

Fear modulates visual awareness similarly for facial and bodily expressions

Bernard M.C. Stienen and Beatrice de Gelder

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1 Running head: FEAR MODULATES VISUAL AWARENESS

2

3 **Fear modulates visual awareness similarly for facial and bodily**
4 **expressions**

5 Bernard M.C. Stienen¹, Beatrice de Gelder^{1,2}

6 ¹Laboratory of Cognitive and Affective Neuroscience, Tilburg University, Tilburg, The Netherlands

7 ²Martinos Center for Biomedical Imaging, Massachusetts General Hospital and Harvard Medical School,
8 Charlestown, Massachusetts, USA

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16

17 **Address for correspondence:**

18 Corresponding author: B. de Gelder

19 Address: Cognitive and affective neuroscience lab

20 Tilburg University

21 PO Box 90153

22 5000 LE Tilburg, The Netherlands

23 E-mail addresses: B.deGelder@uvt.nl

24

1 **Abstract**

2

3 **Background**

4 Social interaction depends on a multitude of signals carrying information about the emotional
5 state of others. But the relative importance of facial and bodily signals is still poorly understood
6 Past research has focused on the perception of facial expressions while perception of whole body
7 signals has only been studied recently. In order to better understand the relative contribution of
8 affective signals from the face only or from the whole body we performed two experiments using
9 binocular rivalry. This method seems to be perfectly suitable to contrast two classes of stimuli to
10 test our processing sensitivity to either stimulus and to address the question how emotion
11 modulates this sensitivity.

12

13 **Method**

14 In the first experiment we directly contrasted fearful, angry and neutral bodies and faces. We
15 always presented bodies in one eye and faces in the other simultaneously for 60 seconds and
16 asked participants to report what they perceived. In the second experiment we focused
17 specifically on the role of fearful expressions of faces and bodies.

18

19 **Results**

20 Taken together the two experiments show that there is no clear bias towards either the face or
21 body when the expression of the body and face are neutral or angry. However, the perceptual
22 dominance in favor of either the face or the body is a function of the stimulus class expressing
23 fear.

24

1 **Fear modulates visual awareness similarly for facial and bodily expressions**

2
3 Social interaction relies on a multitude of signals carrying information about the emotional state
4 of others. Facial and bodily expressions are among the most salient of these social signals. But
5 the relative importance of facial and bodily signals is still poorly understood. Past research has
6 focused on the perception of facial expressions while perception of whole body signals has only
7 been studied recently. Many studies now provide direct and indirect evidence for visual
8 discriminations of facial expressions in the absence of visual awareness of the stimulus (e.g.
9 Esteves et al., 1994;de Gelder et al., 1999;Dimberg et al., 2000;Jolij and Lamme, 2005;Tamietto
10 et al., 2009). For bodily expressions this is shown in healthy participants (Stienen and de Gelder,
11 in press) and hemianopic patients (Tamietto et al., 2009). Also, unattended bodily expressions
12 can influence the judgment of the emotion of facial expressions (Meeren et al., 2005;Van den
13 Stock et al., 2007) and the emotion of crowds is determined by a relative proportion expressing
14 the emotion (McHugh et al., 2011) and influences the recognition of the individual bodily
15 expressions (Kret and de Gelder, 2010). However, the relative importance of facial and bodily
16 signals and its relation to visual awareness is still poorly understood.

17
18 In this study we investigate directly the contribution of both signals in a binocular rivalry (BR)
19 experiment. BR forces perceptual alternation when two incompatible stimuli are presented to the
20 fovea of each eye separately. This perceptual alternation can be biased by factors such as
21 differences in contrast, brightness, movement and density of contours (Blake and Logothetis,
22 2002).In addition visual attendance is necessary for rivalry to occur (Zhang et al., 2011). Given
23 certain parameters the two stimuli compete with each other for perceptual dominance rather
24 creating a percept that is a fusion of both. This method seems to be perfectly suitable to contrast
25 two classes of stimuli to test our processing sensitivity to either stimulus and to address the
26 question how emotion modulates this sensitivity.

27
28 Previous BR studies have shown that meaning of the stimulus influences the rivalry pattern as
29 well (e.g., Yu and Blake, 1992). Subsequent studies have used BR to investigate dominance
30 between faces expressing different emotions (Alpers and Gerdes, 2007;Yoon et al., 2009) and
31 found that emotional faces dominate over neutral faces. In an fMRI study Tong, Nakayama,
32 Vaughan, & Kanwisher (1998) showed that the fusiform face area (FFA), a category specific
33 brain area for processing faces (Haxby et al., 1994), is activated with the same strength as when
34 the faces were presented in a nonrivalrous condition.

35
36 fMRI studies using BR in which emotional faces were contrasted showed that suppressed images
37 of fearful faces still activated the amygdalae (Pasley et al., 2004;Williams et al., 2004). When
38 visual signals are prevented to be processed by the cortical mechanisms via the striate cortex the
39 colliculo-thalamo-amygdala pathway could still process the stimulus (de Gelder et al., 1999;Van
40 den Stock et al., in press). This is in line with recent functional magnetic resonance imaging
41 studies that have suggested differential amygdala responses to fear faces as compared to neutral
42 faces when the participants were not aware (Morris et al., 1998b;Whalen et al., 1998). However,
43 to date no binocular rivalry experiments have been conducted using bodily expressions or
44 comparing body and face stimuli.

45

1 We performed two behavioural experiments addressing relative processing sensitivity to facial
2 and bodily expressions and investigated how specific emotions modulate this sensitivity. First,
3 we performed an experiment involving the rivaling of bodies and faces with fearful, angry and
4 neutral expressions. We always presented bodies in one eye and faces in the other and asked
5 participants to report what they perceived while stimuli were presented simultaneously for 60
6 seconds. In line with BR studies using facial expressions (Pasley et al., 2004; Williams et al.,
7 2004; Alpers and Gerdes, 2007; Yoon et al., 2009) we expected that emotional bodily expressions
8 would dominate over neutral expressions. The first experiment showed a special role of fearful
9 expressions and therefore we isolated this condition in a second, more sensitive, experiment. In
10 this second experiment we used the rivalry pattern resulting from the contrasting of neutral facial
11 and bodily expressions as baseline performance and created two conditions in which fearful
12 bodily expressions were contrasted with neutral facial expressions and fearful facial expressions
13 with neutral bodily expressions. We expected that the perceptual dominance of the stimulus
14 would be a function of the stimulus expressing fear.

15
16

17 **Experiment 1**

18

19 In this first experiment we contrasted bodily and facial expressions directly in a binocular rivalry
20 design in which the emotion of the faces and bodies were fearful, angry or neutral.

21

22 **Material and Methods**

23

24 *Participants*

25 Twenty-two undergraduate students of Tilburg University participated in exchange of course
26 credits or a monetary reward (19 women, 3 men, M age = 19.8 years, SD = 1.2). All participants
27 had normal or corrected-to-normal vision and gave informed consent according to the declaration
28 of Helsinki. The protocol was approved by the local Ethics Committee Faculteit Sociale
29 Wetenschappen of Tilburg University.

30

31 *Stimuli and procedure*

32 Photos of two male actors expressing fear and anger the same actors performing a neutral action
33 (hair combing) were selected from a well validated photoset as body stimuli (for details see
34 Stienen and de Gelder, in press). All body pictures had the face covered with an opaque oval
35 patch to prevent that the facial expression would influence the rivalry process. The color of the
36 patch was the average grey value of the neutral and emotional faces within the same actor. The
37 face stimuli of two actors expressing fear and anger and the same actors showing a neutral
38 expression were taken from the McArthur set (<http://www.macbrain.org/resources.htm>). A total
39 of six pictures of bodily expressions and six pictures of facial expressions were selected for use
40 in the present study.

41

42 All stimuli were fitted into an area with a white background of 3.00 degrees * 4.83 degrees
43 enclosed by a black frame of with a border thickness of .29 degrees. The function of the black
44 frame was to enhance a stable fusion. A white fixation dot was pasted on each of the stimuli.
45 Because we used a method which is comparable with the mirror stereoscope the faces and bodies

1 were pasted 11.89 degrees left and right from the center. Pairing the face and body stimuli
2 resulted in 18 unique displays (3 bodily expressions x 3 facial expressions x 2 identities).

3
4 One experimental run consisted of 36 trials because the displays were counterbalanced to control
5 for eye dominance. The trials were randomly presented. The stimuli were presented on a 19" PC
6 screen with the refresh rate set to 60 Hz. We used Presentation 11.0 to run the experiment.

7
8 The heads of the participants were stabilized using a chin and head rest. The fMRI compatible
9 binocular rivalry method we used is described in detail by Schurger (2009) but was here adapted
10 for use outside of the scanner. A black 70 cm wooden divider was placed between the screen and
11 the middle of the eyes. The total distance between the screen and eyes was 77 cm. Participants
12 wore glasses in which two wedge-shaped prism lenses of 6 DVA were fitted using gum. The
13 prisms adjusted the viewing angle from which light from the screen enters each eye ensuring that
14 the laterally presented stimuli would fall close to the participants' fovea. The wooden divider
15 was placed between the eyes to keep the visual signals separated. Besides the fact that this is a
16 low-cost method and it can be used in- and outside the MRI scanner there is no crosstalk
17 between the eyes (Schurger, 2009) as is the case with for example red-green filter glasses. See
18 Figure 1 for a picture of the experimental setup.

19
20 --- insert Figure 1 about here ---

21
22 Before each trial two empty frames were shown with a black fixation dot in the middle. The
23 participants were instructed to push and hold a button labeled "M" (Dutch for *mixture* =
24 *mengsel*) on a response box with the middle finger to initiate a trial, but only if they saw one dot
25 and one frame. This ensured that the participants fused the two black frames throughout the
26 experiment. Subsequently, a facial expression and a bodily expression were presented for 60
27 seconds. For an example display see Figure 1. Whenever they saw a face or a body in isolation
28 they were instructed to release the "M" button and push and hold the button corresponding to
29 their percept; the "G" (Dutch for *face* = *gezicht*) if they saw a face or the "L" (Dutch for *body* =
30 *lichaam*) if they saw a body with either their index or ring finger. The "G" and "L" button was
31 counterbalanced across participants and they always used their right hand. When seeing both
32 stimuli they were told to push and hold the button labeled "M" again. The program registered the
33 time the button was pressed and released. The participants were naïve regarding the presentation
34 techniques and during the experiment no reference to the emotions was made.

35
36 Previous to the experimental sessions the participants performed one practice session consisting
37 of two trials. This session used different male identities taken from the same stimulus sets than
38 the ones used in the main experiment. When the participants reported full understanding of the
39 procedures the main experiment started. A total of two runs were presented adding up to a total
40 of 72 trials. After each 10 trials there was a short break. Finally a short validation was performed
41 in a separate session after a 5 minutes break. All stimuli were presented two times for two
42 seconds adding up to a total of 24 trials (2 identities * 3 expressions * 2 face/body*2 runs).
43 Participants were instructed to categorize the bodies and faces in fearful, angry or neutral bodily
44 or facial expressions using three buttons labeled "A" for fearful (Dutch = *angst*), "B" for angry
45 (Dutch = *boos*) and "N" for neutral (Dutch = *neutraal*).

46

1 Results and Discussion

2
3 Cumulative viewing time for faces, bodies, and mixed perceptions were calculated per
4 participant irrespective of experimental condition. Two participants indicating having seen
5 mixed percepts more often than two standard deviations below the group average (group mean =
6 104 s, $SD = 34$ s) were identified as outliers and excluded from analysis. See Figure 2 for the
7 individual data.

8
9 --- insert Figure 2 about here ---

10
11 Wilcoxon Signed Ranks Tests revealed that the cumulative viewing time of faces ($M = 51$ s, SD
12 = 24 s) and bodies ($M = 52$ s, $SD = 17$ s) was equal ($Z = -.075$, $p = .940$) while the cumulative
13 viewing time was longer for mixed perceptions ($M = 111$ s, $SD = 34$ s) in comparison to bodies
14 and faces (resp. $Z = -3.696$, $p < .001$ and $Z = -3.696$, $p < .001$).

15
16 Following Levelt (1965) predominance ratios were calculated. The total time participants
17 indicated seeing the face was subtracted from the total time participants indicated seeing the
18 body. This value was divided by the total amount of time the body and the face was seen. If this
19 predominance ratio has a value of zero it would mean they equally perceived the body and the
20 face in time. A positive value means that the conscious percept of the body predominated over
21 face while a negative value means that the conscious percept of the face dominated over body.

22
23 A 3 (bodily expressions) x 3 (facial expressions) GLM repeated measurements revealed a
24 significant interaction between the bodily expressions and the facial expressions on the
25 predominance ratios ($F(4,76) = 3.877$, $p = .006$) as well as a main effect of facial expressions
26 ($F(2, 38) = 24.718$, $p < .001$). Figure 3 shows the predominance ratios when the bodily or the
27 facial expression was emotional and the other was neutral (Figure 3a), when the facial and bodily
28 expressions were the same (Figure 3b), and when the facial and bodily expressions both differed
29 (Figure 3c). A difference was deemed significant when the p -value was lower than .005
30 (Bonferroni correction: α level divided by 10 comparisons).

31
32 Figure 3a shows that when the body expressed fear and the face was neutral the participants
33 reported more often seeing the body than when the face was fearful and the body was neutral
34 ($t(19) = 2.903$, $p = .009$), but this effect did not survive the Bonferroni correction. The
35 predominance ratios were equal when the bodily or facial expression was angry. Figure 3b shows
36 that when both stimulus classes express fear the face dominates over the body compared when
37 they are both neutral ($t(19) = 3.471$, $p = .003$). Figure 3c shows that when the expressions were
38 both emotional but different (fearful and angry) the fearful body triggered a stronger conscious
39 percept of the body when the rivaling face was angry compared to when the face was fearful and
40 the rivaling bodily expression was angry in which case the conscious percept of the face
41 predominated $t(19) = 4.586$, $p < .001$). None of the conditions differed from zero.

42
43 To test the main effect of facial expressions pairwise Bonferroni corrected comparisons were
44 performed between the predominance ratios irrespective of bodily expressions. When the facial
45 expression was fearful the face dominated over the body more than when the facial expression
46 was angry or neutral ($p < .001$).

1
2 --- insert Figure 3 about here ---

3
4 A 2 (face/body) x 3 (fear/angry/neutral) GLM repeated measurements on the correct
5 categorizations in the validation task revealed a main effect of stimulus class ($F(1,17) = 14.806$,
6 $p = .001$). It appeared that the facial expressions were categorized better in general regardless of
7 expression. Because the results in the main experiment are specific for fearful expressions a
8 general effect on the recognition of faces alone cannot explain the specific effect. See Figure 4a
9 for the validation results.

10
11 --- insert Figure 4 about here ---

12
13 In line with previous reports on the special role of fearful expressions (Öhman, 2002;,
14 2005;Stienen and de Gelder, in press) the main finding of this first experiment is that the
15 stimulus class carrying the fearful expression suppresses the percept of the competing stimulus
16 more than angry and neutral expressions do. In addition, participants seemed to be equally
17 sensitive in perceiving the face and the body when the emotional expression was neutral or
18 angry.

19
20 Past research has focused on for example the perception of facial or bodily expressions in
21 isolation, but never compared these two important social signals together in one display.
22 Although Meeren et al. (2005) and Van den Stock et al. (2007) showed the influence of
23 unattended bodily expressions on the task relevant facial expressions, this study revealed how the
24 two stimuli compete for visual awareness when they are both task relevant as it the case in
25 natural situations.

26
27 There was no indication in this experiment that neutral or angry expressions modulated the
28 rivalry pattern but there were clues indicating that fearful expressions modulated the resulting
29 dominant percept. However, none of the conditions explicitly deviated from the value zero. The
30 value zero meant an equal ratio between reporting the face or the body. To create a more
31 sensitive design we repeated the first experiment but this time with only three conditions; one
32 baseline condition in which neutral facial and bodily expressions were contrasted and two
33 experimental conditions in which either the face or the body was expressing fear. By lowering
34 the amount of conditions we could increase the number of trials.

35 36 **Experiment 2**

37
38 In this experiment a baseline was created by contrasting a neutral facial expression with a neutral
39 bodily expression. This was compared when either the bodily or the facial expression was fearful
40 while the other was neutral. Although these conditions were present in the first experiment as
41 well we wanted to test these conditions in isolation. We hypothesized that based on our first
42 experiment either the body or the face will dominate depending on which is expressing fear.

43 44 **Material and Methods**

45
46 *Participants*

1 Nineteen new undergraduate students of Tilburg University who had not taken part in the first
2 experiment participated in exchange of course credits or a monetary reward (15 women, 4 men,
3 M age = 19.9 years, SD = 1.6). All participants had normal or corrected-to-normal vision and
4 gave informed consent according to the declaration of Helsinki. The protocol was approved by
5 the local Ethics Committee Faculteit Sociale Wetenschappen of Tilburg University.
6

7 *Stimuli and procedure*

8 The stimuli were the same as in the first experiment, but this time only the bodily and facial
9 neutral and fearful expressions were used. There were three conditions: a neutral body and face
10 (baseline), a fearful body and a neutral face (fearful body), and a neutral body and a fearful face
11 (fearful face). In total there were 12 different displays (2 body/face x 3 baseline/fearful
12 body/fearful face x 2 identities). One complete run consisted of 24 trials because the displays
13 were counterbalanced to control for eye dominance. A total of two runs were presented adding
14 up to a total of 48 trials. The rest of the procedure remained the same as in experiment 1.
15

16 **Results and Discussion**

17
18 Wilcoxon Signed Ranks Tests revealed that the cumulative viewing time of faces (M = 11 s, SD
19 = 6 s) was longer than for bodies (M = 7 s, SD = 3 s), Z = -3.622, p < .001. The cumulative
20 viewing time was longer for mixed perceptions (M = 23 s, SD = 8 s) in comparison to bodies and
21 faces (resp. Z = -3.702, p < .001 and Z = -2.696, p = .007).
22

23 Predominance ratios for all three conditions (baseline, fearful body, and fearful face) were
24 calculated in the same manner as the predominance ratios in the first experiment were calculated.
25 The ratio when the baseline trials were presented was subtracted from the predominance ratios of
26 the fearful body condition and the fearful face conditions.
27

28 Figure 5a shows the baseline condition where neutral bodies were contrasted with neutral faces.
29 A one sample t-test showed that the predominance ratio was not significantly different from zero
30 which means that participants equally perceived the body or the face when the expressions were
31 neutral ($t(18)$ = .085, p = .933). Figure 5b shows the modulation of the fearful expression when
32 either the neutral body or the neutral face was substituted by respectively a fearful body or a
33 fearful face. As indicated by a paired t-test a fearful body triggered a more dominant body
34 percept and a fearful face triggered a more dominant face percept ($t(18)$ = -4.60, p < .001). When
35 comparing directly to the baseline only fearful faces triggered a more dominant face percept
36 ($t(18)$ = 3.975, p = .001).
37

38 --- insert Figure 5 about here ---
39

40 A different way of analyzing the results is by considering the participants' initial percept per
41 condition (Berry, 1969; Long and Olszweski, 1999; Yoon et al., 2009). The frequency of reporting
42 a face or a body as initial percept when a trial started was indexed. Subsequently the data was
43 treated the same way as the predominance ratios.
44

45 As Figure 6 shows these results follow approximately the same pattern. When both the bodily
46 and facial expressions were neutral the reported initial percept was equally bodies and faces

1 (t(18) = -.042, $p = .967$). Figure 5b shows that as an initial percept fearful body triggered more a
2 body percept and a fearful face triggered more a face percept (t(18) = -4.60, $p < .001$). Neither a
3 fearful body nor a fearful face triggered more initial percepts of their own stimulus class when
4 directly compared to baseline performance.

5
6 --- insert Figure 6 about here ---
7

8 See Figure 4b for the validation results. Also here a 2 (face/body) x 2 (fear//neutral) GLM
9 repeated measurements revealed a main effect of stimulus class on the validation scores ($F(1,17)$
10 = 11.311, $p = .004$). It appeared that facial expression was categorized again better in general
11 regardless of emotional expression.

12
13 This second experiment shows that indeed the stimulus class expressing fear leads to perceptual
14 dominance of the stimulus class carrying this information, although the effect seems stronger for
15 the fearful faces.

17 **General Discussion**

18
19 Taken together our experiments show that there is no clear bias towards either the face or body
20 when both have either a neutral or an angry expression. When both the face and the body were
21 expressing fear participants perceived more the face compared to when both categories were
22 neutral. As especially the results of the more sensitive second experiment showed, the perceptual
23 dominance in favor of either the face or the body is a function of the stimulus class expressing
24 fear while the effect was stronger for fearful faces. In the second experiment the faces were
25 perceived longer than bodies. Finally, the validation results of both experiments show that facial
26 expressions were recognized better.

27
28 When there is no emotion expressed, the reported conscious percept of the body and face was
29 equal indicating that in this case we have equal processing sensitivity to either stimulus class.
30 Only when signals of fear are transferred by the stimulus the perceptual alternation is influenced
31 by suppressing non-fearful expressions. This is in accordance with Öhman (2002, 2005)
32 suggesting that fear stimuli automatically activate fear responses and captures the attention as
33 shown in visual search tasks where participants had to detect spiders, snakes or schematic faces
34 among neutral distracters (Öhman et al., 2001a; Öhman et al., 2001b), and real faces when the
35 emotion was not task relevant as in our study (Hodsoll et al., 2011) although this is not always
36 found in other studies (e.g. Calvo and Nummenmaa, 2008). It is known that voluntary
37 endogenous involuntary exogenous attention can modulate the rivalry pattern (Blake and
38 Logothetis, 2002; Tong et al., 2006). However, The relative dominance of perceiving bodies
39 when the body is fearful and the face is neutral in contrast when the face is fearful and the body
40 is neutral is also consistent with a recent study of Pichon, de Gelder, and Grèzes (in press)
41 showing that threatening bodily actions evoked a constant activity in a network underlying
42 preparation of automatic reflexive defensive behavior (periaqueductal gray, hypothalamus and
43 premotor cortex) that was independent of the level of attention and was not influenced by the
44 task the subjects were fully engaged in. Also, the fact that bodies expressing fear dominate the
45 visual percept is in line with our recent finding that the detection of fearful bodies is independent
46 on visual awareness (Stienen and de Gelder, in press).

1
2 The dominant perception of the faces and bodies expressing fear was mostly relative but there
3 was one case, in the second experiment, in which the conscious percept of the fearful face
4 dominated in absolute terms. Although the recognition of faces was better regardless of
5 expression in both experiments; this alone cannot explain the specific effect of fearful faces on
6 the rivalry pattern. The fearful face deviated from zero in the second experiment and not in the
7 first probably because of two reasons. Firstly, there were fewer conditions and more trials
8 increasing the signal-to-noise ration. Secondly, the fearful expressions are likely to pop-out more
9 when among neutral expressions without the angry expressions being present within the same
10 experiment. Although, as already mentioned, this pop-out effect for fearful stimuli is not always
11 found in visual search tasks using real faces.

12
13 Furthermore, it is possible that the relative proximity to the viewer of the faces in contrast with
14 bodies could explain why the face was more dominantly perceived than baseline and bodies were
15 not. As suggested earlier (de Gelder, 2006;Van den Stock et al., 2007;de Gelder, 2009) the
16 preferential processing of affective signals from the body and/or face may depend on a number
17 of factors and one may be the distance at which the observer finds himself from the stimulus.

18
19 The special status of fear stimuli is still a matter of debate, specifically in relation to the role of
20 the amygdalae (Pessoa, 2005;Duncan and Barrett, 2007). Theoretical models have been
21 advanced arguing that partly separate and specialized pathways may sustain conscious and
22 nonconscious emotional perception (LeDoux, 1996;Morris et al., 1998a;Morris et al.,
23 1998b;Panksepp, 2004;Tamietto et al., 2009;Tamietto and de Gelder, 2010). Our results are in
24 line with Pasley et al. (2004) and Williams et al. (2004) showing amygdala activity for
25 suppressed emotional faces. This hints at the possibility that the suppressed fearful faces are
26 being processed through the the colliculo-thalamo-amygdala pathway.

27
28 The underlying process may play an important role in everyday vision by providing us with
29 information about important affective signals in our surroundings. Further research using
30 neurological measures will give us insight whether the relevant pathways are indeed mediating
31 detection of fearful signals independently of visual awareness. In addition, future studies using a
32 different stimulus set or broadening the set to include other emotions would be of great value for
33 the matter of validation and to investigate the generalization of the present findings to other
34 emotions.

35

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Figure 1.TIF

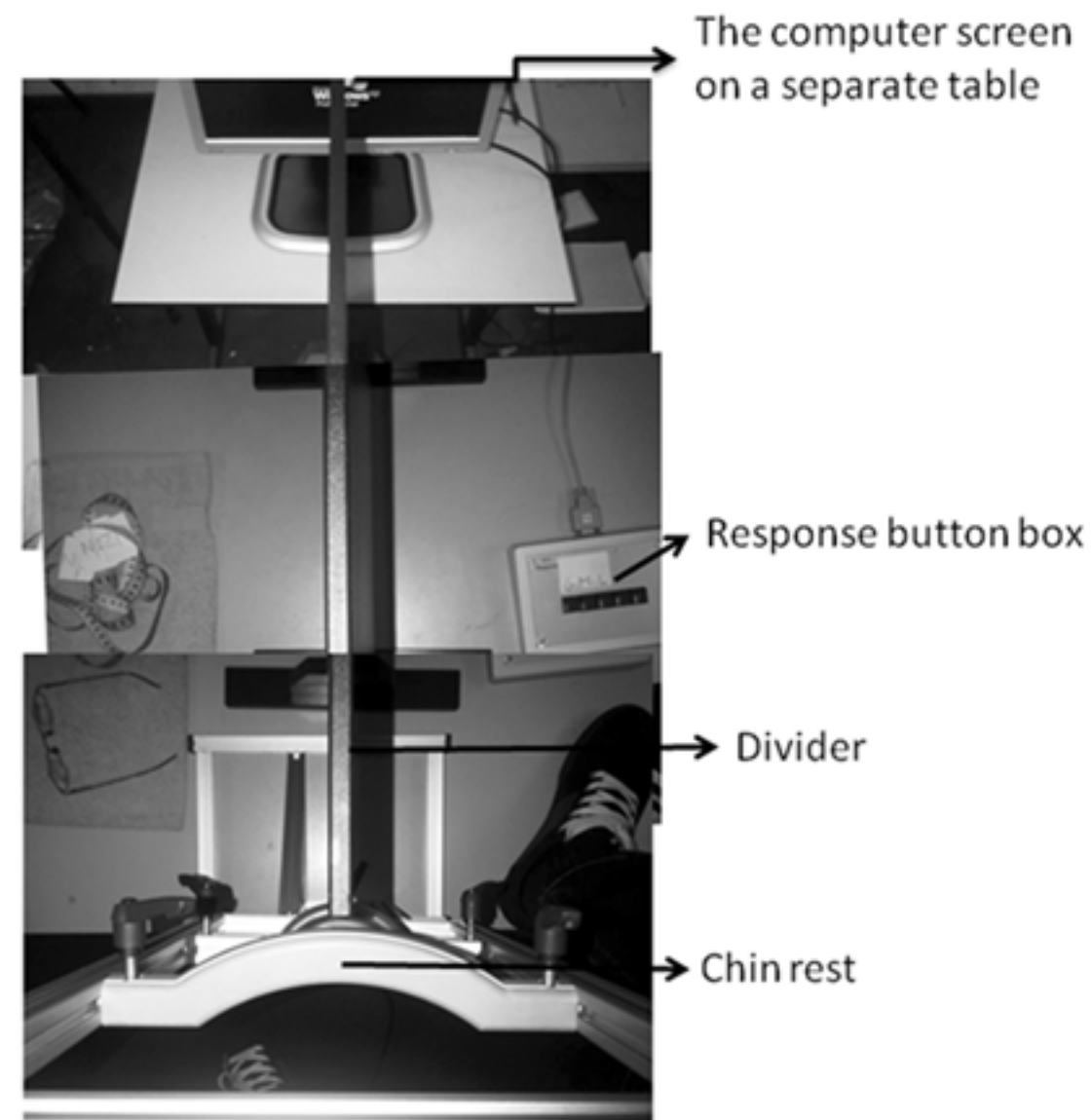


Figure 2.TIF

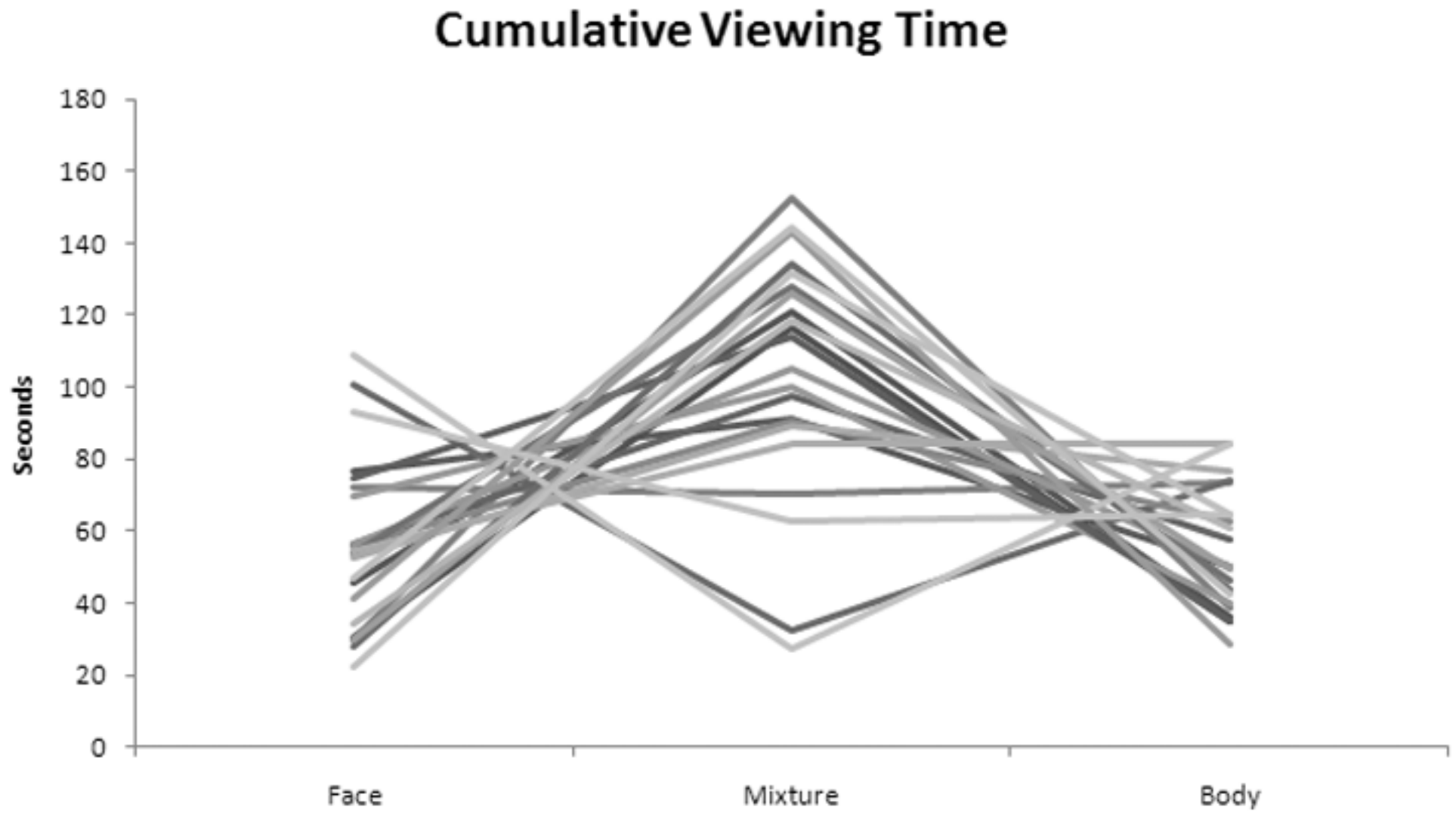


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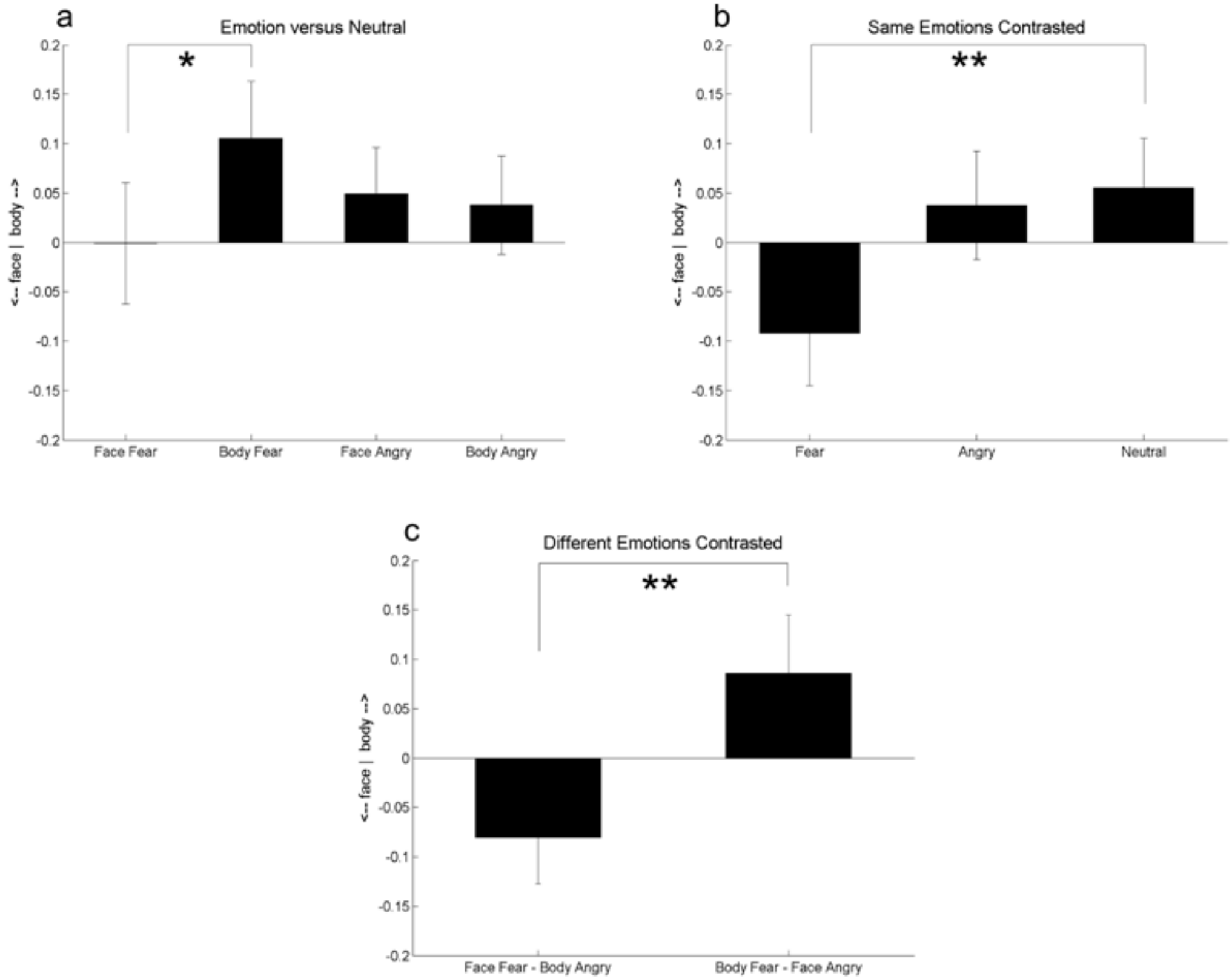
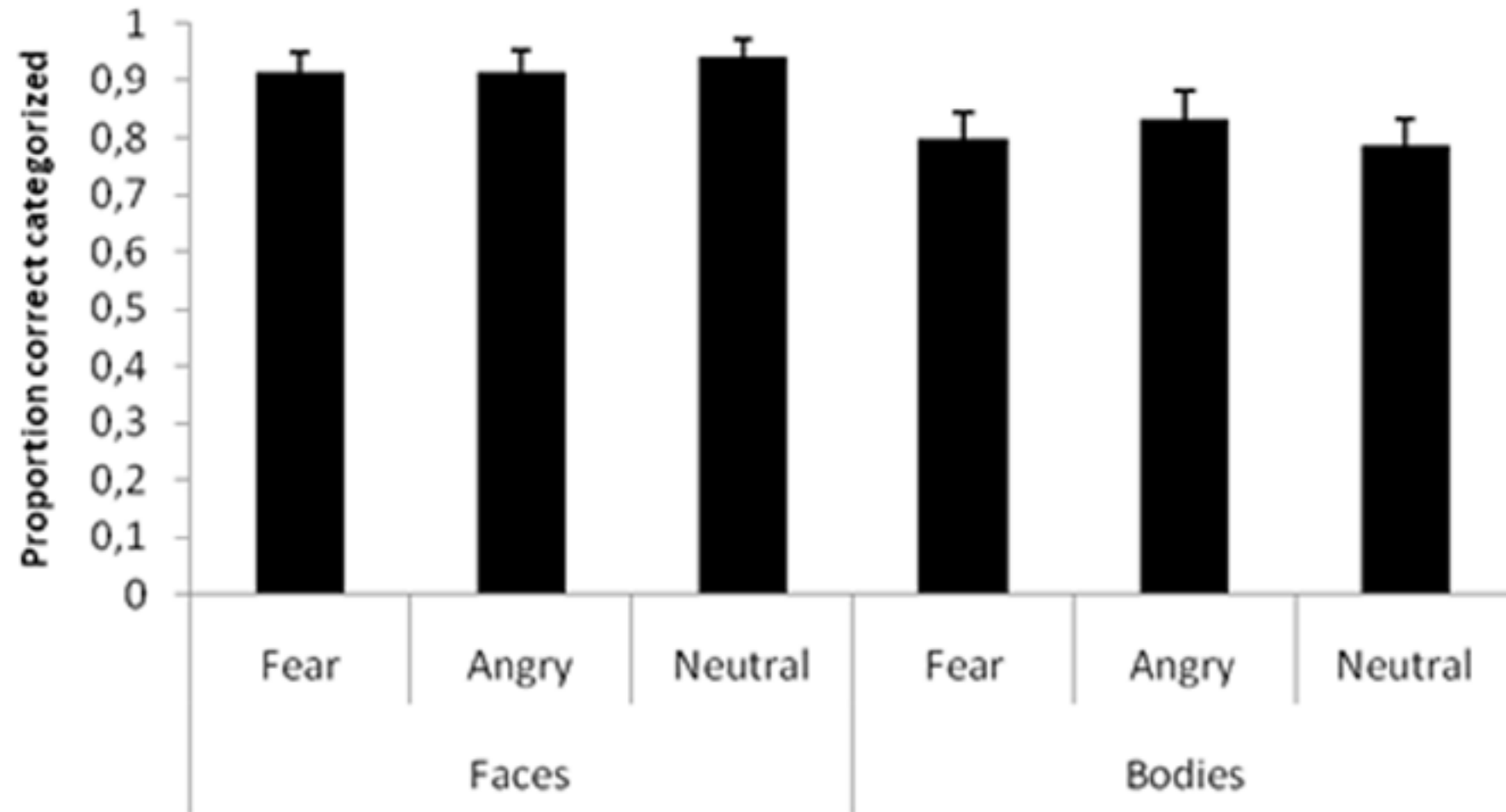


Figure 4.TIF

Validation Results Experiment 1



Validation Results Experiment 2

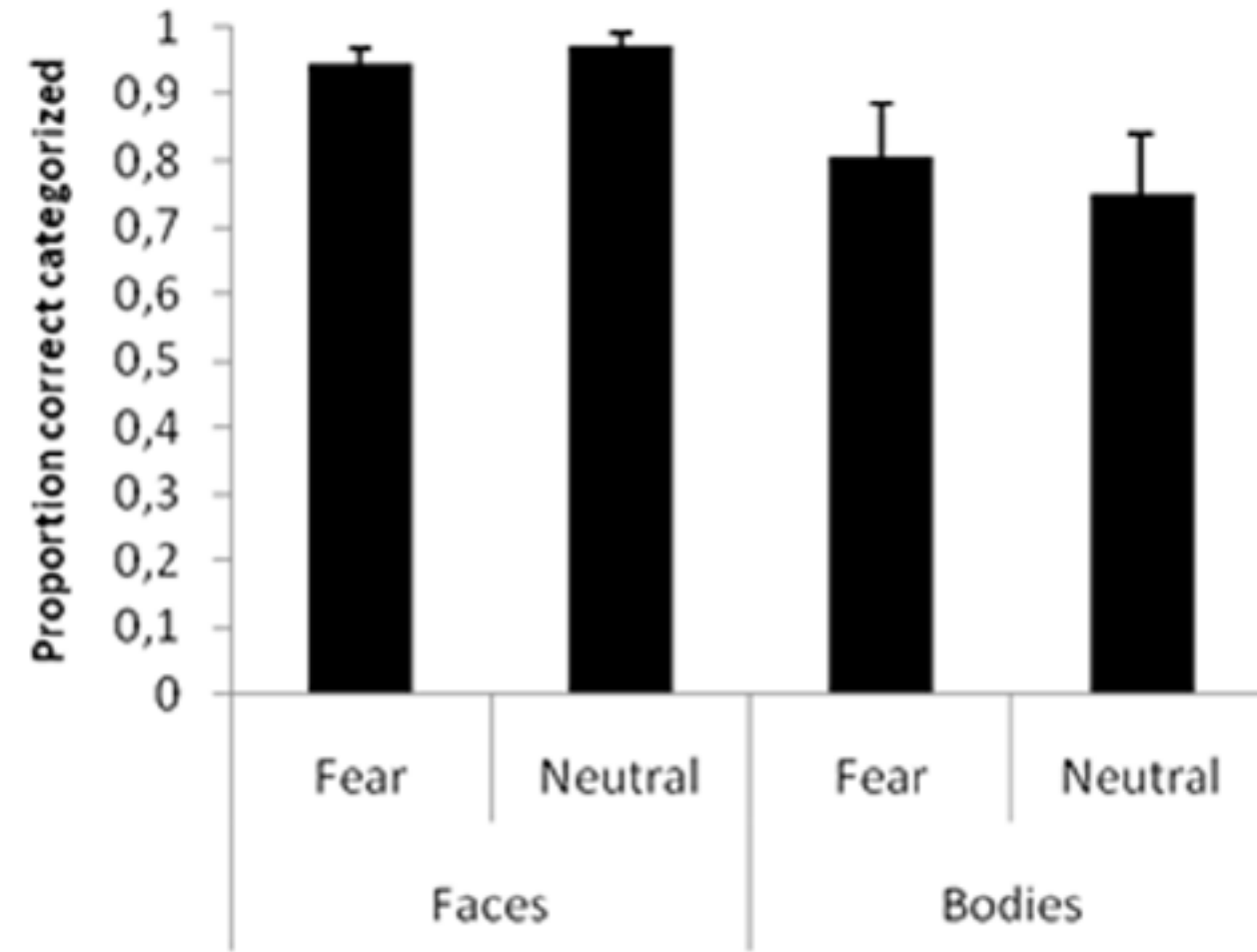


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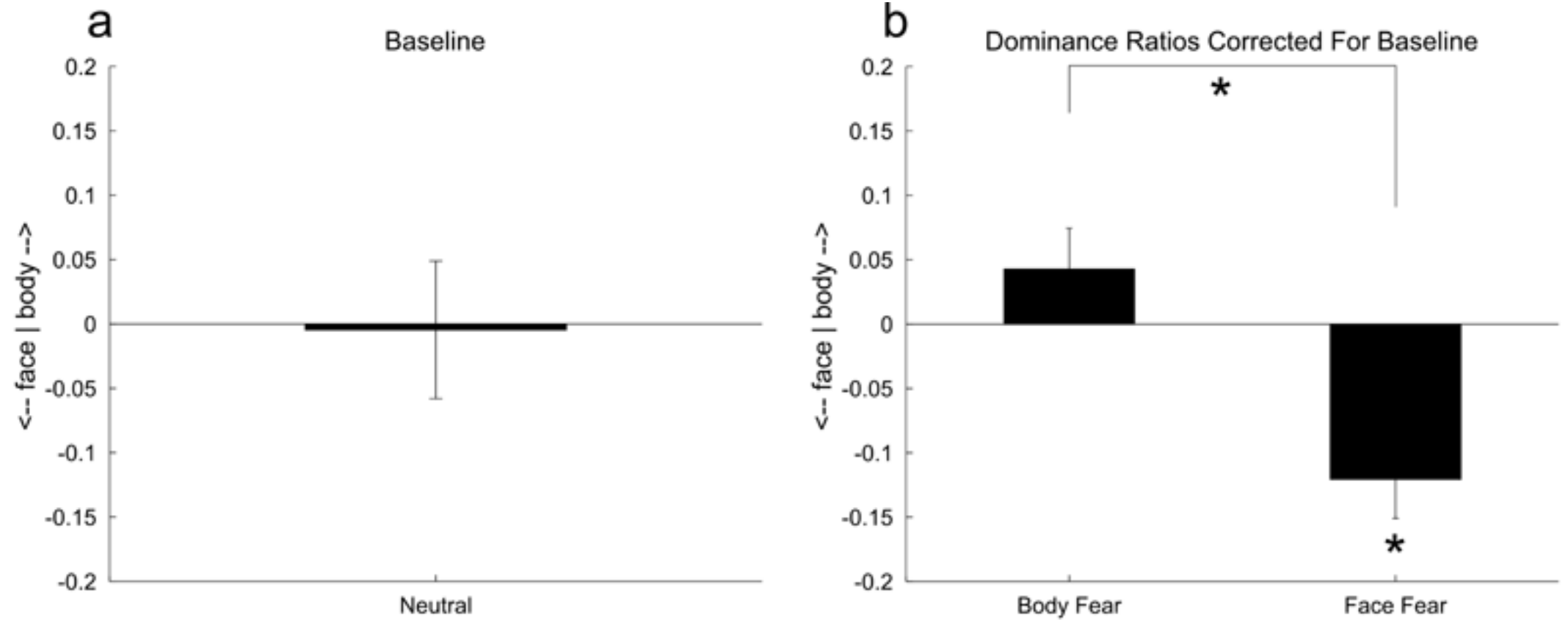


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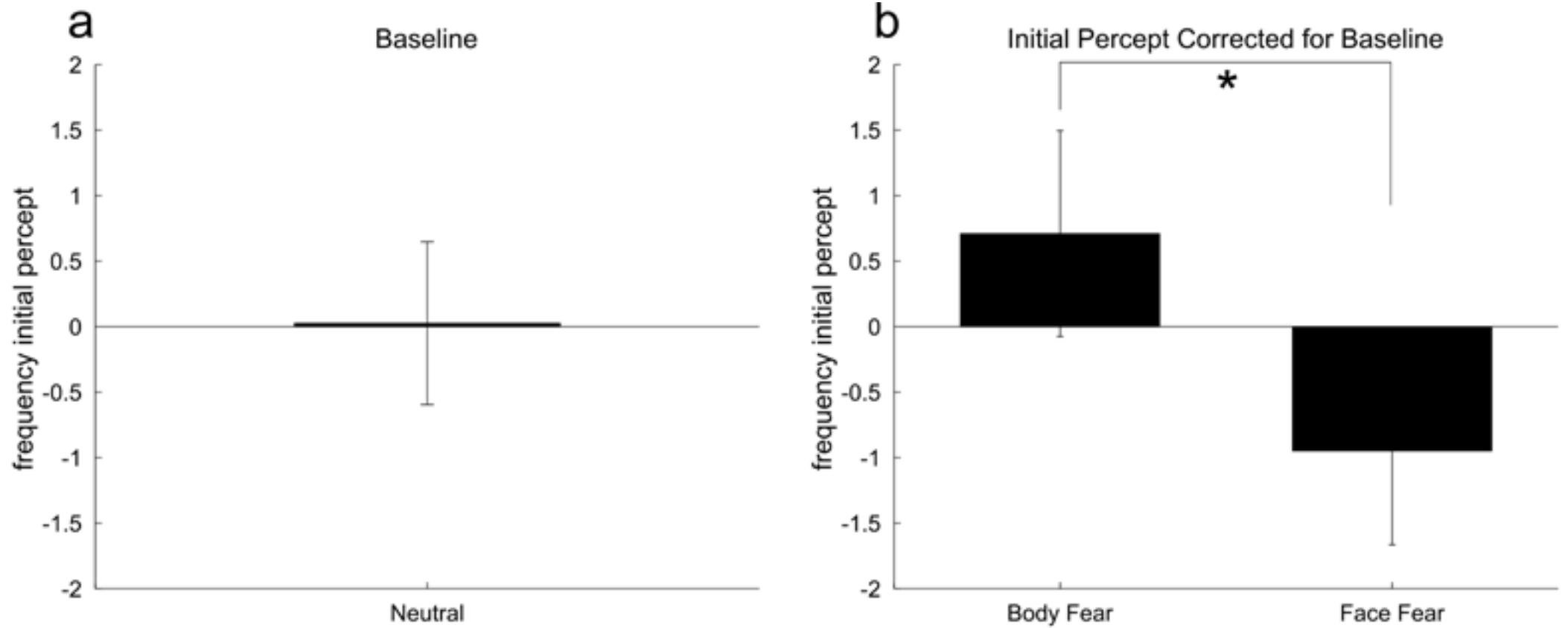


Figure 7.TIF

Emotion versus Neutral

