Studying trait-characteristics and neural correlates of the emotional ego- and altercentric bias using an audiovisual paradigm

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Abstract

In social interactions, emotional biases can arise when the emotional state of oneself and another person are incongruent. A person's ability to judge the other's emotional state can then be biased by their own emotional state, leading to an emotional egocentric bias (EEB). Alternatively, a person's perception of their own emotional state can be biased by the other's emotional state leading to an emotional altercentric bias (EAB). Using a modified audiovisual paradigm, we examined in three studies (n=171; two online & one lab-based study) whether emotional biases can be considered traits by measuring two timepoints within participant and relating empathy trait scores to emotional biases, as well as the electrophysiological correlates of emotional biases. In all studies, we found a congruency effect, reflecting an EEB and EAB of small size. Both biases failed to correlate significantly within participants across timepoints and did not display significant relationships with empathy trait scores. On the electrophysiological level, we did not find any neural emotional bias effects in the time-frequency domain. Our results suggest that EEB and EAB effects are strongly task sensitive. Caution is warranted when studying interindividual differences in emotional biases using this paradigm, as they did not show significant test-retest reliabilities.

Keywords: emotional egocentricity bias, EEB, emotional altercentric bias, self-other distinction, audiovisual, EEG

INTRODUCTION

When humans interact, they commonly *read* the interacting partner: what they might think, how they may react, and how they may feel. The ability to understand the other's emotions in these interactions is mainly linked to empathic abilities (Decety & Jackson, 2004). Empathy is multifaceted, entailing both an emotional component, which is about sharing the other's affective state, and a cognitive component, which refers to the rational understanding of the other person's state (Decety & Jackson, 2004; Lamm et al., 2016). Crucially, empathy requires also self-other distinction, i.e., the monitoring of the source — self or other — of the emotional state. Self-other distinction becomes especially relevant when one's own and the other's emotion are incongruent. In such situations people can show a bias toward their own emotion, a so-called emotional egocentric bias (EEB, Silani et al., 2013). People thus tend to perceive the other's emotion as more similar to their own emotional state than it actually is. Contrarily, other's emotion can influence the own emotional state and bias it in a negative or positive direction, too. The latter has been called an emotional altercentric bias (EAB, Bukowski et al., 2020; Hoffmann, Banzhaf, et al., 2016). Measuring these emotional biases experimentally is challenging, as it requires the manipulation of emotional valence and the induction of conflicts between own and other's emotional experiences in highly constrained lab settings. Here, we used a modified version of a previously introduced audiovisual paradigm (von Mohr et al., 2020) to study the EEB and EAB, to test their trait characteristics, and to investigate the electrophysiological correlates of the EEB and EAB.

Previous work has already studied interindividual differences of emotional biases, showing implications of age (Riva et al., 2016), gender (Tomova et al., 2014), and personality traits, such as empathic skills (Hoffmann, Banzhaf, et al., 2016). Specifically, subscales of empathy have been linked to emotional biases, where higher scores in perspective taking correlate with decreased EEB (Trilla et al., 2020) and higher scores in personal distress correlate with increased EAB (Hoffmann, Banzhaf, et al., 2016). These relationships point to trait-characteristics of emotional biases. Self-other distinction capacities, moreover, manifest differently in healthy and patient populations, including alexithymia (Hoffmann, Banzhaf, et al., 2016), depression (Hoffmann, Banzhaf, et al., 2016), and autism (Hoffmann, Koehne, et al., 2016). Interestingly, socio-cognitive training does not necessarily lead to improvements in self-other distinction (Bukowski et al., 2021), again suggesting that it is a stable trait. However, no previous study has directly examined whether EEB and EAB remain stable across time within individuals.

Former EEB paradigms mostly manipulated emotional valence using visuotactile stimulation of different valence, e.g., the touch of rose petals versus slimy worms. Participants were asked to rate their own or the other person's feelings while both received tactile stimulation. A bias becomes apparent as altered ratings in cases of incongruent stimulation compared to congruent tactile stimulations. Using this paradigm and functional magnetic resonance imaging, converging evidence has shown that increased activity in the right supramarginal gyrus (rSMG) is key in overcoming the EEB (Bukowski et al., 2020; Hoffmann, Koehne, et al., 2016; Silani et al., 2013). So far no neural correlates using other methods, such as electroencephalography or magnetoencephalography, have been described.

Recently, an alternative audiovisual setup to study the EEB has been suggested (von Mohr et al., 2020) that has some advantages compared to the visuotactile setup. In this paradigm, two people are exposed to pleasant or aversive sounds, indicated with visual cues. The advantages of this paradigm include: (i) precise control over the stimulation, i.e., same recorded sound each trial, (ii) the stimulation of two public channels – visual and audio – versus the stimulation of a public – visual – and a private channel – touch (see von Mohr et al., 2020 for details), and (iii) the fully computer-based presentation of the stimulus, which allows an online implementation. Using this paradigm, von Mohr et al. (2020) found in online and lab studies a significant EEB effect, which was significantly larger than the EAB.

Here, we expanded on the audiovisual EEB paradigm in a three separate experiments that built on each other, performed both online and in the lab. We changed the task setting from a block-based target rating to a trial-based target rating. In a block-based paradigm, the task whose emotion has to be rated remains constant throughout a block, whereas in our paradigm, participants only knew after the stimuli were presented whose emotional response should be evaluated in the trial. We expected that a trial-based rating should lead to larger EAB and EEB effects, as the task requires paying attention always to both one's own and the other's stimulation. Our aims using this trial-based paradigm were threefold: First, we wanted to replicate the EEB effect and test for a possible EAB effect in the paradigm. Second, we examined whether the EEB and EAB reflect traits rather than states by testing for their stability over time. Moreover, we correlated them to relevant personality measures, in particular subscales of the Interpersonal Reactivity Index (IRI; Davis, 1980). We expected a negative relationship between Perspective Taking and the EEB (Trilla et al., 2020), and a positive relationship between Personal Distress and the EAB (Hoffmann, Banzhaf, et al., 2016). In addition, we collected mood ratings as a control using the German Positive and Negative Affect Schedule (Janke & Glöckner-Rist, 2012). Third, we explored the electrophysiological correlates of the EEB effect. In line with the formerly suggested conflict detection in the audiovisual setup (von Mohr et al., 2020) and monitoring resources needed for self-other distinction (Decety & Jackson, 2004), we focused on a neural correlate of conflict monitoring and cognitive control, the EEG theta band (Cavanagh & Frank, 2014; Michael X. Cohen & Donner, 2013). We expected a theta increase in conditions, where conflict monitoring was necessary, i.e., in incongruent conditions compared to congruent conditions.

METHODS

We present results of three studies using the same paradigm SODA (Self-Other Distinction Audiovisual) and a total sample size of N=171. Experiment 1 and 2 were behavioral studies conducted online. Measurements of online experiment 1 took place in February of 2021 and each individual measurement lasted around 30 minutes, while measurements of online experiment 2 took place in June and July of 2021 and lasted around 35-50 minutes. Experiment 3 was conducted in the laboratory including behavioral and neural measures using a combined measurement of Electroencephalography (EEG) and functional Near Infrared Spectroscopy (fNIRS). Measurements took place in August and September of 2021 and lasted around 120 minutes. All studies were approved by the Ethics Committee of the University of Lübeck. Participants agreed to perform the task by informed consent prior to the experiment. An age-range of 18 to 35 years was defined for participants to measure a homogenous sample in all three studies, given the target population was student based.

Online experiment 1 aimed to replicate the emotional bias effects. Online experiment 2 tested the stability of the emotional biases within participants by assessing it at two timepoints with 14 days in between. The lab experiment included neural measures to assess the relationship of the size of the behavioral EEB effect and neural activity by simultaneously measuring EEG and fNIRS. FNIRS results will not be reported here due to methodological issues. This was the first combined fNIRS and EEG recording in our lab. To validate the recorded signals, we tested for responses to the auditory stimuli in our EEB paradigm (compare Chen et al., 2015), but could not detect reliable BOLD responses to the sensory stimuli (i.e., activity in the auditory area to auditory stimuli). A meaningful interpretation of the fNIRS data is therefore not possible and we refrained from reporting fNIRS (null-)results here.

SODA paradigm

This setup uses audiovisual stimuli of positive or negative valence – e.g., a bird chirping or nails scratching on a board. Participants see their own and another person's stimulus, while only hearing their own auditory stimulus. They are asked to rate their own or another person's experience to the stimulus, which could be congruent or incongruent in valence. Importantly, this setup differs from other emotional bias setups by varying the target person in a trial-wise manner as opposed to the commonly used block-wise manner. The setup follows a 2 x 2 x 2 design (see Fig 1a; compare Silani et al., 2013), i.e., three factors with two levels each: Valence (pleasant vs unpleasant), Congruency (congruent vs incongruent), and Target (self vs other).

The SODA setup has two parts: (i) a prerating of each stimulus with n=20 trials and (ii) the main experiment with n=80 trials, i.e., 10 trials per condition. Only in the lab experiment, the main experiment had n=160 trials, i.e., the same 80 trials were repeated once, to increase the signal-to-noise ratio for EEG analysis.

In the prerating, the trials are self-paced. The image is presented with its associated sound and the participant is asked to rate it on a scale from 1 (very unpleasant) to 10 (very pleasant). Presentation of the stimuli was randomized for each participant.

An example trial of the main task is shown in Figure 1b. It starts with the presentation of a fixation cross (2 s in online exp. 1 & 2 and 5 s in the lab exp.), which is followed by the presentation of two images simultaneously on the left and right side of the center of the screen (2 s). The image on the left shows the upcoming auditory stimulus (e.g., a bird) for the participant and the image on the right shows the upcoming stimulus (e.g., nails scratching on a board) for another person. Afterwards the corresponding stimulus (i.e., the sound of a bird chirping) is presented to the participant (4 s). A colored circle is then presented (2 s), which indicates the target whose experience has to be rated (e.g., magenta for oneself and blue for the other person). Hence, the participant does not know beforehand whom she has to rate and must pay attention to both images depicting both experiences. Finally, the rating scale is a Likert scale from 1 (very unpleasant) to 10 (very pleasant). The rating scale disappears after a choice has been made or latest after five seconds to encourage a spontaneous answer. In the online experiments 1 & 2, the next trial was started with a click on a button. No bigger breaks were incorporated, since the timing of each new trial was self-paced. In the lab experiment, the next trial was started automatically without a break in between. Breaks were included after each 40-trial block, leading to three breaks between four blocks.

For all experiments, the order of the trials was pseudorandomized impeding more than three consecutive trials of same congruency, more than three consecutive trials of same valence, more than three consecutive trials of same target, or repetition of the same stimulus (self or other) within the next two trials (see supplementary table 1 for an overview). Participants were instructed that they performed the task together with a second person. In the online experiments 1 & 2, the instruction mentioned another actor, but no further cover story was used. In the lab experiment, a confederate was introduced as the co-actor and was present during instructions (compare Lab experiment – Procedure).

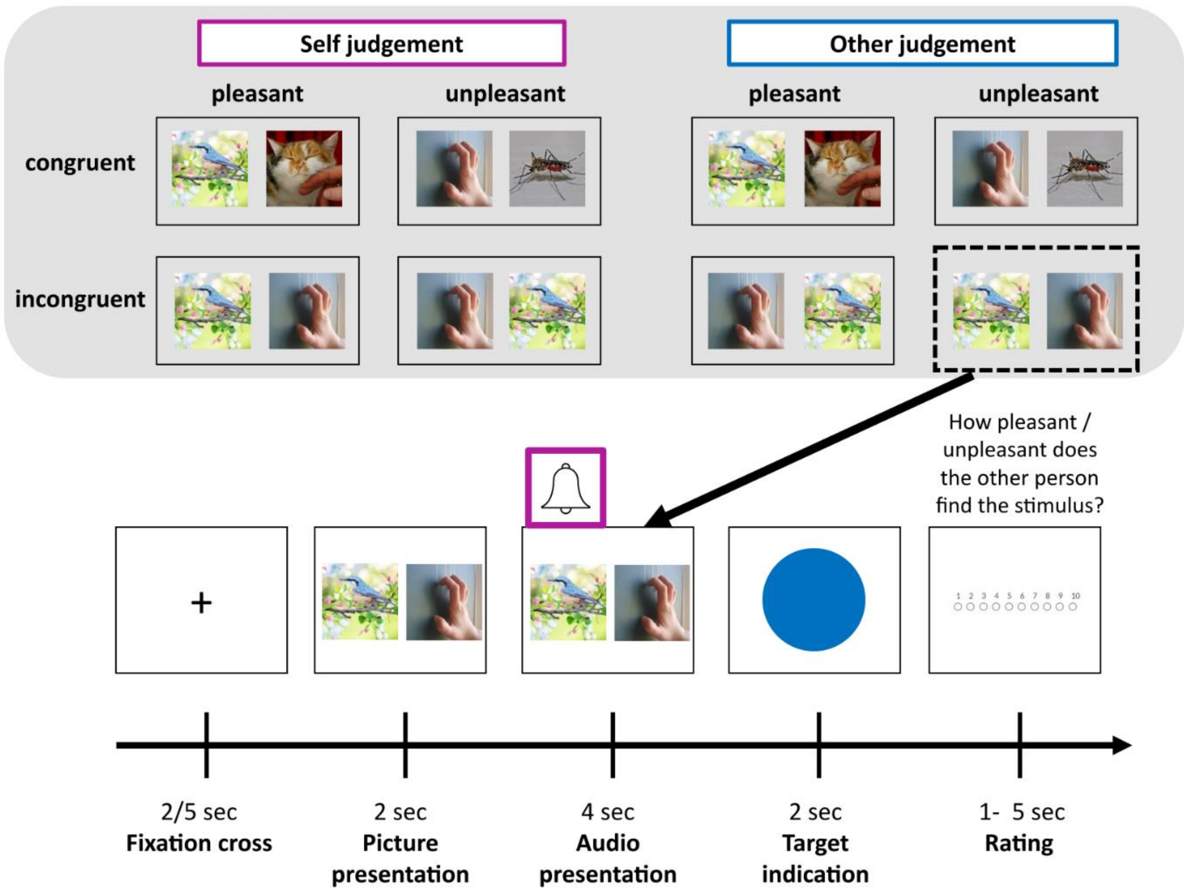


Figure 1. SODA paradigm. (a) Example stimuli for the eight conditions are shown: Target (Self vs. Other) x Valence (pleasant vs unpleasant) x Congruency (congruent vs incongruent). (b) Example timeline for other judgment incongruent condition: Fixation cross presentation time was 2 s for online experiments 1 & 2 and 5 s for the lab experiment. The left picture always indicated the self stimulation and the right picture the stimulation for the other person. Target indication was color-coded (in this example magenta for self and blue for other). Rating was self-paced with a timeout after 5 s with a scale from 1 (very unpleasant) to 10 (very pleasant).

Material

A total of 20 audiovisual stimuli were used for this study, of which 10 were categorized as pleasant and the other 10 as unpleasant (see Table 1). Audiovisual material was compiled from different sources: (1) the IADS-E (Yang et al., 2018), (2) the internet: copyright free images and sounds from pixabay.com, youtube.com, commons.wikimedia.org, and soundbible.com, and (3) created specifically for this study: three pictures, one visualized in Fig.1 – '*Nails scratching on board*'. Using Praat software (Boersma, 2001), audio wav files were edited (converted to mono, cut at zero crossings to an approximate length of 3.5 s, and adjusted to a comparable intensity). In a pilot rating study with n=17 participants in Labvanced (www.labvanced.com), the audiovisual material (picture and audio presented simultaneously) was rated on a Likert scale from 1 (very unpleasant) to 10 (very pleasant). We found a significant difference between unpleasant (2.4 ± 1.3) and pleasant stimuli (8.3 ± 1.4), $t(18) = 18.5$, $p < .001$. A summary of ratings is provided in Table 1.

Online experiment 1

Participants

A total of 95 participants (34 female, 59 male, 2 not specified) took part in this online study. Participants were recruited via crowdsourcing in Labvanced and monetarily compensated for their participation. All participants were self-reportedly proficient German speakers within an age range of 18 to 35 years (mean age 28.72 ± 4.67).

Procedure

The experiment was performed online in Labvanced (www.labvanced.com) in German. The SODA paradigm was split into the prerating and the main rating task. Before the prerating, participants did a practice trial and could adjust the volume of their computer to hear the auditory stimuli at a comfortable volume. Before the main task, a practice trial with stimuli not used in the experiment was presented (example trial shown in Figure 1b, compare section SODA Paradigm). After the main task, three evaluation questions were asked: '*How well could you rate your own experience?*' and '*How well could you rate the experience of the other person?*' (both on a scale from 1=very poorly to 10=very well), and '*What do you think does this experiment investigate?*'.

Table 1
Pilot ratings of audiovisual stimuli

Description	Rating	
	M	SD
Pleasant stimuli		
Baby laugh	8,4	1,59
Rainfall	8,8	1,39
Cat purring	7,9	1,27
Whirlpool	7,2	1,82
Harp	8,2	1,56
Singing bowl	7,1	1,65
Bird	8,3	1,80
Crackling fire	9,2	0,81
Jungle sounds	9,0	0,94
Wave	8,4	1,37
Totals (N=10)	8,3	1,42
Unpleasant stimuli		
Fire alarm	2,3	0,92
Scratching fork on plate	2,2	1,33
Man snoring	2,8	1,13
Woman scream	2,8	2,02
Leaf blower	3,4	1,84
Siren	2,9	1,11
Mosquito	1,5	0,80
Dentist's drill	1,6	0,80
Smacking sounds	3,3	1,50
Nails scratching on board	1,6	1,20
Totals (N=10)	2,4	1,26

Note: An independent pilot rating study (n= 17 subjects) led to the selection of these 10 pleasant and 10 unpleasant audiovisual stimuli. Ratings were given on a Likert scale from 1 (very unpleasant) to 10 (very pleasant). Picture and audio were presented simultaneously.

Behavioural analysis

Analyses were performed in R (*Version 4.0.3*, 2021) and with SPSS (*Version 22.0.*, 2013). We excluded participants from further analyses if one or more of three conditions were met for the main ratings: (1) if over 40% (n=40) trials were rated with 5 or 6 indicating non-compliance in the task, (2) if they had more than one missing trial in any condition, (3) if they had five or more trials with ratings above a defined upper limit or below a defined lower limit dependent on the valence. Limits were defined by calculating for each valence (across congruency conditions, and target) over all participants the quantiles (0.25 & 0.75) and the interquartile ranges (IQR) of the ratings. Lower limit was lower quantile minus 1.5 * IQR and upper limit was the upper quantile plus 1.5 * IQR (compare boxplot outlier detection, Walfish, 2006). We used criterion 3 to ensure that participants followed the instructions and did not, for instance, always evaluate their own stimulation.

For statistical analysis, the mean ratings for each participant and each condition were transformed by subtracting 5.5 from each mean value and taking positive values times -1. This transformation ensured that ratings for pleasant and unpleasant stimuli were within the same range (compare Silani et al., 2013; von Mohr et al., 2020). A repeated-measures ANOVA with the factors Congruency, Valence, and Target was calculated in SPSS. If a significant three-way interaction was present, a post-hoc ANOVA was performed for each Valence separately and follow-up comparisons were performed. Effect sizes are reported as partial eta squared values.

The egocentric and altercentric bias were calculated separately (Bukowski et al., 2020). As visible in Figure 2b & c, the egocentric bias was calculated as $[(-1* \Delta1 + \Delta3) /2]$ and the altercentric bias as $[(-1* \Delta2 + \Delta4) /2]$, where $\Delta1$ = other-rating pleasant $_{\text{incongruent– congruent}}$, $\Delta2$ = self-rating pleasant $_{\text{incongruent– congruent}}$, $\Delta3$ = other-rating unpleasant $_{\text{incongruent– congruent}}$, and $\Delta4$ = self-rating unpleasant $_{\text{incongruent– congruent}}$.

The evaluation questions were summarized and the ratings for the capacity to judge the own and the other's person experience were contrasted with a paired t-test.

Online experiment 2

Participants

A total of 45 participants (39 female, 6 male) took part in this online study with two measurement timepoints (n=51 at timepoint 1). All participants were self-reportedly healthy and had no history of neurological or psychiatric diseases. Participants were recruited via university mailing lists and compensated for their participation (monetary or hourly credit as experimental participants). All participants were proficient German speakers within an age range of 18 to 35 years (mean age 24.33 ± 3.74). The study was preregistered at OSF (osf.io/sv9xn).

Procedure

The experiment was performed online in Labvanced (www.labvanced.com) in German. The second measurement took place 14 days after the first one. The SODA paradigm at both timepoints was split into the prerating and the main task. Procedure of rating and experiment were as in online experiment 1 (see above).

At timepoint 1 after the main task, participants were asked the same questions about the experiment as in online experiment 1 (see above), as well as '*How many days have passed since your last period? (for women)*'. They also filled out the Interpersonal Reactivity Index (IRI) in German (Paulus, 2009) and the Positive Affect and Negative Affect Schedule (PANAS) in German (Janke & Glöckner-Rist, 2012). At timepoint 2, the procedure was the same as at timepoint 1 except that participants did not fill out the IRI. A second emotional bias paradigm was measured at timepoint 2 that is not reported here. The second paradigm included pictures of appetitive and aversive food stimuli combined with videos of emotional displays of happy faces or disgusted faces. Participant's task was to rate their own or the person's in the video attitude towards the presented food stimulus. As this novel paradigm uses a very different approach to operationalize the emotional egocentricity bias, we refrain from adding the data here. Results of this study will be presented elsewhere together with more extensive validation of this paradigm.

Behavioral analysis

We excluded participants from further analyses if one or more of three conditions were met for the main ratings: (1) if over 40% (n=40) trials were rated with 5 or 6 indicating non-compliance in the task (as in the preregistration), and (2) if they had more than one missing trial in any condition (contrary to the preregistration of over 3 standard deviations of missing trials compared to the mean number of missing trials), and (3) if they had five or more trials with ratings above a defined upper limit or below a defined lower limit dependent on the valence (not in preregistration; compare analysis online experiment 1).

Statistical analyses were performed as in online experiment 1 (see above) with the additional factor timepoint (T1, T2) in the repeated-measures ANOVA. To analyze the stability of the biases over time, a spearman correlation was computed.

Results of the IRI were summarized for each subscale. Spearman correlation analyses were performed between the subscale Perspective Taking (PT) and the EEB for each timepoint separately, and between the subscale Personal Distress (PD) and the EAB for each timepoint separately.

Results of the PANAS were summarized in a single positive and a single negative score at each timepoint. Correlations between EEB/EAB and the positive/negative PANAS score of each timepoint are shown in the supplementary materials.

The evaluation questions were summarized and the ratings for the capacity to judge the own and the other's person experience were contrasted with a repeated-measures ANOVA with the factors target (self vs. other) and timepoint (T1 vs T2).

Lab experiment

Participants

A total of 31 participants (22 female, 9 male) took part in this lab study. The data of one participant had to be discarded because of problems during the measurement due to physical indisposition. All participants were self-reportedly right-handed and had no history of neurological or psychiatric diseases. Participants were recruited via university mailing lists and compensated for their participation (monetary or hourly credit as experimental participants). All participants were proficient German speakers within an age range of 20 to 35 years (mean age 24.7 ± 3.9).

Procedure

The experiment was conducted in the laboratory using Psychtoolbox (Brainard, 1997; Pelli, 1997) in Matlab. On the testing day, participants came to the lab and filled out a mandatory covid prevention questionnaire. After giving their informed consent, the EEG cap was fitted, and electrode impedances were checked and kept below 15 kΩ. Meanwhile, the participants filled out some questionnaires on SoSci-Survey (www.soscisurvey.de). These questionnaires included a basic questionnaire on demographic data (age, sex, medication intake), the Interpersonal Reactivity Index (IRI) in German (Paulus, 2009), and the Positive Affect and Negative Affect Schedule (PANAS) in German (Janke &

Glöckner-Rist, 2012). The confederate (also a student working as an assistant) would then arrive and be introduced as the co-actor of the paradigm. The later arrival was explained by the fact that neural measures would only be performed on the participant and experience shows that the setup takes longer. Debriefing verified that confederate and participant had not met each other prior to the measurement. The SODA paradigm was then explained in detail in the same room to the participant and the confederate. The confederate would ask for some clarifications on purpose. The participant, also, was given the chance to ask any questions regarding the following task. The confederate was then (supposedly) seated in an adjacent room to perform the task together with the participant.

After the prerating, the NIRS optodes were placed on the cap. A short practice block was performed and the main task started. Following a 40-trial block, a self-paced pause was given. The end of the pause was (supposedly) coordinated with the confederate sitting in the other room to ensure that both were ready to take up the next block. After two 40-trial blocks, the NIRS optodes were removed. During the remaining two 40-trials blocks, only EEG was recorded. When the experiment was completed, the EEG cap was removed and the participant was given the chance to wash her hair. A short (written) evaluation questionnaire was then handed to the participant asking ‘How was the wearing comfort of the measuring devices?’, ’Did you notice something unusual during the measurement?’, ’What do you think are we studying with this experiment?’, and ‘Is there something else you would like to add?’. Lastly, the experimenter debriefed the participant explaining that the confederate in fact had not performed the task together with the participant.

EEG recording

Brain electrical activity was measured with a 28-channel EEG system (BrainProducts, Gilching, Germany). Electrodes were placed following the 10-20 system with a fronto-central ground and left mastoid as online reference (Easycap, Herrsching, Germany). Three ocular channels were placed over the right eye, the outer right eye, and the outer left eye. Data were digitized with a sampling rate of 500 Hz and recorded with an online high-pass filter of 0.016 Hz and a notch filter at 50 Hz.

Behavioral analysis

The behavioral data was analyzed as in online experiment 2 without the factor timepoint in the repeated measures ANOVA.

EEG analysis

EEG analysis was performed using EEGLAB (Delorme & Makeig, 2004) and Matlab. For EEG artefact attenuation, an Independent Component Analysis (ICA) was conducted on the data. Before ICA, the data was high-pass filtered at 1 Hz and low-pass filtered at 60 Hz (cut-off -6 db) with a finite-impulse response (FIR) filter. Dummy epochs of one second were created and epochs exceeding three standard deviations from the mean signal were excluded. ICA weights were saved on the raw data. Artifactual components were identified and excluded via visual inspection and confirmed using IClabel (Pion-Tonachini et al., 2019), with M=7 components rejected per participant ranging from 4 to 10 components.

For time-frequency analysis, the EEG data was rereferenced to left mastoid and epoched to the onset of the target cue (i.e., the colored circle presentation, see Fig 1b) between -500 to 2500 ms. Epochs were separated into four conditions: other congruent (OC), other incongruent (OI), self congruent (SC), and self incongruent (SI). For reasons of signal-to-noise ratios, the factor valence was averaged. Epochs with amplitudes exceeding three standard deviations from the mean signal were excluded from further analysis (see supplementary table 2 for an overview). Time-frequency analysis was performed with customized Matlab-based functions – cwt with parameter 'cmor1-1.5', where f_b = 1 and f_c = 1.5:

$$\omega(t) = (\pi f_b)^{-0.5} e^{-2\pi i f_c t} e^{-\frac{t^2}{f_b}}$$

A complex morlet wavelet transformation was calculated for frequencies of 1 to 40 Hz (with linear increase and converted to power) respective to a baseline of -250 to 0 ms (a shorter baseline was chosen to avoid artefacts intruding from prior auditory presentation). Averaged time frequencies were converted to decibel to compare power between frequency bands (Mike X Cohen, 2014).

For statistical analysis of a neural effect (similar to the congruency x target interaction calculated on the behavioral level), a non-parametric permutation test (Maris & Oostenveld, 2007) of the averaged time frequencies between 1 to 25 Hz was calculated between the difference of congruent self and incongruent self and the difference of congruent other and incongruent other condition. A cluster-size correction was applied to control for multiple comparisons (Mike X Cohen, 2014). The same analysis was performed as simple permutation comparison tests of (i) congruent and incongruent self (reflecting the EAB on the behavioral level) and (ii) congruent and incongruent other (reflecting the EEB on the behavioral level). On an exploratory basis, a further simple permutation test was performed between averaged congruency: congruent versus incongruent condition (reflecting the main congruency effect on the behavioral level). Further, the same analysis (permutation test and cluster size correction) was performed on an exploratory basis for the target x valence interaction. Permutation tests and cluster-size correction were run using customized Matlab scripts (compare Mike X Cohen, 2014). For the calculation of a null-distribution, conditions (for double difference comparison: condition a=OI-OC and condition b=SI-SC) were randomly assigned between participants with 500 permutations per comparison for the epochs from -250ms to 2000ms. Cluster search was performed using the *bwconncomp* Matlab function, resulting in a distribution of the maximum cluster size for each permutation. Significant cut-offs were set at $\alpha = .05$.

RESULTS

Online experiment 1

Behavioral results

After outlier removal (see Methods and Supplementary Material for details), a sample size of n=80 remained. Results of the prerating (see Fig. 2a) show that participants, as expected, rated on average unpleasant stimuli significantly lower (2.31 ± 0.7) than pleasant stimuli (7.74 ± 0.6, $t(18) = 18.75$, $p < .001$).

In the main task (see Fig. 2b), participants' ratings showed a significantly more intense ratings for congruent than incongruent ratings (main effect of congruency: $F(1,79) = 4.10$, $p = .046$, $\eta_p^2 = 0.049$). Further, participants rated unpleasant stimuli more intense than pleasant stimuli (main effect of valence: $F(1,79) = 38.23$, $p < .001$, $\eta_p^2 = 0.326$), as well as own experiences more intense than the other's experiences (main effect of target: $F(1,79) = 11.60$, $p = .001$, $\eta_p^2 = 0.128$). Contrary to previous research, the intensity of ratings did not vary significantly in the incongruent compared to congruent condition dependent on the target (interaction effect of congruency and target: $F(1,79) = 1.66$, $p = .202$), i.e., there was no significant difference between EEB and EAB (see Fig. 2c). Further, there was no significant interaction between congruency, target, and valence conditions (interaction effect of congruency, target, and valence: $F(1,79) = 0.38$, $p = .538$).

Evaluation question responses showed that participants, on average, rated their capacity to judge their own experience significantly higher (9.04 ± 1.2) than their capacity to judge the other person's experience (7.74 ± 1.84; both on a scale from 1=very poorly to 10=very well; $t(79) = 7.12$, $p < .001$).

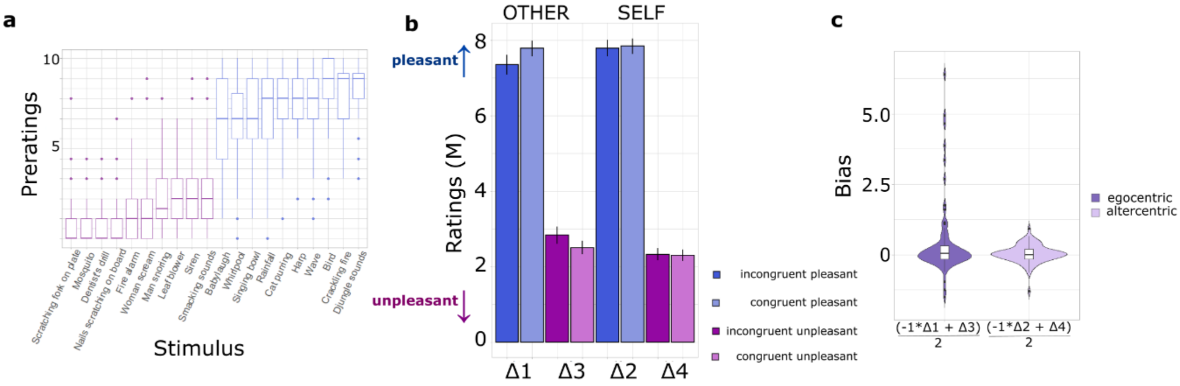


Figure 2. Behavioral results online experiment 1. (a) Preratings sorted by increasing median value (from 1 – very unpleasant to 10 – very pleasant). Unpleasant stimuli are shown in magenta, pleasant stimuli in blue. Name of each stimulus on the x-axis. (b) Mean ratings of the main task (from 1 – very unpleasant to 10 – very pleasant) and SE for other (left) and self conditions (right), separately for pleasant (blue colors) and unpleasant (magenta colors) valence and congruency (congruent in shaded color and incongruent in darker color). Delta 1 to 4 (x-axis) are the difference scores used for the EEB and EAB. (c) Egocentric effect distribution shown in purple and altercentric effect distribution shown in violet (equations for each effect shown below; compare Bukowski et al. 2020). Significance is shown above. ** p < .01;SE = Standard Error

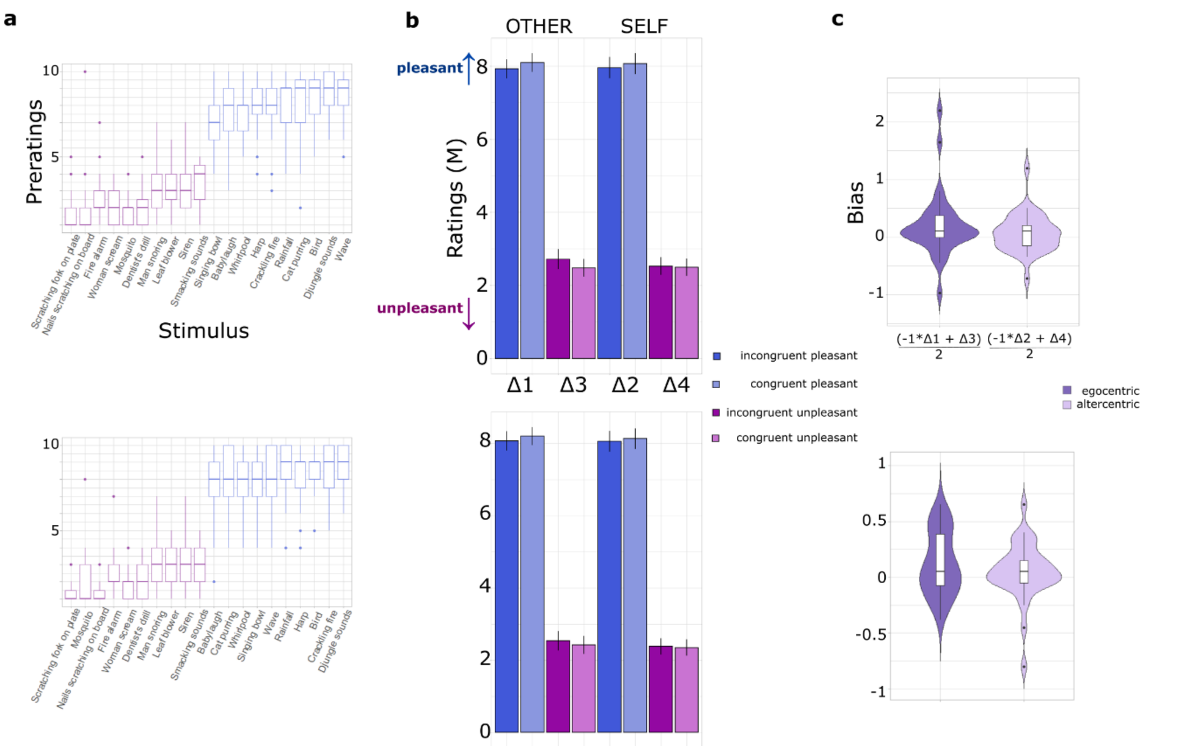


Figure 3. Behavioral results online experiment 2. Timepoint 1 on upper row, timepoint 2 on lower row. (a) Preratings sorted by increasing median value (from 1 – very unpleasant to 10 – very pleasant). Unpleasant stimuli are shown in magenta, pleasant stimuli in blue. Name of each stimulus on the x-axis. (b) Mean ratings of the main task (from 1 – very unpleasant to 10 – very pleasant) and SE for other (left) and self conditions (right), separately for pleasant (blue colors) and unpleasant (magenta colors) valence and congruency (congruent in shaded color and incongruent in darker color). Delta 1 to 4 (x-axis) are the difference scores used for the EEB and EAB. (c) Egocentric effect distribution shown in purple and altercentric effect distribution shown in violet (equations for each effect shown below; compare Bukowski et al. 2020). Significance is shown above. * p < .05; SE = Standard Error

Online experiment 2

Behavioral results

After outlier removal (compare Methods and Supplementary Material for details) a sample size of n=35 remained, with a mean of 14.37 ± 1.3 days between measurement 1 and 2. Preratings show a clear categorization of unpleasant and pleasant stimuli at both measured timepoints (see Fig. 3a), again with a significantly lower rating for unpleasant (T1: 2.56 ± 1.5, T2: 2.31 ± 1.4) than pleasant stimuli (T1: 7.98 ± 1.7, $t(17) = 18.54$, $p < .001$; T2: 8.25 ± 1.6, $t(13) = 23.55$, $p < .001$).

In the main task (see Fig. 3b), participants rated congruent conditions more intense than incongruent conditions at both timepoints (main effect of congruency: $F(1,34) = 6.64$, $p = .014$, $\eta_p^2 = 0.163$). Similar to online experiment 1, participants rated unpleasant stimuli more intense than pleasant stimuli (main effect of valence: $F(1,34) = 9.20$, $p = .005$, $\eta_p^2 = 0.213$). Own and other's experiences were not rated significantly different (main effect of target: $F(1,34) = 0.87$, $p = .357$). The timepoint of measurement did not significantly influence results (main effect of timepoint: $F(1,34) = 2.29$, $p = .140$). Similar to online experiment 1, the intensity of ratings did not vary significantly dependent on congruency and target conditions (interaction effect of congruency and target: $F(1,34) = 3.48$, $p = .071$), meaning that EEB and EAB were not significantly different (see Fig. 2c). As in online experiment 1, we found no interaction effect between congruency, target, and valence conditions (interaction effect of congruency, target, and valence: $F(1,34) = 1.14$, $p = .294$). Further, there was no significant four-way interaction of congruency, valence, target, and timepoint ($F(1,34) = .55$, $p = .465$) or an interaction of timepoint with any other factor (all $p > .4$).

Spearman's rank correlation revealed no significant correlation between the egocentric bias measured at both timepoints ($r(33) = .30$, $p = .081$; see Fig. 4a) or the altercentric bias measured at both timepoints ($r(33) = .32$, $p = .059$; see Fig. 4a), questioning test-retest reliability. However, for both biases, correlations were significant on a trend-level (both $p < .1$).

To assess the relationship between IRI subscales and egocentric/altercentric effects, spearman's rank correlations were computed. IRI subscale Perspective Taking, and the egocentric effect did not correlate significantly (timepoint 1: $r(33) = .19$, $p = .290$, see Fig. 4b; timepoint 2: $r(33) = .01$, $p = .959$). Likewise, IRI subscale Personal Distress and the altercentric effect were not correlated significantly (timepoint 1: $r(33) = .11$, $p = .534$, see Fig. 4b; timepoint 2: $r(33) = .06$, $p = .729$).

As in online experiment 1, evaluation question responses showed that participants rated their capacity to judge their own experience significantly higher at both timepoints (T1 – 8.71 ± 1.1; T2 – 8.26 ± 1.2; main effect of target: $F(1,34) = 39.85$, $p < .001$) compared to judging the other person's experience (T1 – 7.11 ± 1.8; T2 – 7.11 ± 1.6, on a scale from 1=very poorly to 10=very well). There was no significant effect of timepoint (main effect of timepoint: $F(1,34) = 1.24$, $p = .273$), but a significant interaction of timepoint and target ($F(1,34) = 4.39$, $p = .044$), driven by a small decrease in the ratings for the capacity to judge the own experience from timepoint 1 to timepoint 2.

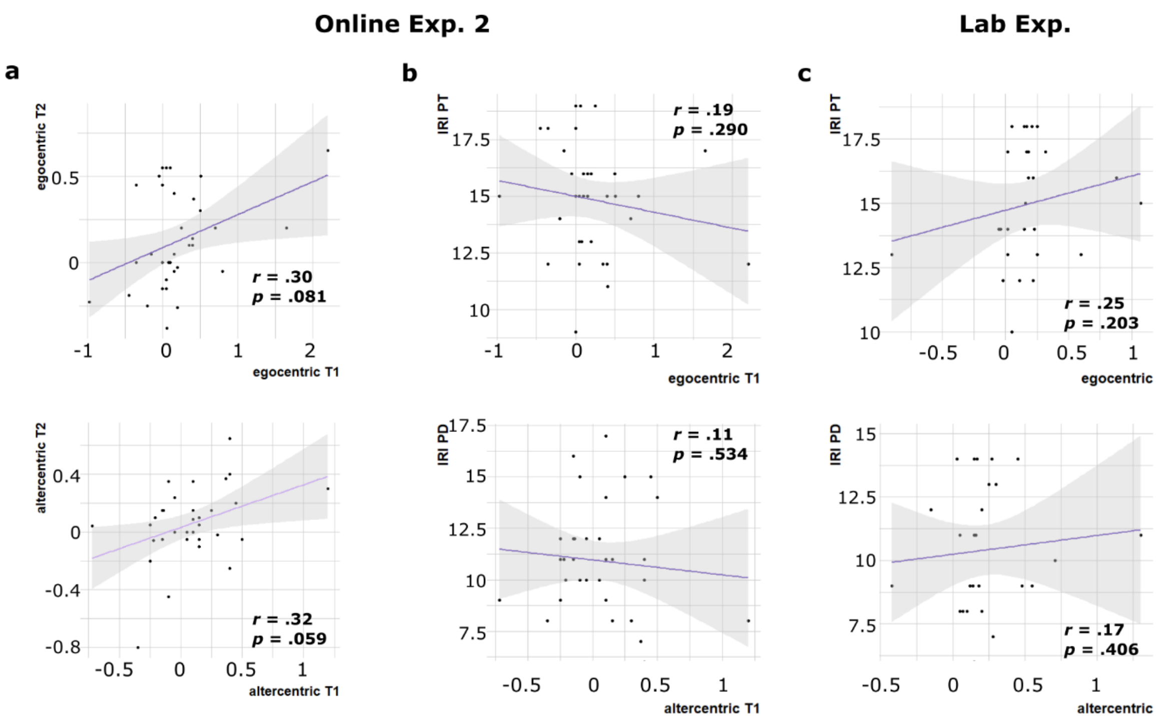


Figure 4. SODA correlations in online experiment 2 and lab experiment. (a) Correlation between egocentric effect at T1 & T2 (upper) and between altercentric effect at T1 & T2 (lower). (b) Correlations (online exp. 2) between IRI subscale PT and egocentric effect at T1 (upper) and between subscale PD and altercentric effect at T1 (lower). (c) Correlations (lab exp.) between IRI subscale PT and egocentric effect (upper) and between PD and altercentric effect (lower). PD = Personal Distress, PT = Perspective Taking, T1 = Timepoint 1, T2 = Timepoint 2

Lab experiment 3

Behavioral data

After outlier removal (compare Methods and Supplementary Material for details) a sample size of n=27 remained. As in both online experiments, the preratings show a clear categorization of valence of stimuli (see Fig. 5a), with significantly lower ratings for unpleasant stimuli (2.94 ± 1.6) than pleasant stimuli (7.98 ± 1.8; $t(17) = 17.67$, $p < .001$).

In the main task (see Fig. 5b) and similar to online experiment 2, participants rated the stimuli more intense in congruent than in incongruent conditions (main effect of congruency: $F(1,26) = 12.15$, $p = .002$, $\eta_p^2 = .318$) and there was no difference in ratings between own and other's experience (no main effect of target: $F(1,26) = 2.97$, $p = .097$). Contrary to the results in both online experiments, participants did not rate unpleasant stimuli significantly more intense than pleasant stimuli (no main effect of valence: $F(1,26) = 0.02$, $p = .903$). Again, there was no significant difference in ratings between differing congruency and target conditions (interaction effect of congruency and target: $F(1,26) = 1.09$, $p = .306$). However, we found two other significant interactions between target and valence (interaction effect of target and valence: $F(1,26) = 6.18$, $p = .020$, $\eta_p^2 = .192$) and congruency and valence (interaction effect of congruency and valence: $F(1,26) = 7.27$, $p = .012$, $\eta_p^2 = .219$). Moreover, only in the lab study, there was a significant interaction between congruency, target, and valence conditions (interaction effect of congruency, target, and valence: $F(1,26) = 19.54$, $p < .001$, $\eta_p^2 = .429$). Follow-up analyses revealed a significant interaction of congruency and target conditions for pleasant stimuli (congruency x target: $F(1,26) = 5.40$, $p = .028$, $\eta_p^2 = .172$) and unpleasant stimuli (congruency x target: $F(1,26) = 16.35$, $p < .001$, $\eta_p^2 = .386$). This shows that EEB and EAB (see Fig. 5c) differed in both valence conditions, but more so for unpleasant stimuli. Paired samples t-tests showed that for pleasant stimuli the EEB (congruency effect for "other" rating) was larger ($t(26) = -4.37$, $p < .001$) than the EAB ($t(26) = -2.14$, $p = .042$). In contrast, for unpleasant stimuli, the EEB was smaller and in fact not significant ($t(26) = 0.13$, $p = .9$) compared to a significant EAB ($t(26) = -4.70$, $p < .001$).

To assess the relationship between IRI subscales and egocentric/altercentric effects, spearman's rank correlations were computed. IRI subscale Perspective Taking and the egocentric effect did not correlate significantly ($r(25) = .25$, $p = .203$; see Fig. 4c). Likewise, IRI subscale Personal Distress and altercentric effect did not correlate significantly ($r(25) = .17$, $p = .406$; see Fig. 4c).

The results of the evaluation questionnaire showed that one person did not believe that the confederate was a real interacting partner. Moreover, several participants reported discomfort while wearing the NIRS optodes (n=12 reported some discomfort, n=1 found the moment of removal of optodes just right, n=3 reported discomfort up to pain), which might have generally affected the participants' task performance.

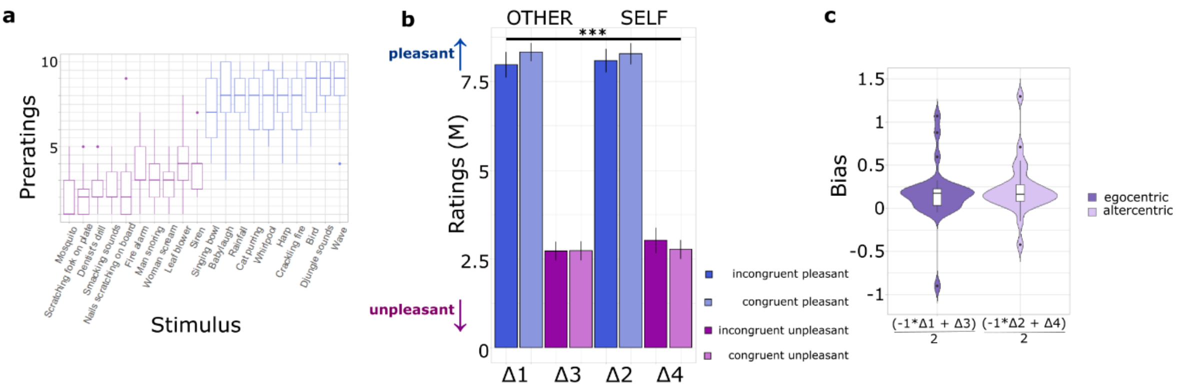


Figure 5. Behavioral results lab experiment. (a) Preratings sorted by increasing median value (from 1 – very unpleasant to 10 – very pleasant). Unpleasant stimuli are shown in magenta, pleasant stimuli in blue. Name of each stimulus on the x-axis. (b) Mean ratings of the main task (from 1 – very unpleasant to 10 – very pleasant) and SE for other (left) and self conditions (right), separately for pleasant (blue colors) and unpleasant (magenta colors) valence and congruency (congruent in shaded color and incongruent in darker color). Delta 1 to 4 (x-axis) are the difference scores used for the EEB and EAB. (c) Egocentric effect distribution shown in purple and altercentric effect distribution shown in violet (equations for each effect shown below; compare Bukowski et al. 2020). Significance is shown above. * p < .05, *** p < .001; SE = Standard Error

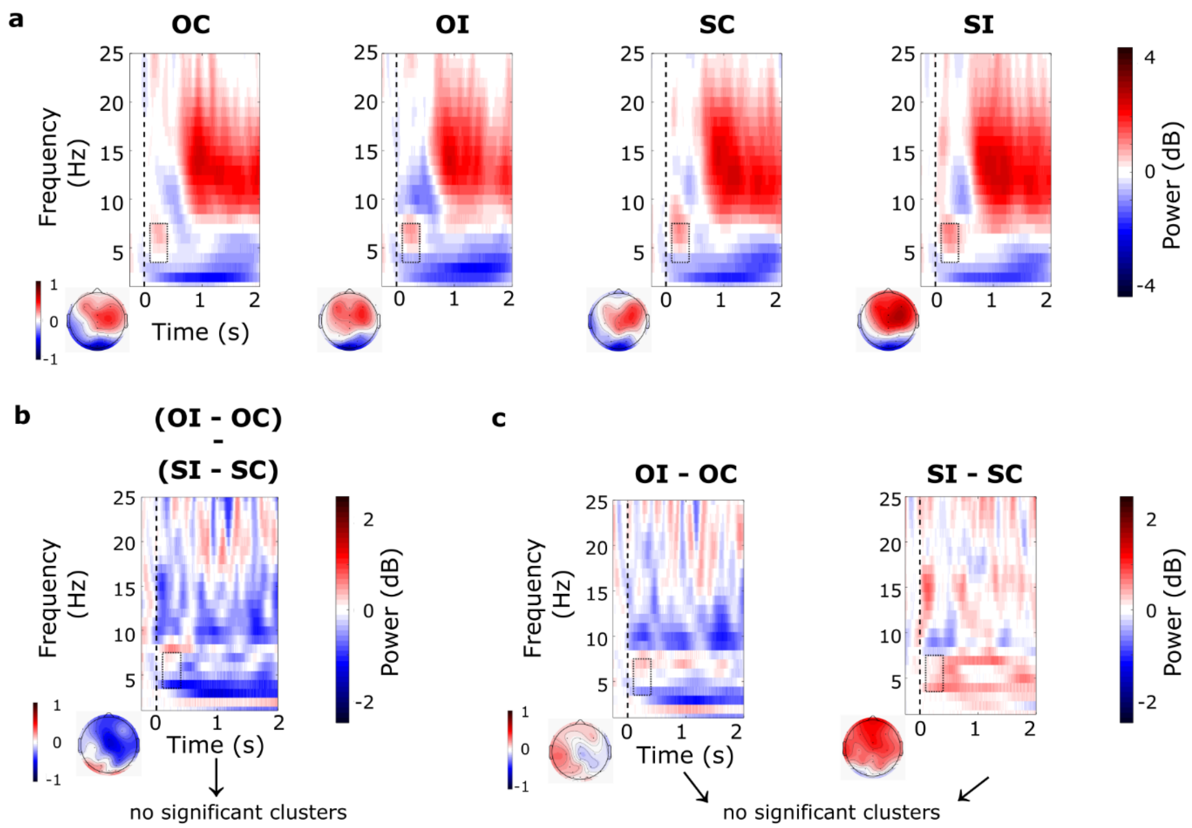


Figure 6. Neural results lab experiment. (a) Time-frequency responses (TFR) at electrode Cz for each condition: other congruent (OC), other incongruent (OI), self congruent (SC), self incongruent (SI). Zero denotes onset of target indication (colored circle, see Fig. 1). Below, the activation map is shown for the theta range (4-7 Hz) from 100 to 400 ms (time-window highlighted in TFR plot). (b) Double difference of time-frequency responses at electrode Cz [(OI-OC) - (SI-SC)]. Below, the activation map is shown for the theta range (4-7 Hz) from 100 to 400 ms (time-window highlighted in TFR plot). (c) Differences of time-frequency responses at electrode Cz for the other condition (OI-OC) and the self condition (SI-SC). Below, the activation map is shown for the theta range (4-7 Hz) from 100 to 400 ms (time-window highlighted in TFR plot).

EEG results

To test for a neural bias effect following a hypothesis driven-approach, conditions were averaged over valence leading to four conditions (target x congruency): other congruent (OC) and other incongruent (OI), and self congruent (SC) and self incongruent (SI). Time-frequency analysis showed a frontal theta power increase from 100 to 400 ms in all four conditions (see Fig. 6a). A permutation test with cluster size correction was conducted on the difference of differences [(OI-OC)-(SI-SC), depicting the congruency x target interaction]. No significant clusters were found (see Fig. 6b), neither for the theta band nor for other frequency bands. Likewise, no significant clusters were observed for the single differences (OI-OC & SI-SC, reflecting the EEB and EAB respectively; see Fig. 6c). Results of the exploratory analysis can be found in the supplementary materials (EEG analysis and results, supplementary figures 3-4).

DISCUSSION

In an experiment series of two online studies and a lab-based study, we used a modified version of an audiovisual paradigm to study the emotional egocentric (EEB) and altercentric bias (EAB). As expected, the paradigm led to both an EEB and EAB, although the congruency effect size was smaller in the online studies (0.049 & 0.163) than in the lab study (0.318). In contrast to our prediction, the EEB was not more pronounced than the EAB. Testing trait-characteristics of the EEB and EAB, test-retest reliability was not found, as both biases were not stable across time as revealed by low correlations between two measurement timepoints. Moreover, EEB and EAB were unrelated to trait empathy measures. Using EEG, we found a general stimulus-related theta increase, but no significant condition-specific differences were detected. Our findings indicate that an audiovisual setup with trial-based target definition allows to capture both, EEB and EAB. However, both emotional biases were not large, and no specific electrophysiological correlate was found. Both EEB and EAB failed to show significant test-retest reliabilities or relationships with trait empathy measures. Therefore, caution is warranted when studying interindividual differences in emotional biases using this paradigm.

EEB and EAB in the online studies and lab study

The main consistent finding across all three studies is a significant congruency effect (marginal with p = .06 in online study 1), indicating that congruent conditions are rated as more intense (i.e., more pleasant or more unpleasant) than incongruent conditions. In other words, an EEB and EAB was found in our data, in line with prior EEB studies (Bukowski et al., 2020; Hoffmann, Koehne, et al., 2016; Silani et al., 2013; von Mohr et al., 2020). Importantly, the EEB was not larger than the EAB, which has been described in some prior studies (Silani et al., 2013; von Mohr et al., 2020). However, mixed results have been described in previous studies, too (Bukowski et al., 2020; Hartmann et al., 2022; Silani et al., 2013), which used different sensory modalities and tasks. Two factors might be contributing to these differences: on the one hand, interindividual differences and hence differences in sample composition could influence results, on the other hand, the task could influence the role of self and other perception and salience (Pronizius et al., 2022). Here, only the lab study showed a significant three-way interaction of congruency, target, and valence, where follow up results showed an EEB effect for the pleasant condition only, whereas the EAB effect was significant for both valences.

Our paradigm differed in one important aspect from previous setups using visuo-tactile or audio-visual stimuli: the trial-wise versus block-wise manipulation of the target to be rated. In the studies of Silani et al. (2013), Bukowski et al. (2020), and von Mohr et al. (2020), participants were informed before each block, whether they had to evaluate their own or the other's experience. In contrast, we decided to vary the target on a trial-wise basis. Participants hence had to keep both their own and the other's stimulus in mind before they were informed whose experience they should rate. Because participants had to attend to both stimuli before the rating, as opposed to being able to attend more to the stimulus of the respective target, we expected stronger egocentric and altercentric biases since both stimuli were always relevant before the rating. Our expectation, however, was not met, as both EEB and EAB effects (i.e., the congruency effect size) were rather small, especially in the online studies. Moreover, in contrast to von Mohr and colleagues (2020), the EEB was not larger than the EAB. When contrasting findings of the present and the former audiovisual paradigm, however, we must consider that the employed audiovisual stimuli are not identical and could have influenced results.

A further observation in our experiment series was a general increase in effect size of the emotional bias (i.e., the congruency effect) from online experiment 1 to online experiment 2, and lastly to the lab study. The sample composition might explain this effect partly. In online experiment 1, the sample was composed of crowdsourced participants, whereas in online experiment 2 and the lab study a local student sample was measured. We carefully pruned the data to ensure that only task-compliant participants were considered in the analyses (see Methods – Behavioral analysis), which led to a high number of excluded participants, especially in both online experiments. This shows that when using crowdsourced samples, but also more generally in online studies, one should thoroughly control the data and apply adequate criteria to ensure data quality (Lutz, 2016; Stewart et al., 2017).

When further contrasting the online studies and the lab study, the lab study led to the strongest emotional biases similar to previous research using an audiovisual paradigm (von Mohr et al., 2020). We attribute this finding to the fact that a confederate was introduced in the lab study. The presence of a confederate could have influenced and increased the emotional engagement of participants, as they had met the interacting partner and did not have to imagine her as during the online experiment (von Mohr et al., 2020). Since we did not manipulate the presence or absence of a confederate within participant, future research is needed to address whether and how a more salient other in form of a confederate influences EEB and EAB.

The lab study, further, did not only evoke larger biases, it was the only study where egocentric and altercentric bias interacted with the valence of the stimuli, which had not been described in an audiovisual setup before. Another recent emotional bias study employing a modified Cyberball paradigm also found an interaction of the emotional bias with valence (Hartmann et al., 2022). However, the authors did not further discuss this finding, and as their paradigm differs strongly from ours, it is difficult to directly compare these findings. As we did not have any hypotheses on valence specific effects, we refrain here from speculations and await further research to test the robustness of this effect.

Trait characteristics of the EEB and EAB

Although previous research investigated whether the EEB and EAB relate to other personality measures (Bukowski et al., 2020, 2021; Hoffmann, Banzhaf, et al., 2016; Hoffmann, Koehne, et al., 2016; Trilla et al., 2020), no other study has hitherto investigated the test-retest reliability of EEB and EAB. Temporal stability of an effect, however, as indexed by a test-retest reliability, is a basic pre-requisite for interpreting interindividual differences (Hedge et al., 2018).

Here, we could not replicate the relationships between emotional biases and empathy scales, as described in prior studies (Hoffmann, Banzhaf, et al., 2016; Trilla et al., 2020). Further, neither the egocentric nor the altercentric bias showed a significant test-retest reliability, as they did not correlate between two measured timepoints within subjects. These results might have different reasons. One explanation for the lack of retest reliability could be that since the bias effects in online experiment 2 were not very strong, the underlying cognitive effect might not be very robust either; on the other hand, interindividual variance was also low, making the study of interindividual differences difficult (Hedge et al., 2018). Hedge and colleagues (2018) pointed out that low interindividual variability commonly results in low intraindividual reliability and subsequently in a low retest-reliability. The correlation on trend level across time-points of EEB and EAB questions whether low interindividual variance indeed is the problem here. Moreover, the trend-level correlation points to another potential problem: a too small sample. Of further consideration is the fact that the correlational values are low, challenging an analysis of trait-specifics. Low task reliability might further limit the interpretability of the described correlational values (compare Parsons et al., 2019). Evidently, we need more research using this audiovisual paradigm and comparing it to results from other setups to answer the question of how robust the effect is on an interindividual level and how reliable it is on an intraindividual level. We cannot exclude that the second EEB paradigm measured at the second timepoint influenced task performance. However, we believe this influence (if any) to be marginal.

The small effects in the present paradigm could also explain the low correlations with personality measures, which showed no link between empathy scales and emotional biases. A further explanation for this result, however, could be characteristics of our samples. We measured a neurotypical population only, who showed little variance in the subscales of the IRI. Hofmann and colleagues (2016), in contrast, measured a neurotypical *and* a patient population, leading to a greater variance of empathy scale values. Trilla and colleagues (2020) studied a neurotypical population only but used a different emotional egocentricity paradigm, which makes direct comparisons difficult. Lastly, as mentioned above, if emotional biases are not reliable within participant, a correlational approach to empathy scales is questionable (Hedge et al., 2018). These points together could explain why we could not replicate prior findings of a correlative relationship between empathy scales and EEB/EAB.

Importantly, the lack of test-retest reliability and the failure to establish a link between trait empathy measures and emotional biases could also be due to the paradigm. Our conclusions only hold for this specific paradigm, as differences to the former audiovisual paradigm already lead to differences in the behavioural results (compare section – EEB and EAB in the online studies and lab study). In line with this argument we stress that the sample size might have been too small to capture significant retest reliabilities in this setting (compare above). We would expect that paradigms that elicit increased emotional biases and increased interindividual variance (cf. Hedge et al., 2018) can further our understanding of possible trait-characteristics of the EEB and EAB.

Electrophysiological correlates of EEB and EAB

To our knowledge, this is the first study to target the electrophysiology of the egocentric and altercentric bias. As for the behavioral measures, we tested for an electrophysiological correlate of the EEB and EAB effect (as in Bukowski et al., 2020) and for potential differences between EEB and EAB (Silani et al., 2013). Our prediction was to see an increase in theta power as a result of conflict monitoring (Cavanagh & Frank, 2014; Michael X. Cohen & Donner, 2013). Although theta power generally increased in response to the decision prompt, we could not find any condition-related differences. We interpret this result with caution, since there is no prior literature describing an electrophysiological EEB/EAB effect. A main reason for the lack of EEG correlates of an EEB/EAB could be the small size of the behavioral EEB/EAB effect. The argument for the involvement of specific brain regions (Bukowski et al., 2020; Silani et al., 2013) to overcome the EEB is directly linked to the effort that is needed in a specific setting. If the behavioral EEB/EAB is already small, as in our present setup, one explanation is that the requirements for self-other distinction and conflict detection are minimal to begin with. We would argue that in the present audiovisual paradigm conflict detection and monitoring is smaller than expected. Future studies will have to show whether an electrophysiological correlate of the EEB and EAB can be measured when these effects are stronger on a behavioral level.

Limitations and future directions

The testing of retest-reliabilities in online experiment 2 was limited by two interacting factors: (i) the small remaining sample size, and (ii) the small emotional bias effects in this audiovisual paradigm. The combination of these two make it challenging to interpret the lack of retest-reliabilities as evidence for state characteristics. Future studies should take both factors into consideration to answer whether emotional biases show either trait or state characteristics.

Our paradigm differed from other EEB paradigms in the used rating scale. We implemented a purely positive scale from 1 to 10, using a Likert scale, whereas other researchers (Bukowski et al., 2020; Silani et al., 2013; von Mohr et al., 2020) opted for negative to positive rating scales (e.g., -4 to +4), sometimes implemented as visual analogue scale (VAS). Given the online setup, a VAS implementation was not possible here due to technical limitations. To keep results comparable, we implemented the same scale in our lab-based setup. The difference in rating scales could have influenced the rating behavior of the participants. However, we expect that our normalization of the values makes them rather comparable across different scales.

A further limitation is that the uncomfortable fNIRS optodes might have influenced our results in the lab study. Half of our participants reported discomfort up to pain due to the fNIRS optodes. Given that the paradigm asks participants to evaluate their emotional experience, unpleasantness induced by pain might have influenced the ratings of the participants and ultimately the EEB and EAB scores.

In contrast to previous work on emotional biases, the presented sample includes both, males and females. However, online experiment 2 and the lab study have a very low percentage of males, complicating a generalization of the results equally to the male and female population.

While the audiovisual implementation of the EEB paradigm allows for online studies without a confederate, which can be considered a strength compared to the visuotactile setup, the differences between online and lab-based results make it questionable whether lab- and online implementation are comparable. The debate of moving psychological paradigms into more ecologically valid settings (Albert & De Ruiter, 2018) rather speaks for a confederate or interaction partner. At the same time, online studies facilitate data acquisition also under constrained situations, such as a pandemic, when testing clinical populations or when needing larger samples (Lutz, 2016; Stewart et al., 2017). One option to make the other person and her emotional experience more salient in online studies might be to use stimuli presenting another person. For example, videos or pictures with others bearing emotional facial expressions (Trilla et al., 2020) could be used to further study emotional biases.

Conclusion

In a series of three studies, we investigated the emotional ego- and altercentric bias using an adapted audiovisual setup with trial-based target instruction. Our results show an overall congruency effect reflecting emotional biases, which were strongest in the lab-based study with a confederate compared to both online studies. The emotional biases showed only marginally significant test-retest reliabilities and no correlations with empathy scales, challenging trait-characteristics. No electrophysiological correlate of the egocentric/altercentric bias was found. It remains to be clarified whether trait-characteristics and an electrophysiological correlate of EEB/EAB can be detected with stronger behavioral effects than in the current study. We conclude that the emotional bias is strongly task dependent, and that caution is warranted when studying interindividual differences in emotional egocentric and altercentric biases using this paradigm.

REFERENCES

Albert, S., & De Ruiter, J. P. (2018). Improving Human Interaction Research through Ecological Grounding. *Collabra: Psychology*, *4*(1). https://doi.org/10.1525/collabra.132

Boersma, P. (2001). Praat, a system for doing phonetics by computer. *Glot International*, *5*(9/10), 341–345. http://www.fon.hum.uva.nl/paul/papers/speakUnspeakPraat_glot2001.pdf

Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision*, *10*, 433–436. https://doi.org/10.1163/156856897X00357

Bukowski, H., Tik, M., Silani, G., Ruff, C. C., Windischberger, C., & Lamm, C. (2020). When differences matter: rTMS/fMRI reveals how differences in dispositional empathy translate to distinct neural underpinnings of self-other distinction in empathy. *Cortex*, *128*, 143–161. https://doi.org/10.1016/j.cortex.2020.03.009

Bukowski, H., Todorova, B., Boch, M., Silani, G., & Lamm, C. (2021). Socio-cognitive training impacts emotional and perceptual self-salience but not self-other distinction. *Acta Psychologica*, *216*(103297). https://doi.org/10.1016/j.actpsy.2021.103297

Cavanagh, J. F., & Frank, M. J. (2014). Frontal theta as a mechanism for cognitive control. *Trends in Cognitive Sciences*, *18*(8), 414–421. https://doi.org/10.1016/j.tics.2014.04.012

Cohen, Michael X., & Donner, T. H. (2013). Midfrontal conflict-related theta-band power reflects neural oscillations that predict behavior. *Journal of Neurophysiology*, *110*(12), 2752–2763. https://doi.org/10.1152/jn.00479.2013

Cohen, Mike X. (2014). *Analyzing neural time series data*. The MIT Press. https://doi.org/10.7551/mitpress/9609.001.0001

Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. *JSAS Cat Sel Doc Psychol.*, *10*, 85–104.

Decety, J., & Jackson, P. L. (2004). The functional architecture of human empathy. In *Behavioral and cognitive neuroscience reviews* (Vol. 3, Issue 2). https://doi.org/10.1177/1534582304267187

Delorme, A., & Makeig, S. (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, *134*(1), 9–21. https://doi.org/10.1016/j.jneumeth.2003.10.009

Hartmann, H., Lengersdorff, L., Hitz, H. H., Stepnicka, P., & Silani, G. (2022). Emotional Ego- and Altercentric Biases in High-Functioning Autism Spectrum Disorder: Behavioral and Neurophysiological Evidence. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.813969

Hedge, C., Powell, G., & Sumner, P. (2018). The reliability paradox: Why robust cognitive tasks do not produce reliable individual differences. *Behavior Research Methods*, *50*(3), 1166–1186. https://doi.org/10.3758/s13428-017-0935-1

Hoffmann, F., Banzhaf, C., Kanske, P., Gärtner, M., Bermpohl, F., & Singer, T. (2016). Empathy in depression: Egocentric and altercentric biases and the role of alexithymia. *Journal of Affective Disorders*, *199*, 23–29. https://doi.org/10.1016/j.jad.2016.03.007

Hoffmann, F., Koehne, S., Steinbeis, N., Dziobek, I., & Singer, T. (2016). Preserved Self-other Distinction During Empathy in Autism is Linked to Network Integrity of Right Supramarginal Gyrus. *Journal of Autism and Developmental Disorders*, *46*(2), 637–648. https://doi.org/10.1007/s10803-015-2609-0

Janke, S., & Glöckner-Rist, A. (2012). Deutsche Version der Positive and Negative Affect Schedule (PANAS). *Zusammenstellung Sozialwissenschaftlicher Items Und Skalen (ZIS).* https://doi.org/https://doi.org/10.6102/zis146

Lamm, C., Bukowski, H., & Silani, G. (2016). From shared to distinct self-other representations in empathy: Evidence from neurotypical function and socio-cognitive disorders. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1686). https://doi.org/10.1098/rstb.2015.0083

Lutz, J. (2016). The Validity of Crowdsourcing Data in Studying Anger and Aggressive Behavior. *Social Psychology*, *47*(1), 38–51. https://doi.org/10.1027/1864-9335/a000256

Maris, E., & Oostenveld, R. (2007). Nonparametric statistical testing of EEG- and MEG-data. *Journal of Neuroscience Methods*, *164*(1), 177–190. https://doi.org/10.1016/j.jneumeth.2007.03.024

Parsons, S., Kruijt, A. W., & Fox, E. (2019). Psychological Science Needs a Standard Practice of Reporting the Reliability of Cognitive-Behavioral Measurements. *Advances in Methods and Practices in Psychological Science*, *2*(4), 378–395. https://doi.org/10.1177/2515245919879695

Paulus, C. (2009). *Der Saarbrücker Persönlichkeitsfragebogen SPF (IRI) zur Messung von Empathie: Psychometrische Evaluation der deutschen Version des Interpersonal Reactivity Index.* https://doi.org/http://psydok.sulb.uni-saarland.de/volltexte/2009/2363/

Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: Transforming numbers into movies. *Spatial Vision*, *10*(4), 437–442. https://doi.org/10.1163/156856897X00366
Pion-Tonachini, L., Kreutz-Delgado, K., & Makeig, S. (2019). ICLabel: An automated electroencephalographic independent component classifier, dataset, and website. *NeuroImage*, *198*, 181–197. https://doi.org/10.1016/j.neuroimage.2019.05.026
Pronizius, E., Bukowski, H., & Lamm, C. (2022). Self-other distinction across motor, cognitive, and affective representations is neither unitary nor domain-general. *PsyArXiv*. https://doi.org/10.31234/osf.io/b2pv9
Riva, F., Triscoli, C., Lamm, C., Carnaghi, A., & Silani, G. (2016). Emotional egocentricity bias across the life-span. *Frontiers in Aging Neuroscience*, *8*, 1–7. https://doi.org/10.3389/fnagi.2016.00074
Silani, G., Lamm, C., Ruff, C. C., & Singer, T. (2013). Right supramarginal gyrus is crucial to overcome emotional egocentricity bias in social judgments. *Journal of Neuroscience*, *33*(39), 15466–15476. https://doi.org/10.1523/JNEUROSCI.1488-13.2013
SPSS Inc. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. (2013). Armonk, NY : IBM Corp.
Stewart, N., Chandler, J., & Paolacci, G. (2017). Crowdsourcing Samples in Cognitive Science. *Trends in Cognitive Sciences*, *21*(10), 736–748. https://doi.org/10.1016/j.tics.2017.06.007
Team, R. C. (2021). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. https://www.r-project.org/
Tomova, L., Von Dawans, B., Heinrichs, M., Silani, G., & Lamm, C. (2014). Is stress affecting our ability to tune into others? Evidence for gender differences in the effects of stress on self-other distinction. *Psychoneuroendocrinology*, *43*, 95–104. https://doi.org/10.1016/j.psyneuen.2014.02.006
Trilla, I., Weigand, A., & Dziobek, I. (2020). Affective states influence emotion perception: evidence for emotional egocentricity. *Psychological Research*. https://doi.org/10.1007/s00426-020-01314-3
von Mohr, M., Finotti, G., Ambroziak, K. B., & Tsakiris, M. (2020). Do you hear what I see? An audio-visual paradigm to assess emotional egocentricity bias. *Cognition and Emotion*, *34*(4), 756–770. https://doi.org/10.1080/02699931.2019.1683516
Walfish, S. (2006). A review of statistical outlier methods. *Pharmaceutical Technologcy*, *30*(11).
Yang, W., Makita, K., Nakao, T., Kanayama, N., Machizawa, M. G., Sasaoka, T., Sugata, A., Kobayashi, R., Hiramoto, R., Yamawaki, S., Iwanaga, M., & Miyatani, M. (2018). Affective auditory stimulus database : An expanded version of the International Affective Digitized Sounds (IADS-E). *Behavior Research Methods*, *50*, 1415–1429.

SUPPLEMENTARY MATERIAL

Supplementary table 1. Example of pseudorandomized order of trials.

Trial	Congruency	Valence S1	Valence S2	Stim S1	Stim S2	Target
1	congruent	unpleasant	unpleasant	20	13	S2
2	incongruent	unpleasant	pleasant	16	6	S2
3	congruent	pleasant	pleasant	4	9	S1
4	incongruent	unpleasant	pleasant	13	3	S1
5	congruent	pleasant	pleasant	1	7	S2
6	congruent	pleasant	pleasant	6	2	S2
7	incongruent	unpleasant	pleasant	14	4	S1
8	incongruent	unpleasant	pleasant	19	9	S2
9	incongruent	unpleasant	pleasant	15	5	S2
10	congruent	pleasant	pleasant	7	1	S2
11	incongruent	unpleasant	pleasant	16	6	S1
12	incongruent	pleasant	unpleasant	10	20	S1
13	congruent	unpleasant	unpleasant	11	15	S2
14	incongruent	pleasant	unpleasant	6	16	S1
15	congruent	unpleasant	unpleasant	14	19	S1
16	incongruent	unpleasant	pleasant	17	7	S1
17	congruent	unpleasant	unpleasant	12	16	S2
18	incongruent	pleasant	unpleasant	9	19	S1
19	incongruent	unpleasant	pleasant	18	8	S1
20	congruent	pleasant	pleasant	10	5	S2
21	incongruent	pleasant	unpleasant	7	17	S1
22	congruent	unpleasant	unpleasant	14	19	S2
23	incongruent	unpleasant	pleasant	20	10	S1
24	congruent	pleasant	pleasant	9	4	S1
25	congruent	pleasant	pleasant	6	2	S1
26	incongruent	unpleasant	pleasant	13	3	S2
27	congruent	unpleasant	unpleasant	18	17	S1
28	incongruent	pleasant	unpleasant	1	11	S1
29	incongruent	pleasant	unpleasant	3	13	S2
30	congruent	pleasant	pleasant	10	5	S1
31	congruent	unpleasant	unpleasant	16	12	S1
32	congruent	unpleasant	unpleasant	20	13	S1
33	incongruent	unpleasant	pleasant	17	7	S2
34	incongruent	pleasant	unpleasant	5	15	S2
35	congruent	unpleasant	unpleasant	13	20	S2
36	congruent	pleasant	pleasant	2	6	S1
37	incongruent	pleasant	unpleasant	10	20	S2
38	congruent	unpleasant	unpleasant	15	11	S1
39	congruent	unpleasant	unpleasant	19	14	S1
40	congruent	pleasant	pleasant	5	10	S2
41	incongruent	pleasant	unpleasant	1	11	S2
42	incongruent	pleasant	unpleasant	6	16	S2

43	congruent	pleasant	pleasant	5	10	S1
44	incongruent	pleasant	unpleasant	9	19	S2
45	congruent	unpleasant	unpleasant	12	16	S1
46	incongruent	pleasant	unpleasant	4	14	S1
47	congruent	unpleasant	unpleasant	18	17	S2
48	incongruent	pleasant	unpleasant	2	12	S2
49	incongruent	unpleasant	pleasant	14	4	S2
50	congruent	pleasant	pleasant	1	7	S1
51	congruent	pleasant	pleasant	3	8	S2
52	incongruent	unpleasant	pleasant	12	2	S2
53	incongruent	unpleasant	pleasant	11	1	S1
54	congruent	pleasant	pleasant	4	9	S2
55	incongruent	pleasant	unpleasant	3	13	S1
56	congruent	unpleasant	unpleasant	17	18	S2
57	incongruent	unpleasant	pleasant	19	9	S1
58	congruent	pleasant	pleasant	2	6	S2
59	incongruent	unpleasant	pleasant	15	5	S1
60	congruent	unpleasant	unpleasant	17	18	S1
61	incongruent	unpleasant	pleasant	11	1	S2
62	congruent	pleasant	pleasant	8	3	S2
63	congruent	unpleasant	unpleasant	13	20	S1
64	incongruent	pleasant	unpleasant	5	15	S1
65	congruent	unpleasant	unpleasant	19	14	S2
66	congruent	pleasant	pleasant	3	8	S1
67	incongruent	pleasant	unpleasant	7	17	S2
68	incongruent	pleasant	unpleasant	2	12	S1
69	incongruent	pleasant	unpleasant	8	18	S2
70	congruent	unpleasant	unpleasant	11	15	S1
71	congruent	pleasant	pleasant	9	4	S2
72	incongruent	unpleasant	pleasant	18	8	S2
73	congruent	pleasant	pleasant	7	1	S1
74	incongruent	unpleasant	pleasant	20	10	S2
75	congruent	unpleasant	unpleasant	16	12	S2
76	incongruent	pleasant	unpleasant	8	18	S1
77	congruent	unpleasant	unpleasant	15	11	S2
78	incongruent	unpleasant	pleasant	12	2	S1
79	congruent	pleasant	pleasant	8	3	S1
80	incongruent	pleasant	unpleasant	4	14	S2

Notes: Example of a pseudorandomized trial order, impeding more than three consecutive trials of same congruency, more than three consecutive trials of same valence, more than three consecutive trials of same target, or repetition of the same stimulus (self or other) within the next two trials for the subject. S1 = Subject 1, S2 = Subject 2.

Outlier details

Criteria for outlier definition were: (1) if over 40% (n=40) trials were rated with 5 or 6 indicating non-compliance in the task, (2) if they had more than one missing trial in any condition, (3) if they had five or more trials with ratings above a defined upper limit or below a defined lower limit dependent on the valence (compare Methods). In online experiment 1, 15 participants were defined as outliers. In online experiment 2, 10 participants were defined as outliers. And in online experiment 3, 4 participants were defined as outliers. A description of outlier outcome based on the three mentioned criteria shows that criterion 1 only affected online experiment 1. For criterion 1, the criteria lead to n=4 outlier in online experiment 1 and n=0 outlier in online experiment 2, and n=0 outlier in the lab experiment. For criterion 2, the criteria lead to n=10 outlier in online experiment 1, n=5 outlier in online experiment 2, and n=2 outlier in the lab experiment. For criterion 3, the criteria lead to n=4 outlier in online experiment 1, n=5 outlier in online experiment 2, and n=2 outlier in the lab experiment. It is important to highlight that some participants were defined as outliers by more than one criterion (for instance, in the lab experiment one participant was excluded based on two criterions).

Analyses excluding outlier criterion 3

To address concerns regarding the newly applied criterion filtering for odd rating behaviour (criterion 3 for outlier definition), we re-conducted the behavioural analyses without this outlier criterion (i.e., including the defined subjects). The now presented results/analyses only excluded participants based on the defined outlier criteria 1 & 2 (compare Methods):

For online experiment 1, the remaining sample size is n=83 (instead of n=80). The results are qualitatively similar, with significant main effects for congruency ($F(1,82) = 4.61$, $p = .035$, $\eta_p^2 = 0.053$), valence ($F(1,82) = 39.12$, $p < .001$, $\eta_p^2 = 0.323$), and target ($F(1,82) = 13.61$, $p < .001$, $\eta_p^2 = 0.142$), and no interaction effect between congruency and target($F(1,82) = 1.58$, $p = .213$) nor significant three-way interaction ($F(1,82) = 1.05$, $p = .309$).

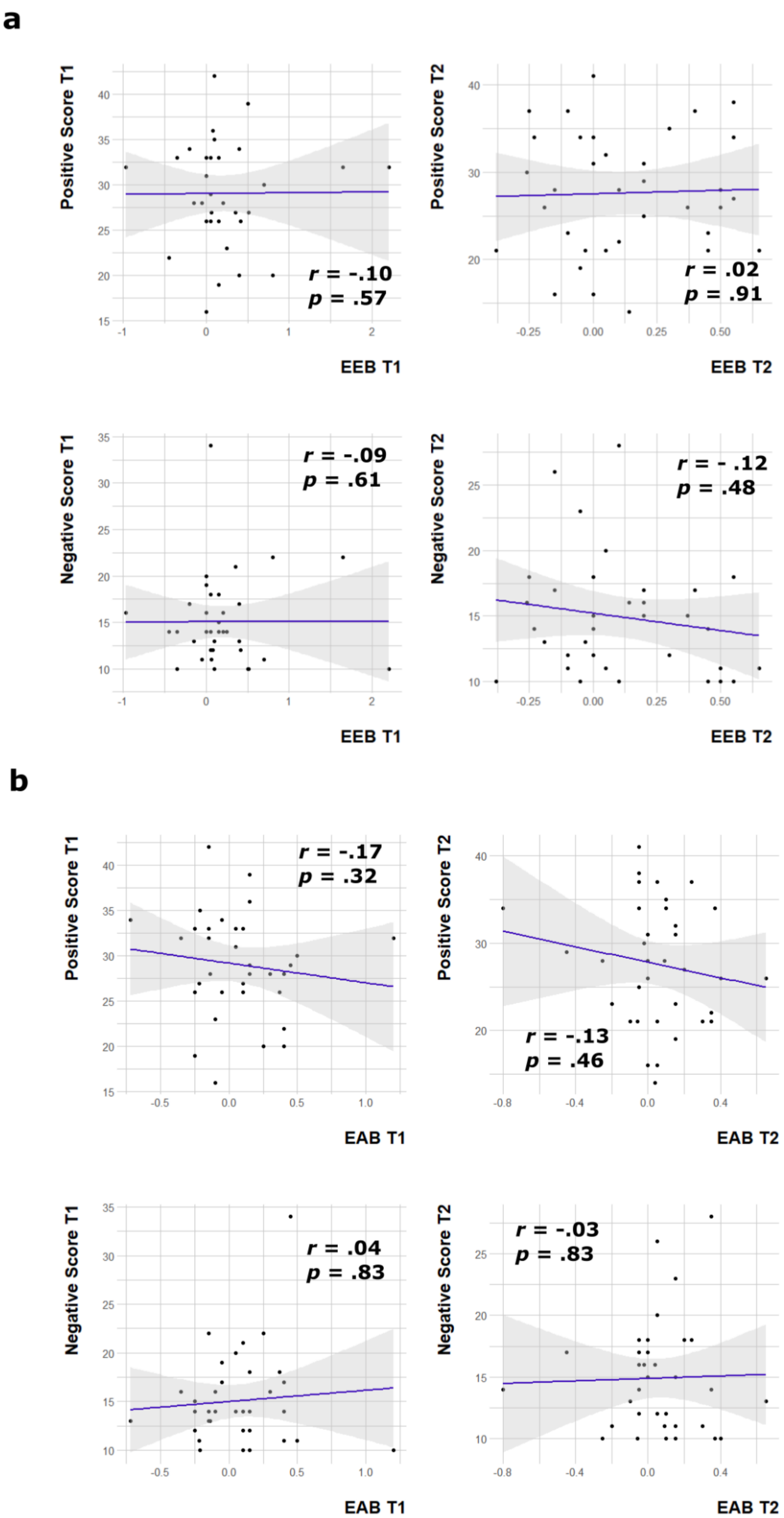
For online experiment 2, the remaining sample size is n=40 (instead of n=35). The results are again qualitatively similar for the main effects, with significant effects for congruency ($F(1,39) = 9.44$, $p = .004$, $\eta_p^2 = 0.195$) and valence ($F(1,39) = 12.83$, $p = .001$, $\eta_p^2 = 0.247$), but not for target ($F(1,39) = 3.60$, $p = .065$) nor timepoint ($F(1,39) = 1.76$, $p = .193$). Interestingly, we here find a significant interaction effect between congruency and target ($F(1,39) = 5.80$, $p = .021$, $\eta_p^2 = 0.129$), which stands in contrast to the results excluding further participants. No significant three-way interaction between congruency, target, and valence was found ($F(1,39) = 1.39$, $p = .245$) nor four-way interaction with timepoint ($F(1,39) = 0.90$, $p = .348$).

For the lab experiment, the remaining sample size is n=28 (instead of n=27). The results are once again qualitatively similar, with significant main effects for congruency ($F(1,27) = 14.01$, $p = .001$, $\eta_p^2 = 0.342$), but not for valence ($F(1,27) = 0.01$, $p = .920$) nor target ($F(1,27) = 3.05$, $p = .092$). Further, there was again no interaction effect between congruency and target ($F(1,27) = 1.84$, $p = .186$) but a significant three-way interaction of congruency, target, and valence ($F(1,27) = 21.79$, $p < .001$). Post-hoc comparisons show the same pattern as the reported results in the main manuscript (congruency x target interaction: for pleasant $p = .035$ and for unpleasant $p < .001$).

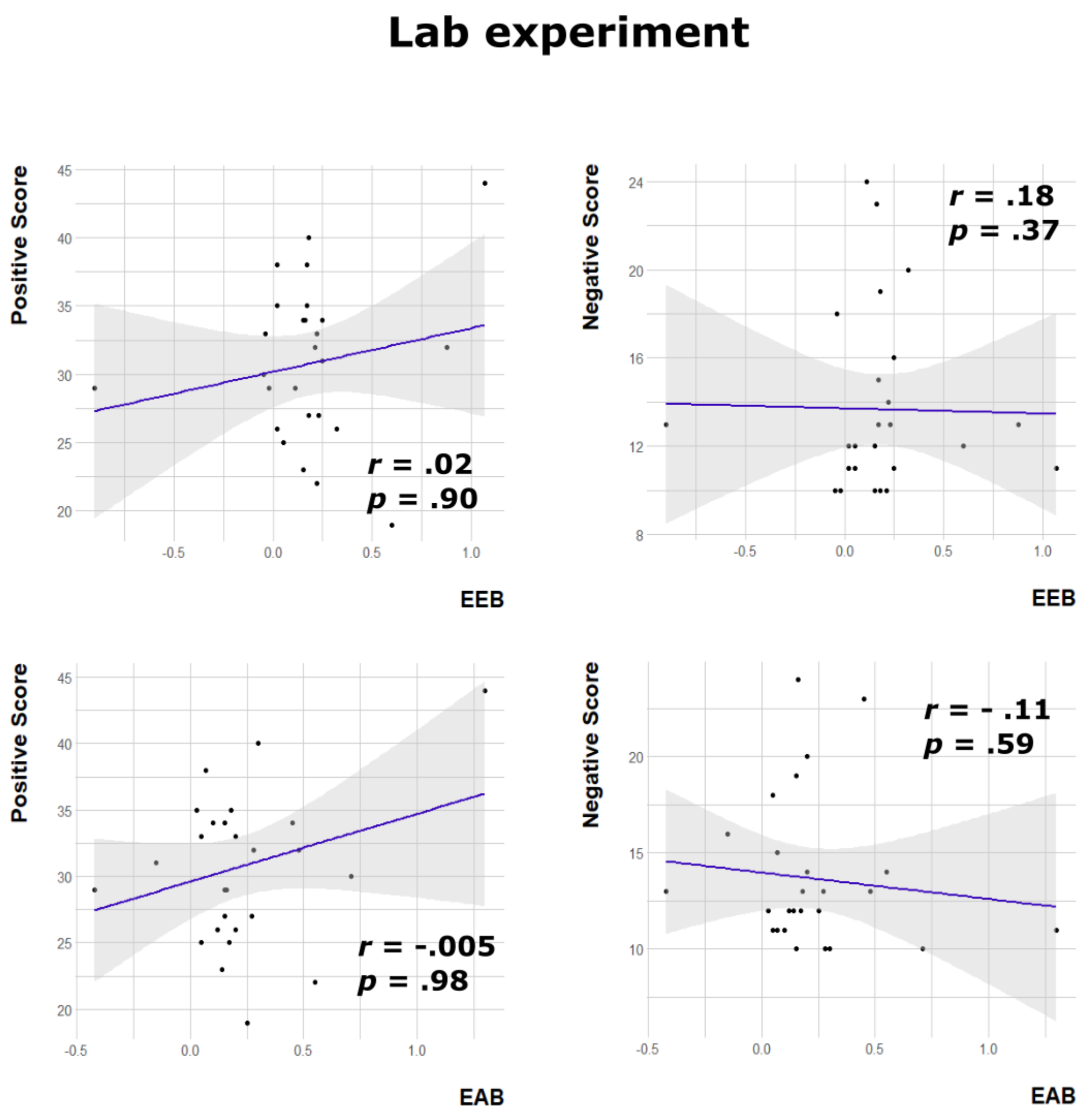
PANAS results

As a control for the current mood of the participants, i.e., reflecting the state of the participant, the PANAS was collected in online experiment 2 and the lab experiment. Spearman rank correlations did not show significant relationships (all $p > .32$) between the resulting positive score and EEB or EAB or between the negative score and the EEB or EAB (see supplementary figures 1 & 2).

Online experiment 2



Supplementary figure 1. Correlations of PANAS and EEB/EAB in online experiment 2. (a) Correlations of the EEB with the Positive (upper) and Negative Score (lower) of the PANAS at T1 (left) and T2 (right). (b) Correlations of the EAB with the Positive (upper) and Negative Score (lower) of the PANAS at T1 (left) and T2 (right).



Supplementary figure 2. Correlations of PANAS and EEB/EAB in online experiment 3. Correlations of the EEB (upper) and EAB (lower) with the Positive (left) and Negative Score (right) of the PANAS.

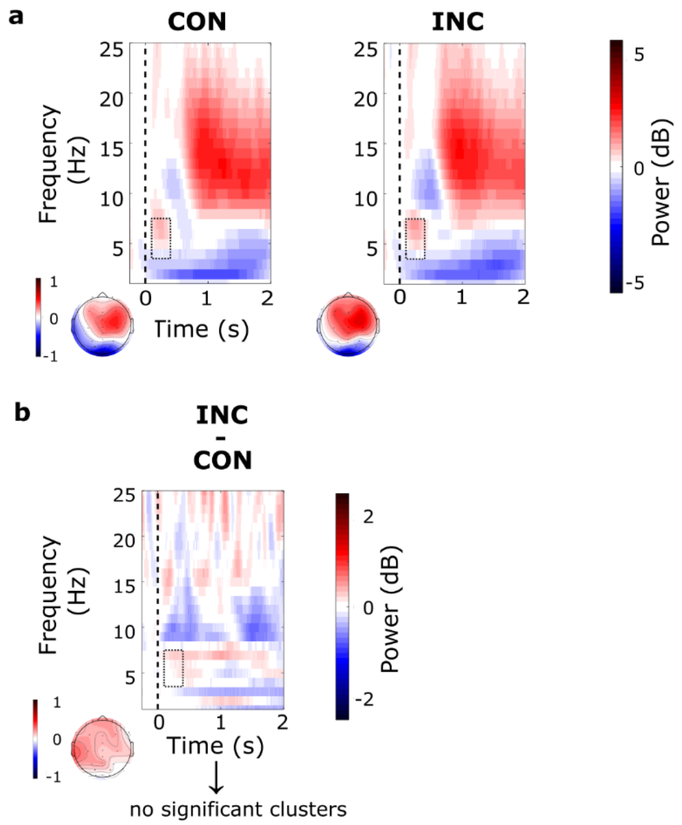
EEG analysis and results

Supplementary table 2. Number of components and trials rejected per participant and condition.

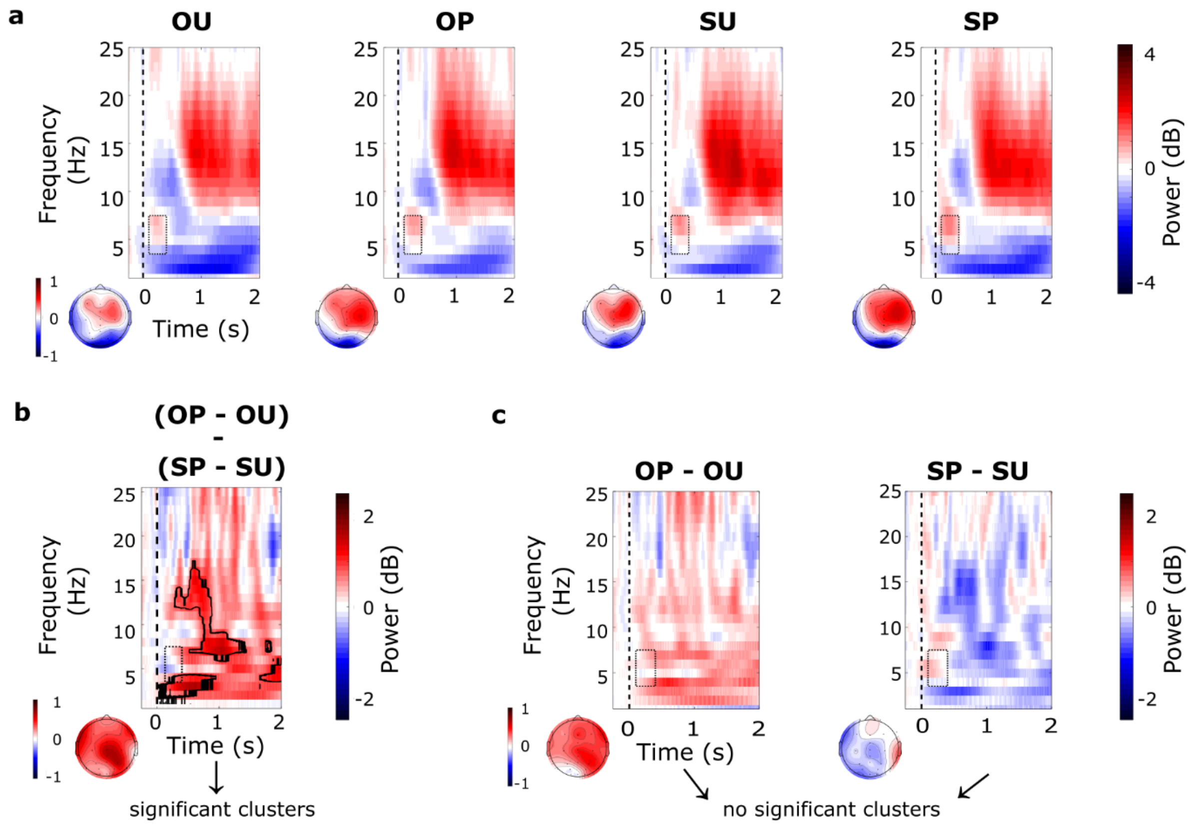
SBJ	Comp	Trials per condition									
		self con. (n=40)	self inc. (n=40)	other con. (n=40)	other inc. (n=40)	con. (n=80)	inc. (n=80)	self ple. (n=40)	self unp. (n=40)	other ple. (n=40)	other unp. (n=40)
1	4	12	7	11	15	26	20	9	11	15	8
2	6	5	4	7	9	11	9	9	4	11	7
3	8	5	9	5	6	9	13	8	3	5	6
4	7	8	7	4	4	11	13	6	5	6	7
6	6	9	6	6	9	12	12	7	4	11	4
7	6	12	14	10	13	23	28	11	12	13	10
8	10	6	8	9	10	14	14	5	7	9	9
9	9	7	4	5	9	12	11	5	4	8	5
10	9	2	2	6	2	10	5	2	2	4	2
11	6	4	5	4	6	9	9	3	6	5	5
12	5	3	2	3	5	9	9	1	3	4	2
13	5	13	6	7	10	15	12	4	7	13	5
14	7	6	7	14	9	13	17	5	5	12	15
15	8	11	8	11	9	27	19	12	9	7	11
16	7	9	8	9	6	16	15	11	9	10	6
17	9	10	10	8	13	19	27	13	9	11	13
19	5	5	7	5	5	9	14	5	7	6	6
20	5	5	6	7	2	13	11	6	9	7	3
21	7	8	5	9	5	16	10	7	5	4	7
22	8	3	6	4	4	8	9	3	5	4	4
23	9	8	5	9	6	15	13	9	7	6	5
24	4	3	4	2	4	4	6	3	3	1	3
25	7	8	3	4	4	9	8	4	6	8	2
26	9	7	9	8	8	13	18	9	10	8	6
27	10	8	10	10	8	15	21	8	8	10	8
28	10	0	0	1	1	2	2	1	0	1	1
31	7	6	2	6	5	11	11	4	6	8	7
M	7	7	6	7	7	13	13	6	6	8	6

Notes: Number of components (comp.) and trials per condition (n=total) rejected per subject (sbj). Con =congruent, Inc=incongruent, Ple=pleasant, Unp=unpleasant. *M* = Mean.

A further possibility to approach the question of the underlying electrophysiological correlates could be to target the main effects separately (Pronizius et al., 2022). In this line of reasoning, the main effect of congruency reflects the self-other conflict, while the main effect of target reflects the self-other salience (Pronizius et al., 2022). Here, to test for a neural bias effect following the behavioural results, first, a single main effect comparison of congruency (incongruent minus congruent) was calculated. We found no significant effect for the congruency contrast (see supplementary figure 3). The second contrast was calculated for the conditions averaged over congruency, leading to four conditions (target x valence): other pleasant (OP), other unpleasant (OU), self pleasant (SP), and self unpleasant (SU), see supplementary figure 4 a. We found no significant clusters for the single contrasts (OP-OU and SP-SU, respectively; see supplementary figure 4 c), but a significant effect for the double difference [(OP-OU)-(SP-SU); see supplementary figure 4 b]. The latter result could reflect a more salient processing for the self than the other dependent on the valence of the stimulus. (See Methods – EEG analysis for details on preprocessing and analysis.)



Supplementary figure 3. Neural results lab experiment – exploratory analysis 1. (a) Time-frequency responses (TFR) at electrode Cz for each congruency condition: congruent (CON), incongruent (INC). Zero denotes onset of target indication (coloured circle, see Fig. 1). Below, the activation map is shown for the theta range (4-7 Hz) from 100 to 400 ms (time-window highlighted as square in TFR plot). (b) Difference of time-frequency responses at electrode Cz (INC – CON). Below, the activation map is shown for the theta range (4-7 Hz) from 100 to 400 ms (time-window highlighted in TFR plot).



Supplementary figure 4. Neural results lab experiment – exploratory analysis 2. (a) Time-frequency responses (TFR) at electrode Cz for each condition: other unpleasant (OU), other pleasant (OP), self unpleasant (SU), self pleasant (SP). Zero denotes onset of target indication (coloured circle, see Fig. 1). Below, the activation map is shown for the theta range (4-7 Hz) from 100 to 400 ms (time-window highlighted in TFR plot). (b) Difference of time-frequency responses at electrode Cz [(OP-OU) – (SP-SU)]. Below, the activation map is shown for the theta range (4-7 Hz) from 100 to 400 ms (time-window highlighted in TFR plot). Significant clusters are shown by contouring black lines. (c) Differences of time-frequency responses at electrode Cz for the other condition (OP-OU) and the self condition (SP-SU). Below, the activation map is shown for the theta range (4-7 Hz) from 100 to 400 ms (time-window highlighted in TFR plot).