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Configural face processing and its influence on the timeline of mentalization☆

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A B S T R A C T

When mentalization fails, dehumanization can occur. Perceiving others as lacking fundamental mental states is the basic principle of dehumanization. Past research has already demonstrated the influence of both perceptual and contextual information on mentalization, while a recent line of research has tried to distinguish mentalization in a two-stage process: a mind detection phase in which we first identify a mind in others thanks to primary visual cues and a mind attribution phase in which both perceptual and contextual information are integrated to finalize the attribution of mental states to others. The current research aimed at deepening our understanding of the timeline of the mentalization process by specifically manipulating a perceptual, visual cue that has been related to dehumanization: the configural face process. This process was tested adapting the inversion effect that allowed us to show for the first time how and when this effect impacts and modulates the timeline of mentalization. Results indicated that the inversion effect impacted the early mind detection phase and resulted later in time in the elaboration of inverted human stimuli as more object-like.

Introduction

Dehumanization occurs whenever humans are denied fundamental mental capacities and are therefore perceived as lacking humanity. By focusing specifically on the role of visual perceptual cues, the aim of the current paper is to deepen our understanding of the timeline of the mentalization process. Indeed, a recent finding distinguished mentalization into an initial mind detection and a later mind attribution phase (Ruzzante and Vaes, 2021) in which only in the latter phase the process of mentalization was modulated by the integration of both perceptual and contextual information. Previous research, however, has never managed to show any modulation of perceptual information on the initial mind detection phase, while the past literature has clearly related dehumanization and mentalization processes with low-level visual processes (Fincher and Tetlock, 2016; Hugenberg et al., 2016). One such process is configural face processing manipulated through the Inversion of face stimuli (Yin, 1969). Therefore, we specifically manipulated the inversion of face stimuli with the aim to show how and at what point in time this process impacts people's capacity to attribute a mind to social targets.

Dehumanization and (de-)mentalization

Inferring other people's minds constitutes a fundamental step in developing social connections (Waytz et al., 2010). When we connect and interact with others, we need to think about how others might feel, what they might think, plan or desire. This is the so-called mentalization process, a complex cognitive process that happens when we perceive and attribute mental states to others. Attributing a mind to others is important as it allows us to understand, predict and anticipate other's behavior.

One can think about a mind in terms of conscious experiences, the capacity to sense and feel, or in terms of intentional agency, the capacity to engage in reasoned action (Gray et al., 2007). Similarly, a mind can be perceived as reflecting abilities central to our human nature, the capacity for emotional responsiveness, or our human uniqueness, the capacity to be civil and rational (Haslam, 2006). As such, mentalization has been studied as one of the central components in the

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dehumanization process, because the extent to which we attribute a mind to others is directly linked with the degree to which we perceive them as human.

When considering perceptions of humanity, denying uniquely or central human characteristics is what defines a dehumanized person or group (see Haslam, 2006; Haslam and Loughnan, 2014; Leyens et al., 2007 for a review). The common reported finding is that some outgroups are perceived as less human than the ingroup. Over the years, this hypothesis has been corroborated using emotion-based (e.g., Leyens et al., 2001, 2003, 2007; Paladino et al., 2002), trait-based (e.g., Bain et al., 2009; Haslam et al., 2005), and metaphor-based measures (e.g., Goff et al., 2008; Kteily et al., 2016), as well as perceptual (e.g., Fincher and Tetlock, 2016) and neural evidence (e.g., Harris and Fiske, 2006; Ruzzante and Vaes, 2021). Indeed, focusing on the latter approach, dehumanization can be defined as a fading of the human-object divide. This divide stems from the observation that human and non-human entities are typically elaborated and processed very differently by the human brain (Haxby and Gobbini, 2011; Kanwisher et al., 1997; Peelen and Downing, 2005), implying that dehumanized targets are likely elaborated and processed more similarly to non-human entities (for a review see, Ruzzante and Vaes, 2023).

Dehumanization and the inversion-effect

To date a lot of research has explored the role of perceptual information in the dehumanization process. Indeed, the perception of humanness in social targets can be influenced by perceptual and visual cues in several ways. Most studied perceptual cues are facial features, such as the presence of eyes (Looser and Wheatley, 2010) or the Facial Width to Height ratio (FHRW, Deska et al., 2018). However, the perceptual process that has been associated most widely with dehumanized perceptions, is the well-known inversion-effect. This mechanism has its roots in visual perceptual processes. When considering a stimulus, people tend to process it either as a holistic entity, by using configural processes that involve perceiving spatial relations among the features of the stimulus, or as an assemblage of parts, that are processed analytically. The general reported finding is that human faces are elaborated holistically, while objects tend to be processed more analytically (Peterson and Rhodes, 2003). One way to verify these different types of processes consists in comparing the elaboration of object and face stimuli that are presented upright or inverted. Inverting a stimulus keeps the perceptual elements of the stimulus intact, but changes the spatial relations among the stimulus features. Thus, the inversion effect is a face-sensitive perceptual mechanism in which upright faces that preserve a normal configuration of the stimulus features (i.e., eyes, nose, mouth), are properly and easily recognized compared to the same faces that are presented upside-down changing the normal configuration of these features.

Previous research has tried to demonstrate the link between dehumanized perceptions and the disruption of configural face processing (Hugenberg et al., 2016). For example, across seven studies Fincher and Tetlock (2016), suggested that people tend to change face-typical processing towards dehumanized targets and this shift facilitates punitive behavior. In a similar vein, presenting inverted vs. upright faces has shown to inhibit the inferences of trustworthiness and humanity traits (Wilson et al., 2018), to undermine the decoding of emotions from the eyes and to trigger more dehumanized evaluations (Cassidy et al., 2021). Deska and colleagues (2017) used mindful human and mindless doll-like faces that were presented upright or inverted to participants. In two studies they demonstrated that both the humanity of these faces (i.e., being human or doll-like) together with the possibility of using configural face processing mechanisms (i.e., when faces were presented upright instead of inverted) are fundamental to ascribe a mind to others. Taken together, these studies suggest how disrupting face configural processes can be indicative of perceptual dehumanization given that the inversion effect does not occur with faces of dehumanized targets and can interrupt the inference of mental states from faces.

Inversion effect and neural activation

While the inversion effect has been clearly associated with dehumanized perceptions (Fincher and Tetlock, 2016; Hugenberg et al., 2016), past studies have linked this process to a specific ERP component, the N170. The N170 is an early Event-related Potential (ERP) that typically peaks around 170 ms after stimulus onset, informative of the early face configuration and associated in particular with the disruption of the configural processing of faces (Rossion et al., 2000). Specifically, the N170 seems to increase for inverted faces and bodies (Reed et al., 2003), but not for houses (Bossi et al., 2020). As such, the inversion effect is typically found for human faces, but not for non-human objects (see Busey and Vanderkolk, 2005; Rossion et al., 2000; Thierry et al., 2007 for notable exceptions).

More recently, Ruzzante and Vaes (2021, 2023) associated the N170 with yet another process. Directly comparing how mindful, human and mindless, doll-like faces were elaborated by participants, they found that these faces were first distinguished in a negative ERP that strongly overlapped with the N170. Indeed, mostly over central electrodes, the mindful, human faces showed a stronger negative deflection in the time window that is typically associated with the N170. These researchers coined this moment in which human, mindful and doll-like, mindless faces are distinguished for the first time, the mind detection phase, the phase in which mindful stimuli are simply detected and differentiated from perceptually similar mindless objects.

The timeline of mentalization

Given that the inversion effect has been related to dehumanized perceptions (Fincher and Tetlock, 2016; Hugenberg et al., 2016), has been associated with a specific activation of the N170 (Rossion et al., 2000) and the N170 has been related with the first moment in which human and non-human face stimuli are distinguished for the first time (Ruzzante and Vaes, 2021), it becomes interesting to investigate how these processes that were studied separately until now integrate at a neural level. A potentially promising way to do this, is to analyze the timeline of mentalization. In a first attempt to map this timeline, Ruzzante and Vaes (2021, 2023) conceptualized the mentalization process as a two-phase process. An initial mind detection phase, that allowed participants to distinguish human, mindful and doll-like, mindless faces for the first time and a later mind attribution phase in which both perceptual and contextual information were integrated in order to determine the amount of mental capacities that were ascribed to the social targets.

Ruzzante and Vaes (2021) tested this conceptualization introducing a novel EEG paradigm – the (De-)Mentalization Oddball Paradigm (D-MOP). In this paradigm perceptually similar mindful, human and mindless doll-like stimuli are directly compared. In several experiments results confirmed that the human and object stimuli were distinguished to a lesser extent when the human stimuli represented potentially dehumanized targets (Ruzzante and Vaes, 2021; Vaes et al., 2019). Based on the observation that human and non-human entities are typically elaborated and processed very differently by the human brain (Haxby and Gobbini, 2011; Kanwisher et al., 1997; Peelen and Downing, 2005), the results of this paradigm allow to gauge dehumanization directly as the fading of the human-object divide demonstrating the extent to which social targets become truly similar to mindless objects.

Specifically, the D-MOP focusses on two ERPs. The N170, in which human and non-human stimuli are distinguished for the first time and that has been related with the mind detection phase of mentalization; and the P300, an ERP that occurs between 360 and 600 ms after stimulus onset and has been associated with mind attribution, the phase in which people are believed to attribute more or less mental capacities to social targets. Previous research has demonstrated that the latter phase was clearly influenced by variables that are known to modulate dehumanized perceptions (Ruzzante and Vaes, 2021). Specifically, race, group membership and FWHR all impacted the P300 demonstrating how outgroup human faces were elaborated more similarly to their doll-like counterparts compared to the same human-object comparison for ingroup faces. Moreover, the activation of the P300 correlated with an external criterion, that is, an Implicit Association Test that measured people's tendency to attribute a mind to ingroup and outgroup members. Both findings corroborated the idea that modulations in the P300 when measured in the D-MOP can signal differences in mind attribution and dehumanized perceptions. Instead, in all experiments conducted until now, the N170, only signalled the first moment in which mindful human targets were differentiated from mindless objects, without any modulation of race, group membership or FWHR. These results seem to suggest that the initial mind detection phase occurs independently from the dehumanized status of the targets that are judged.

Therefore, in the current research we manipulated the inversion effect, a face perception cue that has been associated both with dehumanization processes (Fincher and Tetlock, 2016; Hugenberg et al., 2016) and modulations in the N170 (Rossion et al., 2000). Specifically, by disrupting the configural face processing we aimed to verify whether the mind detection phase can be indicative of an initial dehumanization process and whether and how it will moderate the elaboration of mindful and mindless targets in an early and/or later time window.

The present research

With all this in mind, the present research project had the aim to verify when the inversion effect will moderate the elaboration of mindful human and mindless doll-like faces allowing us to determine the moment when the inversion effect will lead to dehumanized perceptions in the timeline of the mentalization process. In order to test this hypothesis, we adapted the *(*De-)Mentalization Oddball Paradigm (D-MOP). The oddball paradigm is a well-known paradigm used in EEG experiments in which a sequence of repetitive frequent stimuli (i.e., human faces) are infrequently interrupted by an oddball target (i.e., perceptually similar doll-like avatars) (Picton, 1992). In line with previous research, we analyzed two main ERP components: the N170 and the P300. The first one was considered because it is defined as the central component of the mind detection phase (Ruzzante and Vaes, 2021, 2023) and is closely related with face perception (Eimer, 2011) and the face inversion effect (Rossion et al., 2000). The P300, instead, is a central component in the odd-ball paradigm, which amplitude is triggered by both the frequency of the oddball stimulus and the extent to which the oddball is perceptually differentiated from the frequent stimulus (Polich, 2012).

Specifically, in the current study we manipulated the inversion effect given that it has previously been associated with dehumanized perceptions (Fincher and Tetlock, 2016; Hugenberg et al., 2016) and with early stages of face elaboration (Rossion et al., 2000). The perception of humanness was gauged measuring the differences in electrical brain activity when participants elaborated human and perceptually similar doll-like faces. Finally, and in line with previous research, we manipulated the group membership of the presented faces.

Specifically, all Caucasian human and doll-like faces were presented upright and inverted and labelled as "Italians" (ingroup) or "Romanians" (outgroup). Given that the rate with which frequent and infrequent stimuli appeared was kept constant, differences in the activation of the P300 can be interpreted as an indication of the extent to which stimuli with (i.e., human faces) and without a mind (i.e., perceptually similar doll-like avatars) are elaborated and recognized (see Ito and Urland, 2003b; Ruzzante and Vaes, 2021; Tomelleri and Castelli, 2012; Vaes et al., 2019, for a similar reasoning). The more the activation of the P300 between the frequent and infrequent stimuli is similar, the more the human targets are elaborated similarly to a mindless object and thus dehumanized. Therefore, comparing the way in which inverted or upright presented faces belonging to ingroup or outgroup members modulate the P300, can allow us to identify the extent to which these variables influence the mind attribution stage of the mentalization process. Specifically, we expect both perceptual (i.e., the inversion effect) and contextual cues (i.e., group membership) to influence the P300 in such a way that the difference between the doll-like and human faces should be smaller for those social targets that are more likely dehumanized, that is, inverted and outgroup faces.

The N170, instead, is a negative and early wave that has been related to configural face processing (Ofan et al., 2011; Rossion et al., 2000; Wheatley et al., 2011), and to animacy and perceptions of humanity (Hadjikhani et al., 2009; Ruzzante and Vaes, 2021). Based on previous research, two alternative hypotheses can be tested for the N170 that represents the mind detection phase. On the one hand, (a) the inversion and the humanity effect can be expected to interact with one another. Indeed, given the relationship between configural face processing and dehumanization (Deska et al., 2017; Fincher and Tetlock, 2016; Hugenberg et al., 2016), one might expect that the inversion effect will modulate the N170 in interaction with the humanness of the faces (human vs. doll-like faces) in such a way that the inversion effect should be especially pronounced for the human faces. Indeed, only when human, mindful faces are perceived differently from the doll-like, mindless targets especially when they are inverted, we can say that the disruption of configural face processes is directly related with dehumanized perceptions. Alternatively, (b) following past studies that did not find any effect of perceptual cues on the N170 (Ruzzante and Vaes, 2021; Wheatley et al., 2011), one can expect the N170 component to be modulated by the differentiation between the human and the doll-like faces and by the inversion effect separately in two main effects, without these cues having to interact with each other.

Even though both hypotheses would sustain the close relationship between configural face processing and dehumanized perceptions, the first would demonstrate that this relationship is able to affect processes early in time during the mind detection phase and sustain over time during the mind attribution phase. The second hypothesis, instead, would demonstrate that configural face processes occur independently from the moment participants detect a mind in a face for the first time, and only result in dehumanized perceptions in the mind attribution phase when both perceptual (i.e., the face inversion effect) and contextual (i.e., group membership) information are integrated.

Methods

Participants

Based on previous research that used the D-MOP (Ruzzante and Vaes, 2021), we recruited 30 healthy volunteers that received a fee of 15.00 € or university credits for their participation. All participants had normal or corrected to normal vision and reported no history of neurological impairments. Due to an excessive rate of EEG artefacts in each condition (exceeding 50 %) two participants were excluded from the analysis. A final sample of 28 participants, all Italian citizens, (9 males; $M_{age} = 25.44$, $SD = 3.91$; 17 females; $M_{age} = 22.64$, $SD = 3.01$) was retained for the analysis. A sensitivity power analysis using PANGEA (for details see www.jakewestfall.org/pangea/) indicated that we had sufficient power (0.803) to detect a partial eta squared of $\eta_p^2 = 0.07$ with an alpha = 0.05 for the interaction effect and a partial eta squared of $\eta_p^2 = 0.045$ with an alpha = 0.05 for any of the main effects. The study was performed in accordance with relevant guidelines and regulations and all methods were approved by the University's Human Research Ethics Committee (protocol 2016–004) and all participants gave their consent at the beginning of the experiment.

Stimuli

We selected faces of White males taken from the Chicago Face

Database (Ma et al., 2015). Specifically, from the norming data and codebook we selected 32 faces that we divided into 2 different lists of faces. In this way each list was presented as containing ingroup or outgroup faces and the group membership of each face was counterbalanced between participants. Instead, all faces were both presented inverted and upright for each participant. For example, participant number one saw picture number 040 as Ingroup Inverted and Ingroup Upright and picture number 039 as Outgroup Inverted and Outgroup Upright, vice versa for participant number 2 and so on. Therefore, we had a total of two groups of 16 faces that were perceived to be equally afraid, angry, attractive, disgusted, baby-faced, dominant, feminine, happy, masculine, prototypic for their race, sad, surprised, threatening, unusual and had a similar luminance and similar FWHR (all *ps*>0.16) (see Supplemental Online Material (SOM) for the full report).

The doll-like avatar faces were created starting from 16 different doll faces we collected on the internet. We then paired each stimulus with a doll face. The doll-like avatar faces were created morphing the original human (30 %) and the doll face (70 %). Then we changed the orientation of each face, creating the inverted faces (see Fig. 1). In this way we had a total of 32 human faces and 32 doll-like avatar faces that were balanced and randomized as explained above. Finally, we balanced the luminance across human and doll-like faces converting each picture to greyscale and then equalizing their luminance using Matlab.

Electrophysiological recording and processing

We recorded the EEG from a 25 electrodes cap, with a left earlobe electrode and a right earlobe reference (bandpass filter: 0.01 – 200 Hz; A/D rate: 1000 Hz). During the EEG registration the electrodes impedance was maintained below 10/5 KΩ. The analyses were conducted with the EEGLAB (Delorme and Makeig, 2004) and the ERPLAB (Lopez-Calderon and Luck, 2014) toolbox of MATLAB. Raw data were filtered with a bandpass filter of 0.1–40 Hz. The data were re-referenced offline to the average of the right and left earlobe electrodes. The horizontal electrooculogram (HEOG) was recorded from two electrodes placed on the outer canthi of both eyes. The raw signal was segmented in 900 ms long epochs that began 200 ms before the stimulus onset. We used a baseline correction of the mean activity during a 200 ms pre-stimulus interval. Artifact rejection started first with an Independent Component Analysis on the continuous signal using the Infomax algorithm (Bell and Sejnowski, 1995) rejecting components related to eye and muscle movements. Then a manual artifact rejection on the remaining epochs was used to remove any other artefacts (any channel exceeding ± 70 μV). The mean number of retained epochs for each participant in each block exceeded 50 %.

Since the D-MOP already provided evidence for two specific steps in the timeline of mentalization, only the N170 and the P300 were taken into consideration. Therefore, we identified the area's latency following the same procedure that was used in Ruzzante and Vaes (2021), running a latency analysis, in which we identified the specific time windows of the N170 by centring the peak and by verifying the scalp maps distribution. Specifically, the N170 was found over T8 and C4, and was maximal over the Cz-electrode between 100 and 160 ms after stimulus onset. The P300 instead was identified using the same procedure that was used in Vaes et al. (2019) and later in Ruzzante and Vaes (2021) dividing the signal into 20 ms segments between 300 and 600 ms after stimulus onset and identifying when the doll-like faces significantly started and finished to differ from the human faces for both in- and outgroup targets. Following this procedure, the P300 was found maximal over the parietal region between 340 and 600 ms after stimulus onset.

Procedure

A total of 128 stimuli, 64 representing Ingroup faces (16 Upright human stimuli and 16 Upright doll-like avatar stimuli and 16 Inverted human stimuli and 16 Inverted doll-like avatar stimuli) and 64 representing Outgroup faces (16 Upright human stimuli and 16 Upright doll-like avatar stimuli and 16 Inverted human stimuli and 16 Inverted doll-like avatar stimuli) appeared at the centre of the screen. The dimensions of each picture were kept constant (733 × 465 pixels). Targets were presented 2.67° under the centre of the screen on a uniformly grey background. The fixation cross was located 1.91° above the centre of the screen. We used the oddball paradigm to present the stimuli in which the human faces were the frequent stimuli that were infrequently interrupted by the doll-like faces, that always constituted the deviant stimuli (see Fig. 2 for an example of the experimental procedure).

In the D-MOP participants were asked to categorize the pictures by pressing two keys on the keyboard: one for the doll-like faces and another for the human faces. Four blocks were presented in a randomized order. Two of them only contained Ingroup targets, once presented Upright and once Inverted, while only Outgroup faces were presented in the other two blocks, once Upright and once Inverted. Each block contained 400 pictures (80 % frequent stimuli ($N = 320$) and 20 % infrequent stimuli ($N = 80$), and care was taken that every infrequent stimulus was followed by at least two frequent stimuli. As such, each participant at the end of the experiment was always presented with a total of 1600 trials divided into: 800 Inverted faces (400 Ingroup and 400 Outgroup) and 800 Upright faces (400 Ingroup and 400 Outgroup). Each trial began with a fixation cross that lasted for 1500 ms and remained on the screen when the face appeared. All target pictures remained on the screen until participants gave their response.

After the D-MOP, participants were asked to complete an Implicit Mind Association Task (IMAT).[1]

Results

Behavioral results

A fully crossed within-participants ANOVA 2 (Face presentation: Upright faces vs Inverted faces) X 2 (Group: ingroup vs outgroup) X 2 (Target humanity: human faces vs doll-like faces) was conducted on both participants' accuracy and reaction times. In all statistical analyses, the alpha level was set to 0.05 and all pairwise comparisons were Bonferroni-corrected.

Participants' accuracy was only influenced by target humanity, $F(1,27)=66.07$, $p<.001$, $\eta_p^2=0.71$. Human faces ($M = 0.99$, $SD=0.01$) were categorized more accurately than doll-like faces ($M = 0.91$, $SD=0.04$). Neither the Target group, $F(1,27)=0.042$, $p=.839$, $\eta_p^2=0.002$, nor the Inversion effect, $F(1,27)=0.363$, $p=.552$, $\eta_p^2=0.013$, affected participants' accuracy. Moreover, none of the interaction effects emerged significantly (all $ps>0.51$).

Similarly, reaction times were influenced by the target's humanity, $F(1,27)=56.65$, $p<.001$, $\eta_p^2=0.67$, and by target's Upright and Inverted presentation, $F(1,27)=12.53$, $p=.001$, $\eta_p^2=0.32$. Human faces ($M = 548.46$, $SD=111.11$) and Upright faces ($M = 569.26$, $SD=102.89$) elicited faster reaction times compared to doll-like ($M = 627.67$, $SD=122.66$) and Inverted faces ($M = 607.86$, $SD=130.41$). Participants' reaction times were not influenced by the target group, $F(1,27)=0.243$, $p=.626$, $\eta_p^2=0.009$, and none of the interaction effects emerged significantly (all $ps > 0.21$).

Electrophysiological results

A fully crossed within-participants ANOVA 2 (Face presentation: Upright faces vs Inverted faces) X 2 (Group: ingroup vs outgroup) X 2 (Target humanity: human faces vs doll-like faces) was conducted on

[1] Given that results of the IMAT are less central to the purpose of the current manuscript, the procedure and the results of the IMAT can be found in the Supplemental Online Material (SOM).

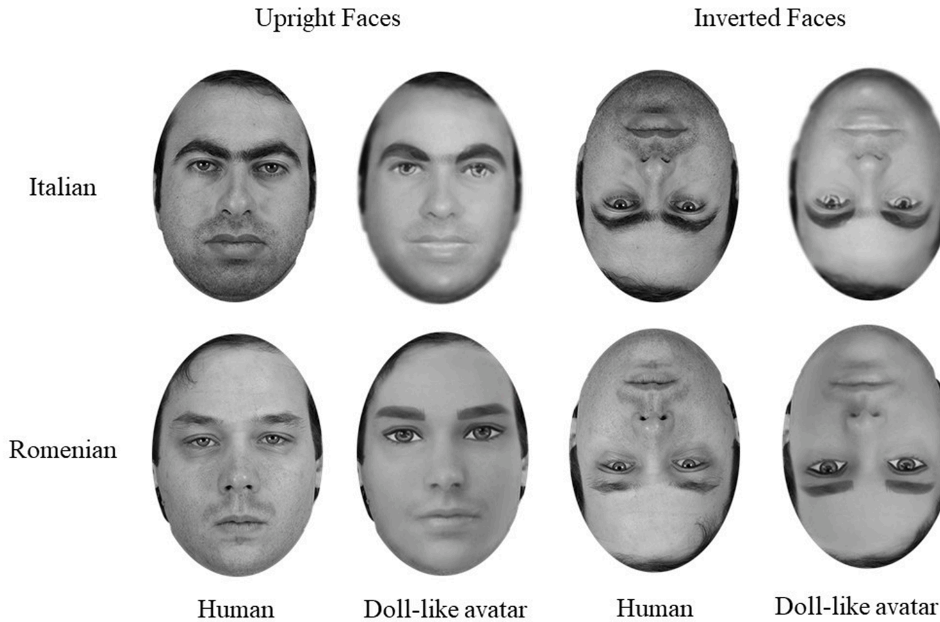

Fig. 1. Example of Upright and Inverted Ingroup and Outgroup faces and their doll-like counterparts.

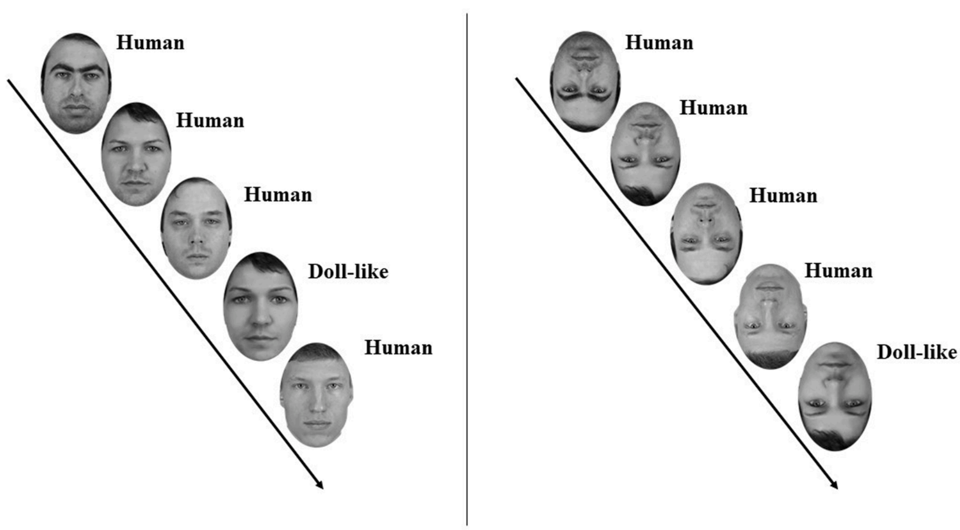

Fig. 2. Example of experimental procedure in the upright (left panel) and in the inverted block (right panel).

both the N170 and the P300. In all statistical analyses, the alpha level was set to 0.05 and all pairwise comparisons were Bonferroni-corrected.

Electrophysiological results of the N170

Even though the amplitude of the N170 was maximal over Cz, we first conducted an ANOVA 2 (Face presentation: Upright faces vs Inverted faces) X 2 (Group: ingroup vs outgroup) X 2 (Target humanity: human faces vs doll-like faces) X 3 (Channel: CZ, C4 and T8), and a main effect of the channel, $F(2,54)=36.80$, $p<.001$, $\eta_p^2=0.57$, emerged showing that all three electrodes were significantly different from each other ($CI_{CZ\text{-}C4}$ [−1.42, −0.75], $CI_{CZ\text{-}T8}$ [−2.58, −1.13], $CI_{c4\text{-}T8}$ [−1.30, −0.23]). Therefore, we decided to report the analyses separately for all electrodes where the N170 was found (i.e., C4, T8, and Cz). In the Cz electrode, a main effect of face presentation, $F(1,27)=52.89$, $p<.001$, $\eta_p^2=0.66$, emerged. Given the well-documented link between the N170 amplitude and the configural processing of faces (Eimer, 2000, 2011), the amplitude of the N170 was more negative for Inverted faces ($M=-4.09$, $DS=2.56$) compared to Upright faces ($M=-2.57$, $DS=2.73$). Further, we found a main effect of target humanity, $F(1,27)=5.70$, $p=.024$, $\eta_p^2=0.17$, replicating the results of Ruzzante and Vaes (2021). Indeed, the N170 was more negative for the human ($M=-3.48$, $DS=2.60$) compared to the doll-like faces ($M=-3.17$, $DS=2.62$) (see Fig. 2). Moreover, replicating the results of Ruzzante and Vaes (2021), neither the effect of target group, $F(1,27)=0.941$, $p=.341$, $\eta_p^2=0.034$, nor the interaction between Target humanity and Face Presentation or any other significant interaction emerged (all *ps*'>0.63) on the N170 amplitude.

In the C4 electrode we found similar results, with a main effect of Face Presentation, $F(1,27)=47.17$, $p<.001$, $\eta_p^2=0.63$, and a main effect of Humanity, $F(1,27)=5.76$, $p=.024$, $\eta_p^2=0.17$. Replicating results of Cz in which the N170 was more negative for Inverted faces ($M=-2.88$, $DS=2.13$) than Upright faces ($M=-1.60$, $DS=2.44$), and for real ($M=-2.38$, $DS=2.18$) compared to doll-like faces ($M=-2.10$, $DS=2.34$). Also in this case, neither the main effect of group membership, $F(1,27)=0.005$, $p=.94$, $\eta_p^2=0.00$, nor any other interaction effect emerged significantly (all *ps*'>0.36).

Finally, we controlled the T8 electrode, where the N170 has been found mostly in the literature given its spatial association with the temporal areas that are related to face perception (Kanwisher et al., 1997) and to the mentalizing network (Frith and Frith, 2003). We found the same main effects of Face presentation, $F(1,27)=39.61$, $p<.001$, $\eta_p^2=0.49$, and humanity, $F(1,27)=7.49$, $p=.011$, $\eta_p^2=0.22$, but in this electrode also a significant interaction effect between Humanity and Face presentation emerged, $F(1,27)=4.62$, $p=.04$, $\eta_p^2=0.14$. Showing in this case how specifically inverted real faces elicited a more negative and active N170 ($M=-2.08$, $DS=1.37$) compared to inverted doll-like faces ($M=-1.70$, $DS=1.39$), $F(1,27)=13.95$, $p=.001$, $\eta_p^2=0.34$. While the same did not occur when the faces were presented upright, $F(1,27)=0.33$, $p=.57$, $\eta_p^2=0.012$. Again, group membership was not significant, $F(1,27)=1.29$, $p=.265$, $\eta_p^2=0.046$, and no other interaction effects were observed (all *ps'*>0.32) (see Fig. 3).

Electrophysiological results of the P300

Given that after a visual inspection of the grand average waveforms a lateralization in the parietal region seemed to emerge, we first conducted an ANOVA 2 (Face presentation: Upright faces vs Inverted faces) X 2 (Group: ingroup vs outgroup) X 2 (Target humanity: human faces vs doll-like faces) X 3 (channel: P3, PZ, P4) and a main effect of the channel, $F(2,54)=9.74$, $p<.001$, $\eta_p^2=0.26$, emerged. The Pz, CI [10.80, 14.01], and P4, CI [10.57, 13.44], electrodes were significantly different from the P3 electrode, CI [9.47, 12.57].

Therefore, the analysis of the P300 was conducted over the right parietal region that implied both Pz and P4. Results showed a main effect of target humanity, $F(1,27)=296.82$, $p<.001$, $\eta_p^2=0.92$, demonstrating the odd-ball effect. The P300 was more activated when the infrequent, doll-like faces were presented ($M=16.79$, $DS=4.82$) compared to when the frequent, real faces appeared ($M=7.62$, $DS=3.18$). Contrary to our expectations, the interaction between group and target humanity did not emerge, $F(1,27)=0.038$, $p=.847$, $\eta_p^2=0.001$. However, the interaction between face presentation (the inversion effect) and humanity showed to be significant, $F(1,27)=9.31$, $p=.005$, $\eta_p^2=0.25$. None of the other main effects or interaction effects emerged (all *ps'*>0.63). In order to better understand how the differentiation between mindful human stimuli and mindless objects was influenced by the configural processing of faces, we calculated the differentials of the P300 waves in which the mean amplitude related to the standard stimulus (e.g., the human faces) was subtracted from the mean amplitude elicited by the deviant stimulus (e.g., the doll-like face). The P300 amplitude difference between the mindful stimulus and the mindless stimulus was larger with the Upright faces ($M=9.57$, $DS=2.84$) compared to the Inverted faces ($M=8.77$, $DS=2.96$), $t_{(27)}=3.05$, $p=.005$, $d=0.27$. Meaning that, the presentation of Upright doll-like faces among a series of Upright human faces elicited a more positive deflection of the P300 compared to the presentation of the Inverted doll-like faces among Inverted human faces. (see Fig. 4). This result supports the hypothesis that the disruption of normal configural face processing influences the mind attribution stage supporting the observation that inverted faces are perceived as more object-like.

General discussion

When dehumanization occurs, a person is considered as less than fully human. This often implies a denial of humanity and human characteristics or the impairment of the mentalization process. The current project wanted to gain more information about the relationship between configural face processing and dehumanization in the two-stages of mentalization, the mind detection and the mind attribution phase (Ruzzante and Vaes, 2021). Specifically, the main aim was to deepen our understanding of the relationship between a perceptual process previously related to dehumanization (the inversion effect) with the first stage of mentalization, that seemed independent from dehumanized perceptions.

With this in mind, we adapted the well-known inversion effect presenting upright and inverted ingroup and outgroup human faces together with their matched, mindless doll-like avatars. Confirming the results of previous research and defining the mind detection phase, the N170 was the first moment in which the human and doll-like faces where differentiated. However, while the N170 was also influenced by the inversion effect, no interaction between the inversion manipulation and the humanity effect was observed for two of the three electrodes in

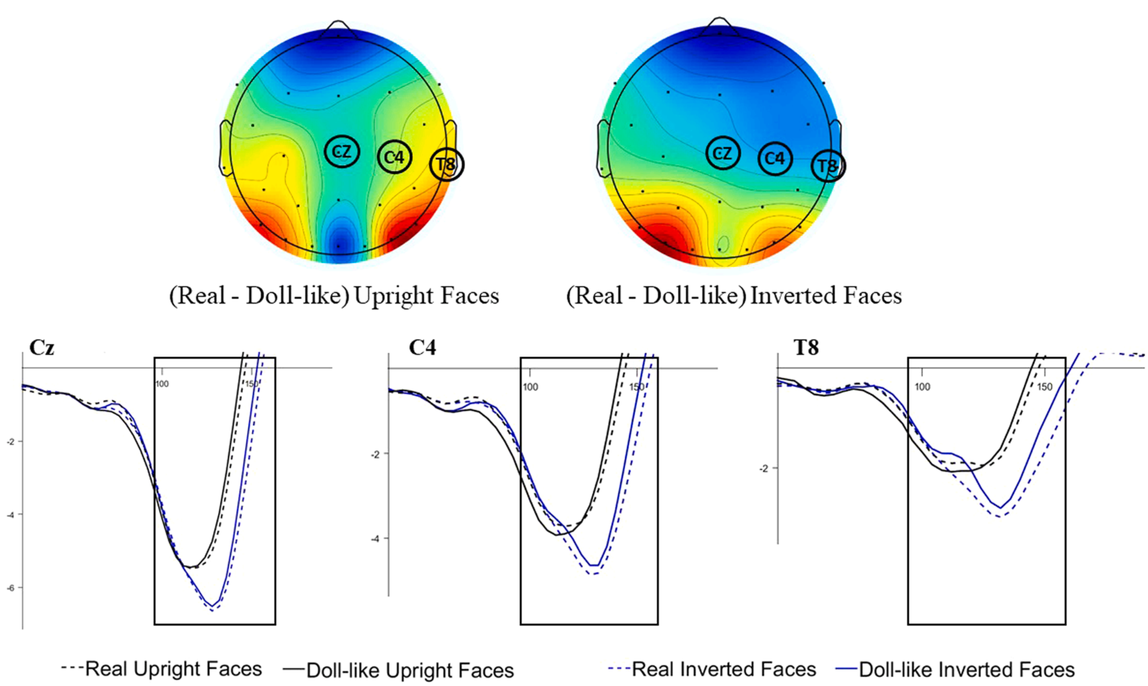

Fig. 3. ERP activation of N170 for upright and inverted, human and doll-like faces. In the upper part: The scalp distribution of the perceptual differences between real and doll-like face presented upright (left) and inverted (right). In the lower part: The mean activation of the N170 towards inverted and upright human and doll-like faces in the three electrodes.

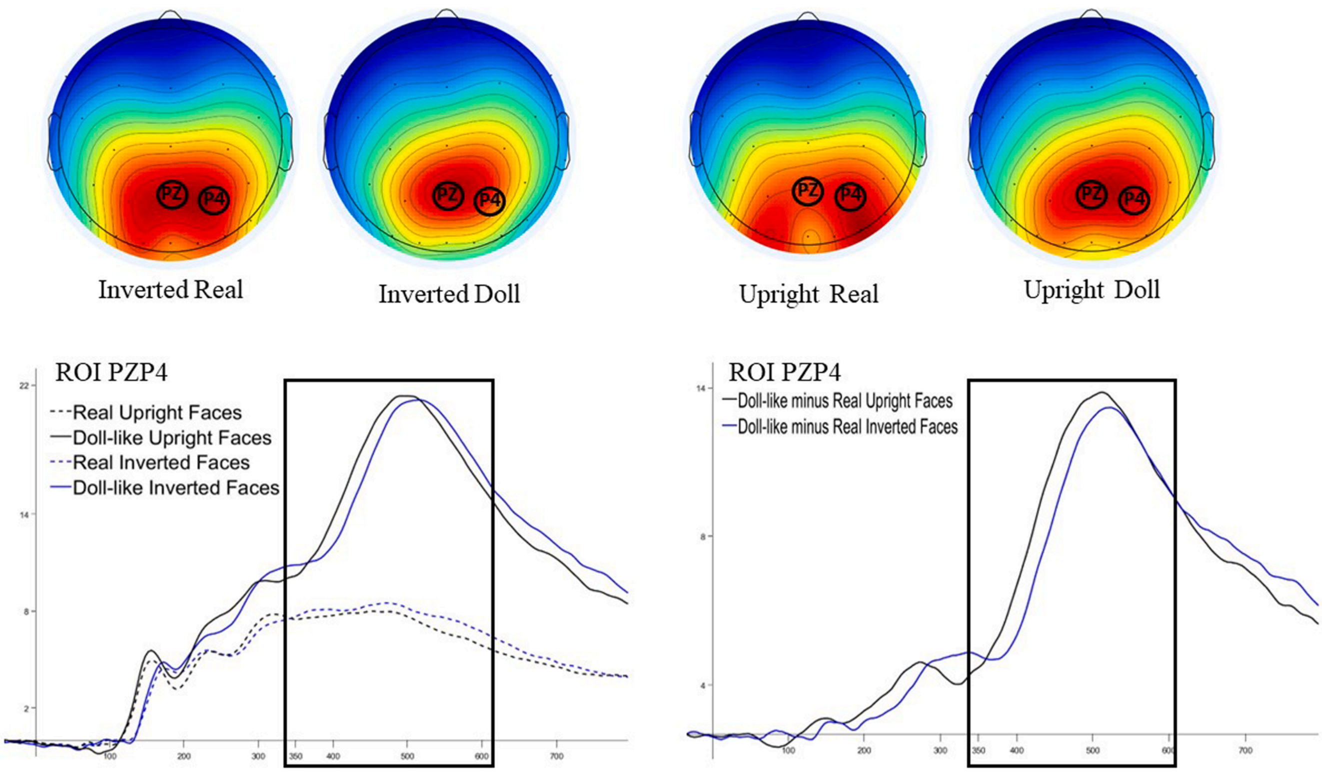

Fig. 4. Electrophysiological results. Upper panel: Scalp distribution of the P300 differential. Lower panel: Grand average waveforms for Upright and Inverted human targets and their respective doll-like faces (left) and grand average waveforms for the differentials of the P300 wave (right).

which the N170 was observed. While these main effects were observed over central electrodes, the interaction effect between the inversion manipulation and the humanity effect emerged in the right-central part of the brain (i.e., T8), that has been associated with the temporal brain areas that are specific for face perception (Haxby and Gobbini, 2011; Kanwisher et al., 1997) and that have been associated with the mentalizing network (Frith and Frith, 2003). Specifically, and as expected the interaction indicated that the inversion effect was stronger for the mindful, human compared to the mindless, doll-like faces. These results seem to support the close relationship between configural face processing and dehumanized perceptions. On the one hand, the N170 indicates the first moment in which mindful, human and mindless, doll-like faces are differentiated for the first time signalling the mind detection phase. On the other hand, the N170 seems to change on a spatial continuum. The more the selected electrode was spatially near brain areas previously associated with both the mentalizing and the face perception network, the more the interaction between humanity and face presentation became stronger. This interaction effect is in line with previous research that has demonstrated that relatively more humanness is attributed to faces that are at the same time both human (vs. doll-like) and presented upright (vs. inverted) allowing perceivers to use configural processes to elaborate the face stimuli (e.g., Deska et al., 2017). Overall, both our hypotheses can find partial confirmation from these results. Indeed, the mind detection phase is independently influenced by configural face processing and humanity, but both variables interact the more one moves towards brain areas that are spatially relevant to the face and mentalizing network.

Importantly, the disruption of face configuration through the inversion effect clearly affected dehumanized perceptions in a later stage. This was confirmed by the interaction between the inversion and the humanity effect on the P300 that corresponds to the later stage of mentalization, suggesting that the attribution of a mind to others is, as suggested by previous studies (Fincher and Tetlock, 2016; Hugenberg et al., 2016), influenced by the inversion effect that makes us perceive human stimuli as more object-like. Interestingly, similar to results of the N170, the P300 results were lateralized to the right, in electrodes that seem to correspond with the temporal-parietal junction (Kirkovski et al., 2022). In other words, our results are able to demonstrate how the timeline of mentalization is influenced by perceptual information, specifically on the temporo-parietal side of the brain, where the mentalizing and the face processing network are located.

At the same time and unlike what was observed in past studies (Ruzzante and Vaes, 2021), group membership did not influence the activation of the P300. While this was not the main focus of the current study and given the salience of the inversion effect, a group membership effect was still expected. On the one hand, this might be due to a lack of salience of the group membership manipulation. Indeed, participants could only use the group label that was conveyed at the beginning of each block to determine the group membership of the targets, while no visual cues reinforced the targets' group membership throughout the task. The inversion effect, instead, was apparent in each stimulus and therefore more salient. On the other hand, not all outgroups are dehumanized all the time (e.g., Over, 2021a,b; Vaes et al., 2012).

Still, we did have an external criterium the IMAT (see SOM) that measured the amount of mind that was attributed to ingroup compared to outgroup faces and we found a medium-sized correlation with the difference between the P300 activation of ingroup compared to outgroup faces ($r(25)=0.37$, $p=.064$). Even though correlations in small samples should be interpreted with care, this result partially confirmed the influence of group membership on the P300. In line with what was reported in previous studies (Ruzzante and Vaes, 2021), the more participants attributed a mind to ingroup compared to outgroup targets in the IMAT, the more they differentially elaborated the mindful from the mindless ingroup stimuli compared to those representing the outgroup as indicated by the P300.

Limitations and future directions

While our results are in line with previous findings on mentalization and face perception (Frith and Frith, 2003; Kanwisher et al., 1997; Kirkovski et al., 2022), it is important to note that these results were obtained with a 32-channel EEG. Meaning that, any assumption on the spatial configuration of the brain needs to be taken with extreme care. EEG measures have a high temporal resolution, but a poor spatial accuracy. Therefore, future studies should focus more on the underlying neural areas that guide these processes using more complex analyses with instruments that have a higher spatial resolution.

Another limitation of the current study is the lack of effect of group membership. Important for future studies is to replicate these findings with the aim to better balance the salience of perceptual and contextual influences like group membership in the mentalization process. Such efforts could include the analysis of the role of ideological and socio-contextual variables over and above the group membership of the social targets under study, with the aim to deepen our understanding of contextual influences on the timeline of mentalization.

Conclusion

Overall, this research project furthers our knowledge on the timeline of mentalization and the literature on dehumanization in several ways. First, we were able to confirm how visual perceptual cues play a role in the attribution of a mind to others. By showing how a visual manipulation like the inversion effect influences the mind detection phase especially in those areas of the brain that are associated with the face processing and mentalizing network. Secondly, this effect persisted in the mind attribution phase when people more actively attribute a mind to a face. Taken together, these results sustain the close relationship between configural face processing and dehumanization (Fincher and Tetlock, 2016; Hugenberg et al., 2016) and allow us to determine the moment in which perceptual cues, like the inversion effect impact the cognitive elaboration of others as more object-like.

Open practices

The experiment in this article aims to earn Open Materials and Open Data badges for transparent practices. Materials and data for the experiment are available at https://osf.io/y3h8r/.

Ethical statement

The study was performed in accordance with relevant guidelines and regulations and all methods were approved by the University's Human Research Ethics Committee (protocol 2016–004) and all participants gave their consent at the beginning of the experiment.

Declaration of competing interest

No conflict of interest exists.

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Data availability

I have shared a link in the "Open Practice" section with a link to my data

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cresp.2024.100184.

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