes when a masculinized face cued the shape's location. In Experiment 2, observers were not slower to classify the orientation of a centrally presented letter when it was flanked by masculinized faces. Although in Experiment 3 the effect of Trial Type was significant; observers were faster to classify shapes when the more masculine face in the pair cued target position.

However, this difference was approximately 1 *ms* calling into question the practical significance of this result.

In Experiments 1 to 3 participants viewed men's facial photographs varying on sexual dimorphism without contextual factors. We reasoned that in the absence of a threatening situation people may not show a bias to attend to sexually dimorphic cues meant to signal threat, such as masculinized men's faces. In Experiment 4, we sought to improve upon the previous three experiments by inducing a threat response in our participants, by showing them images from the IAPs of aggressive men.

In Experiment 4, participants did not demonstrate a bias to attend to masculinized faces even after being primed with an image meant to invoke a fear response (Lang et al., 2008). Our findings are not what we would expect based on previous research testing the effects of facial sexual dimorphism on participants' threat and dominance perceptions. Previous research has demonstrated that individuals' threat judgements of men are an accurate index of their upper body strength (Sell et al., 2009), suggesting that they can make accurate inferences of individuals' upper body strength solely from the face. Physical dominance ratings are highly correlated with their estimates of upper body strength, suggesting that observers view an individual's dominance as being highly related to their strength (Toscano et al., 2014). Furthermore, objective measures of facial masculinity are related to men's upper-body strength, suggesting that it is not only observers' perceptions of men's masculinity, but also their craniofacial morphology, which reliably indexes upper body strength. Faces are a more reliable index of threat potential than are other cues involved in dominance assessments, such as the human voice (Han et al., 2017). When considered with findings that masculinized faces are rated as more dominant (Todorov et al., 2015; Watkins et al., 2010) and threatening (Han et al., 2017) and with studies documenting relationships between facial masculinity and formidability (e.g., Little et al., 2015; Sell, et al., 2008; Toscano, et al., 2014; Van Dongen & Sprengers, 2012), observers should possess an attentional bias towards masculinized faces because these faces cue threat. However, the results of the current experiments do not support this hypothesis, as we did not find evidence for enhanced selective attention to masculinized faces.

Based on the results of the four experiments we fail to demonstrate that masculinized faces are perceived as threatening. Previous research on the TSE used stimuli that reliably signals danger to the individual, such as snakes (Fox, 2002), or angry faces (Carlson & Reinke, 2008; Ceccarini & Caudek, 2013; Fox, 2002; Hansen & Hansen, 1988). In the current series of experiments participants were required to engage in up-stream processes in which they must link images of masculinized men's faces with the concept of threat. It is likely that masculinized men's faces without the context of a threatening situation are not sufficient to produce a TSE. Over the course of four experiments, we were unable to find any evidence that masculinized men's faces are more effective at capturing observers' attention. Although masculinized faces may be rated as more threatening observers do not demonstrate the TSE. Future investigations could analyze how facial sexual dimorphism together with facial expression affect observers threat perceptions. Perhaps masculinized men's faces with angry facial expressions could elicit a TSE.

7.1, Limitations and Future Directions

This study has several limitations which provide a basis for future research. In the current investigation we did not test observers' threat perceptions of the presented stimuli. Therefore, even if observers did show a bias for masculine faces, we could not conclude that such a bias was because participants perceived them as more threatening. All we could conclude would be that more masculine faces are more effective at capturing observers' attention. In previous investigations we have found that the masculinized versions of the faces which we used in the current experiments were rated as more physically dominant than the feminized versions by a group of comparable male students, even when these faces were presented for 100 *ms* (*Authors Blinded for Review,* 2021). Furthermore, we have found that men and women rate masculinized men's faces as appearing more dangerous than the feminized versions. These findings would suggest the presentation time used for the four experiments was enough for observers to make their threat evaluations *(Authors Blinded for Review, 2021*; Todorov, Pakrashi, & Oosterhof, 2009). Moreover, it demonstrates that a group of adults, comparable to the ones in the current study, perceived the masculinized faces as more physically dominant and more dangerous, traits closely related to observers' threat perceptions (Han et al., 2017; Sell, et al., 2008; Toscano, et al., 2014).

Our experimental designs relied on participants' RT; however, there are alternative selective attention measures that we could use, such as tracking participants' eye fixations and saccades. Future investigations could benefit by testing if observers are more likely to fixate on masculinized faces using an eye tracking paradigm. If masculinized faces reliably cue threat, we expect observers would be fastest to fixate on these faces, demonstrating an attentional bias to process them. In Experiment 4, our sample size was relatively small, which could have affected our ability to capture individual differences in participants' self-perceived dominance as well as our statistical power to find an effect. Therefore, our null findings may reflect a false negative. In future investigations, we will increase our sample size to increase our chances of detecting an effect if one exists. Furthermore, using the effect size of Jones and colleagues (2010), based on mean comparisons, does not lend itself well to the models used in the current study. When estimating sample size, future investigations should employee power analysis packages for hierarchical generalized linear models such as *SIMR* (Green & MacLeod, 2016).

Furthermore, it appears that there is a disconnect between objective measures of facial sexual dimorphism, that is those global measures of facial sexual dimorphism obtain via geometric morphometrics and experimentally masculinized and feminized faces. Measures of facial dimorphism obtain via geometric morphometrics are a better predictor of perceived masculinity than are shape features hypothesized to signal masculinity (Mitteroecker, Windhager, Müller, & Schaefer, 2015). Moreover, recent research from Hester, Jones, and Hehman (2020) suggests that masculinity and femininity may not be opposing ends on a continuum, but two distinct dimensions. This would suggest that observers evaluate faces on masculinity and femininity separately, meaning that high levels of one of these dimensions need not imply low levels of the other. Future research could test how the interaction between levels of experimentally manipulated masculinity and femininity affect observers' selective attention.

7.2, Conclusion

Our study is the first to test for the presence of an attentional bias towards masculinized faces. Based on the TSE, which asserts that individuals should automatically and rapidly attend to cues of threat in their environment, and results from experiments finding that facial sexual dimorphism affects observers' perceptions of physical dominance (e.g., *Authors Blinded for Review, 2021*; Watkins et al., 2010) and threat ratings (Han et al., 2017), we expected that observers would automatically attend to masculinized faces at the cost of competing distractors. However, observers failed to show an attentional bias towards masculinized faces, it could be that masculinized faces are not perceived as threatening when presented on their own.

Furthermore, even when primed with threatening images there was no difference in participants selective attention towards masculinized faces.

Conflict of Interest Statement: On behalf of all authors, the corresponding author states that there is no conflict of interest.

Data Availability Statement: The data generated during or analysed for the current experiments are available in an Open Science Framework repository: https://osf.io/53cru/

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Table 1. Means and standard deviations (in *ms*) for participants RTs based on Morph Type, Visual Field and Congruence.

		Left		Right	
		Incongruent	Congruent	Incongruent	Congruent
Feminized	Mean	520.4601	503.3565	504.0182	503.7527
	SD	135.1052	130.7027	129.433	120.016
Masculinized	Mean	507.1689	508.6105	510.194	500.9668
	SD	129.9841	124.1839	132.8234	120.9487

Table 2. Fixed effects, standard errors and 95% confidence intervals for models testing the effects of Morph Type, Congruence, Target Position trait anxiety and trait dominance (Model 1), on observers' RT.

Model 1	***b***	***SE***	***t***	***p***	***LL***	***UL***
(Intercept)	2.14	0.04	52.75	<.001	2.06	2.22
Morph Type (Masculinized)	0.02	0.01	1.78	0.08	0.00	0.04
Trial Type (Congruent)	0.03	0.01	3.33	<.001	0.01	0.05
Target Cue (Right)	0.03	0.01	3.02	<.001	0.01	0.05
Trait Anxiety	-0.04	0.03	-1.31	0.19	-0.09	0.02
Self-reported Dominance	-0.05	0.03	-2.00	0.05	-0.10	0.00
Morph Type × Trial Type	-0.02	0.02	-0.96	0.34	-0.05	0.02
Morph Type × Target Cue	-0.02	0.02	-1.51	0.13	-0.06	0.01
Trial Type × Target cue	-0.02	0.02	-1.20	0.23	-0.05	0.01
Morph Type × Trial Type × Target Cue	0.02	0.03	0.66	0.51	-0.04	0.07

Table 3. Means and standard deviations for participants RTs based on Morph Type.

	Feminized	Masculinized	Unmodified
Mean	445.99	444.56	443.80
SD	171.40	1735.00	169.45

Table 4. Fixed effects, standard errors and 95% confidence intervals for models testing the effects of Morph Type, Letter Orientation trait anxiety and trait dominance (Model 2), on observers' RT.

Model 2	***b***	***SE***	***t***	***p***	***LL***	***UL***
Intercept	2.50	0.08	33.19	<.001	2.35	2.64
Morph Type (Masculinized)	0.00	0.01	0.42	0.67	-0.01	0.02
Morph Type (Unmodified)	0.01	0.01	0.76	0.45	-0.01	0.02
Trait Anxiety	-0.07	0.08	-0.89	0.37	-0.24	0.09
Self-reported Dominance	-0.04	0.08	-0.54	0.59	-0.19	0.11

Table 5. Means and standard deviations for participants RTs based on Target Position.

	Target Position (Feminized)	**Target Position (Masculinized)**
Mean	508.2	507.37
SD	234.56	272.62

Table 6. Fixed effects, standard errors and 95% confidence intervals for models testing the effects of Trial Type. Target Congruence, Target cue trait anxiety and trait dominance (Model 3), on observers' RT.

Model 3	***b***	***SE***	***t***	***p***	**LL**	**UL**
(Intercept)	2.20	0.04	54.38	<.001	2.12	2.28
Trial Type (Masculinized vs. Feminized)	0.00	0.02	0.13	0.90	-0.03	0.03
Trial Type (Masculinized vs. Unmodified)	-0.04	0.02	-2.24	0.02	-0.07	0.00
Target Cue (Congruent)	-0.03	0.01	-2.15	0.03	-0.06	0.00
Target Position (Right)	0.01	0.02	0.76	0.45	-0.02	0.04
Self-Reported Dominance	0.02	0.04	0.62	0.54	-0.05	0.10
Trait Anxiety	-0.09	0.04	-2.51	0.01	-0.16	-0.02
Trial Type (Masculinized vs. Feminized)×Target Cue (Congruent)	0.04	0.02	1.84	0.07	0.00	0.07
Trial Type (Masculinized vs. Unmodified) ×Target Cue (Congruent)	0.02	0.02	1.23	0.22	-0.01	0.06
Trial Type (Masculinized vs. Feminized)×Target Position (Right)	-0.01	0.03	-0.47	0.64	-0.06	0.04
Trial Type (Masculinized vs. Unmodified)×Target Position (Right)	0.03	0.03	1.28	0.20	-0.02	0.08
Target Cue (Congruent)× Target Position (Right)	0.04	0.02	2.24	0.03	0.01	0.08
Trial Type (Masculinized vs. Feminized)×Target Cue (Congruent)×Target Position (Right)	-0.05	0.03	-1.89	0.06	-0.10	0.00
Trial Type (Masculinized vs. Unmodified)×Target Cue (Congruent)×Target Position (Right)	-0.03	0.03	-1.17	0.24	-0.08	0.02

Table 7. Means and standard deviations for participants RTs based on Morph Type, Congruence, Image Condition, Picture Presentation Duration.

		Threat		**Arousal**	
		Target Right 100 *ms* Presentation Time			
		Incongruent	**Congruent**	**Incongruent**	**Congruent**
Regular v. Feminized	Mean	573.85	572.10	5674.65	577.4479
	SD	213.43	213.37	203.72	205.1697
Masculinized v. Feminized	Mean	564.79	566.39	579307	571.9522
	SD	213.27	213.15	205.8205	223.903
Masculinized v. Regular	Mean	569.03	574.01	5763413	5657698
	SD	211.55	210.45	220.2157	200.1808
		Target Left 100 *ms* Presentation Time			
		Incongruent	**congruent**	**Incongruent**	**Congruent**
Regular v. Feminized	Mean	570.61	569.18	570.04	567.60
	SD	211.32	207.71	203.40	201.57
Masculinized v. Feminized	Mean	570.49	579.38	583.19	572.41
	SD	193.98	223.51	225.93	195.93
Masculinized v. Regular	Mean	578.86	561.65	570.85	561.29
	SD	221.51	201.25	204.69	189.19
		Target Right 250 *ms* Presentation Time			
		Incongruent	**Congruent**	**Incongruent**	**Congruent**
Regular v. Feminized	Mean	517.47	519.87	520.13	522.79
	SD	202.49	201.47	224.35	205.92
Masculinized v. Feminized	Mean	517.61	521.62	531.62	517.72
	SD	196.88	195.16	214.56	186.84
Masculinized v. Regular	Mean	516.11	520.96	519.57	527.98
	SD	203.87	202.35	219.31	217.96
		Target Left 250 *ms* Presentation Time			
		Incongruent	**Congruent**	**Incongruent**	**Congruent**
Regular v. Feminized	Mean	521.08	524.87	521.92	525.55
	SD	205.12	208.76	198.23	212.10
Masculinized v. Feminized	Mean	516.38	514.88	518.59	524.64
	SD	194.28	193.95	200.10	207.15
Masculinized v. Regular	Mean	513.74	526.36	520.01	528.33
	SD	204.52	204.02	207.38	208.54

Figure 1

Figure 2

Click here to access/download;Figure;Figure2.jpg

Figure 3

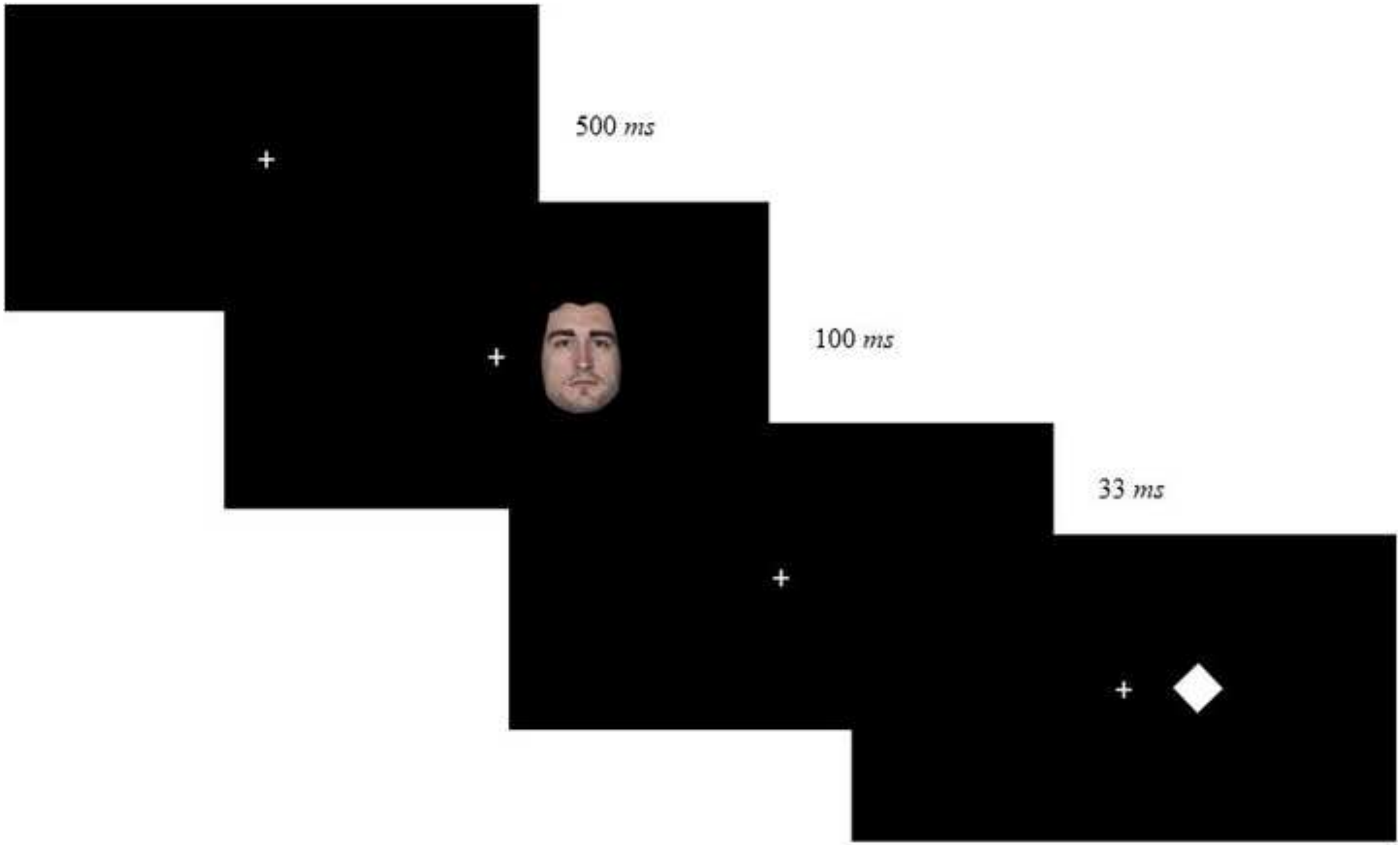

Figure 4

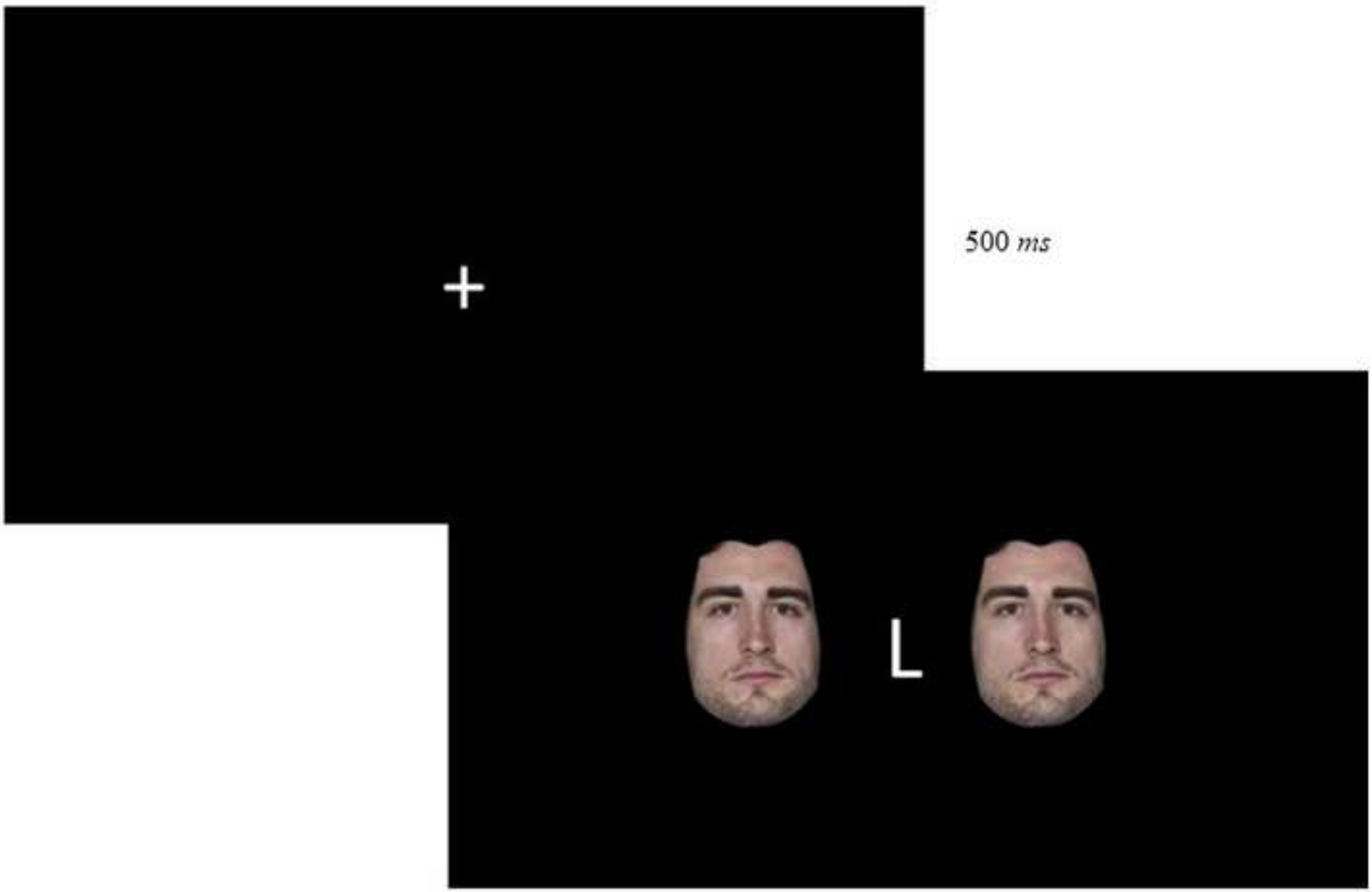

Figure 5

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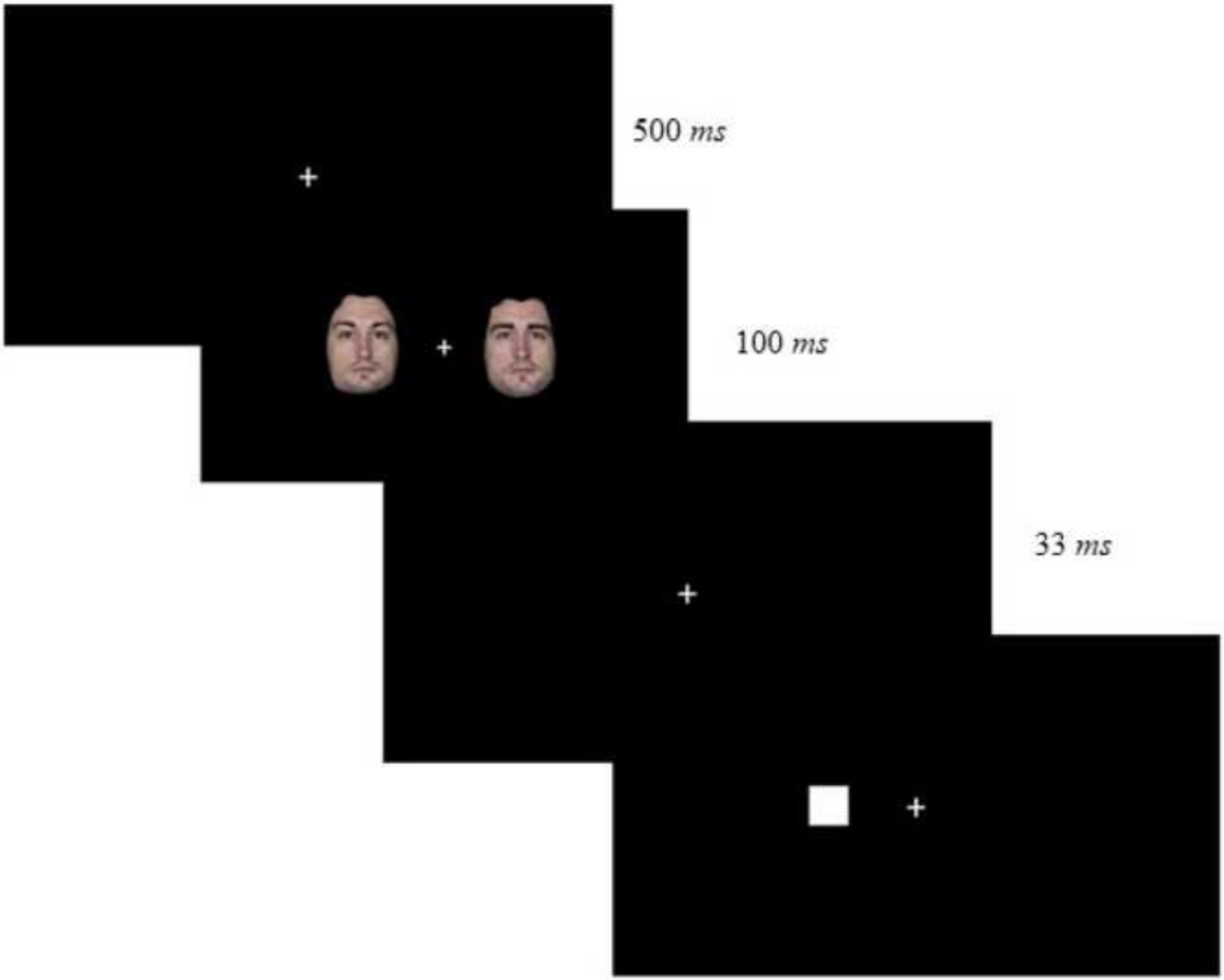

Figure 6

Click here to access/download;Figure;Figure6.jpg

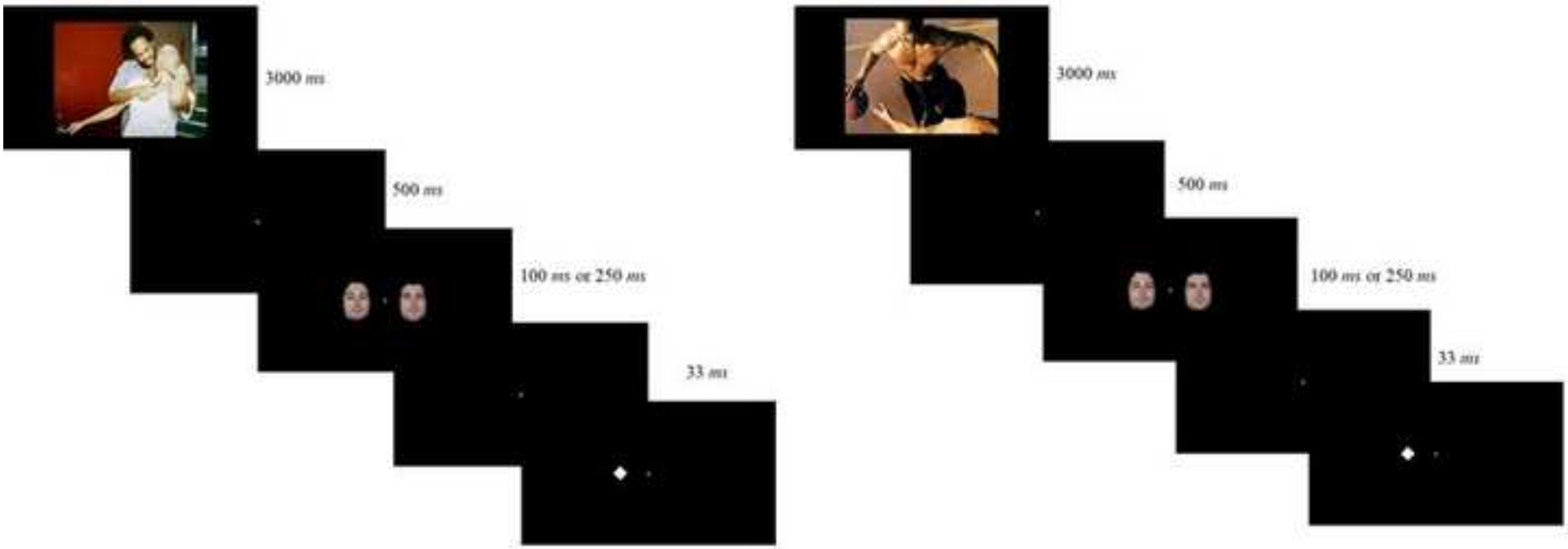

Figure 1. Illustration of the process for morphing an original facial photograph to create masculinized and feminized faces. Step 1 189 landmark points are placed on the features of the photograph. Step 2 75% of the linear differences were added to or subtracted from male and female prototype faces from the London Face Set. Step 3, which results in the production of feminized (left) and masculinized (right) faces.

Figure 2 Example images of feminized (left face of each pair) and masculinized (right face of each pair) faces from the London Face Set (Left) and the *Blinded* University Face Set (Right).

Figure 3. Trial schematic of the Posner Cueing Task.

Figure 4. Trial schematic of the Flanker Task.

Figure 5. Trial schematic of the Dot Probe Task.

Figure 6. Modified Dot Probe Task with IAPs priming images. Arousal trial schematic is on the left and the threat rial schematic is on the right.