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Humanity at first sight: Exploring the relationship between others' pupil size and ascriptions of humanity☆

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ABSTRACT

Social targets' eyes are a rich source of information: partners with dilated and constricted pupils are perceived positively and negatively, respectively. Here, we tested whether observed pupil size influences the ascription of humanity. In Study 1 ($n = 198$) participants were asked to attribute positive uniquely human and non-uniquely human traits to ingroup (i.e., university students), derogated (i.e., homeless people) and non-derogated (i.e., Dutch) targets whose pupils varied in size. Results showed higher attribution of uniquely human traits to targets with dilated (vs. constricted) pupils, whereas no difference based on pupil size emerged on the attribution of non-uniquely human traits. The effect was stronger for non-derogated (vs. derogated and ingroup) targets. In Study 2 ($n = 117$) participants were asked to attribute positive uniquely human and non-uniquely human traits and emotions. Results replicated the effect of pupil size on trait attribution, especially for outgroup (vs. ingroup) members. The effect of pupil size was not qualified by emotions type (uniquely human vs. non uniquely human). Taken together, our findings show that pupil size is interpreted as a cue to attribute humanity to social targets.

The eyes are a key and rich source of social information (Kret, 2018; Kret & De Dreu, 2019). Indeed, people focus on their interaction partner's eye to grasp cognitive and affective states (Farroni, Csibra, Simion, & Johnson, 2002). The unique morphology of the human eye, specifically a clearly visible sclera (Kobayashi & Kohshima, 1997; Lee, Susskind, & Anderson, 2013), sensitizes observers to others' pupils, their size, and the changes they undergo (Kret, Tomonaga, & Matsuzawa, 2014).

Changes in pupil size are autonomic and uncontrollable. Yet, such changes reflect ongoing cognitive effort, social interest, surprise, or uncertainty, as well as emotions (Bradshaw, 1967; Hess, 1975; Lavín, San Martín, & Rosales Jubal, 2014). Thus, people suppose that such changes provide a veridical reflection of a person's inner state (Kret, 2015). As a case in point, a growing body of work has shown that pupil size influences impression formation. For instance, social interaction partners with large pupils are perceived as positive and beautiful, and those with small pupils cold and distant (Hess, 1965; Kret & De Dreu, 2017; Kret, Fischer, & De Dreu, 2015). Moreover, people trust economic partners with dilated pupils more than those with constricted pupils (Kret et al., 2015; Kret & De Dreu, 2019). In line with these findings, Brambilla, Biella, and Kret (2019) showed that partners' dilated and constricted pupils potentiated approach and avoidance behaviours, respectively. The authors asked participants to react to novel faces with different pupil sizes. Specifically, participants viewed facial stimuli with dilated or constricted pupils and responded by either pushing a joystick away from the body (avoidance) or pulling it towards the body (approach; Laham, Kashima, Dix, & Wheeler, 2015). Their findings revealed that pupil size influenced arm movements indicative of approach or avoidance behaviour. Taken together, past research suggests that dilated pupils impact positively upon impression formation. Importantly, such a link seems to be due to an inferred association between dilated pupils and positive emotions (Hess, 1975; Mattavelli, Brambilla, & Kret, 2022).

The present research sought to extend prior work on the social

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implications of pupil size by testing whether pupillary signals may impact upon the ascription of humanity. Although emerging research has addressed how pupil size influences global impressions, research investigating whether pupillary signals impact upon other aspects of social perception is surprisingly limited. Thus, complementing and extending previous insights, we tested the link between observed pupil dilation and the ascription of a human mind.

Ascribing sophisticated minds to others is central to social cognition and perceiving others as human (Harris & Fiske, 2009, 2011). Denying full humanity to an individual or a social group (i.e., dehumanization) is a complex phenomenon (Haslam, 2006a, 2006b; Leyens et al., 2000): It can be blatant or subtle; driven by hate, indifference, or emotional exhaustion (Cameron, Harris, & Payne, 2016; Haslam & Loughnan, 2014). Dehumanization research has shown that, relative to ingroup members, outgroup members are denied traits that uniquely belong to humans, such as civility or rationality (Harris & Fiske, 2011; Haslam, 2006a, 2006b) and are perceived as less likely to feel physical (Hoffman, Trawalter, Axt, & Oliver, 2016; Trawalter, Hoffman, & Waytz, 2012) and social pain (Riva, Brambilla, & Vaes, 2016).

The assumption that others have minds, which means that they have intentions, plans, and goals (Epley & Waytz, 2010; Harris & Fiske, 2009), as well as experiences of pleasure, pain, and other emotions (Gray, Gray, & Wegner, 2007), is the root of social interaction. This mental state inference is flexible: it can be extended to agents without minds, resulting in anthropomorphism, and can be suspended from other people, resulting in a dehumanized perception (Harris, 2017). Despite having a surprising capacity to think about the minds of others (Herrmann, Call, Hernández-Lloreda, Hare, & Tomasello, 2007; Waytz, Schroeder, & Epley, 2014), people may neglect to use this capacity by failing to consider others' minds (Harris & Fiske, 2006, 2011; Haslam & Loughnan, 2014).

Recent work has shown that nonverbal cues, such as the eyes, are essential for considering others' mind (e.g., Baron-Cohen, Wheelwright, & Jolliffe, 1997; Moor et al., 2012; Prochazkova et al., 2018). As such, Schein and Gray (2015) showed that facial stimuli manipulated to appear eyeless were seen as more uncanny, more likely to be missing capacity of emotional experiences, and more likely to be soulless. Other studies have shown the effect of eye-gaze on mentalising, revealing that targets displaying directed eye-gaze were attributed more sophisticated humanlike mental faculties than targets with averted eye gaze (Khalid, Deska, & Hugenberg, 2016). Despite extensive developments in theory surrounding mind attribution, no prior work has shown whether pupil size of an interaction partner impacts upon the attribution of their humanity. In the current work, we seek to extend prior research evidence on the key role of nonverbal cues in shaping inferences of a human mind by considering the role of pupil size variation.

Moreover, we investigated whether such a link varies as a function of the group membership of the target under evaluation. Prior work on the social implications of pupil size has mainly focused on interactions with an "unknown" other, neglecting their group membership. Here, we analyzed the social implication of pupil size by taking into account ingroup and outgroup targets. Combining research showing that people tend to reserve humanity to social targets more familiar and similar (Harris & Fiske, 2006; Vaes, Paladino, Castelli, Leyens, & Giovanazzi, 2003) with findings showing that individuals with large pupil size are trusted and perceived positively (Brambilla et al., 2019; Hess, 1965; Kret et al., 2015; Kret & De Dreu, 2017), we expect that people would ascribe higher humanness to those targets with large pupil size. However, such an effect could vary as a function of the target group membership. Due to the strong impact that intergroup perception exerts during dehumanization (Harris & Fiske, 2006; Haslam & Loughnan, 2014), it is possible that pupil dilation as a cue to humanity would be blocked or suppressed in the case of outgroup members. We tested our hypotheses across two studies in which participants were asked to attribute positive human traits (Studies 1–2) and emotions (Study 2) to ingroup and outgroup targets with dilated (vs. constricted) pupils.

Both studies received approval from the internal Ethical Committee. The studies were preregistered on Open Science Framework (Study 1: https://osf.io/qcp8z/?view_only=6574f4f8a9c042b595d2f9fc7a59a993; Study 2: https://osf.io/gur3y/?view_only=3c86185d96ee4ba68f0ea3ff83bdc5c9). Data and analysis codes for both studies are also available on OSF (Study 1: https://osf.io/6kpg3/?view_only=4b051d713b0949a9897d5dd7f4c93393; Study 2: https://osf.io/cn4g6/?view_only=bc3a9e3f62f74b26b166573fe0a3c5b2).

1. Study 1

Study 1 aimed to test whether pupil size acts as a cue to attribute humanity to ingroup and outgroup targets. To this aim, we tested the impact of pupil size on the attribution of positive traits varying on perceived humanity. Building on prior dehumanization research and considering previous research on the effect of pupil size in person perception, we expected that people would attribute human traits to a greater extent to targets with dilated, rather than constricted, pupils. We also investigated whether the hypothesized effect varies as a function of the target being evaluated (ie., ingroup, stigmatized outgroup, non-stigmatized outgroup).

1.1. Method

We employed a 3 (Group membership: ingroup vs. stigmatized outgroup vs. non-stigmatized outgroup) x 2 (Pupil size: constricted vs. dilated) x 2 (Human uniqueness: uniquely human vs non-uniquely human traits) mixed design, with the first factor manipulated between participants. The dependent variable was the attribution of traits for each target, measured on a 7-point scale (1 = not at all; 7 = very much).

1.1.1. Participants and procedure

We conducted an a-priori power analysis with G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). For a 3x2x2 mixed ANOVA, assuming an alpha of 0.05 and power of 0.80 and a small effect size f = 0.11, the analyses suggested 200 participants. One hundred and ninety-eight students, recruited via Prolific Academic, completed the entire session. Participants had a mean age of 24.19 (*SD* = 3.06), and 47.3% of the sample consisted of women. All the participants were Italian.

The experiment was programmed in Inquisit 6. Before starting the experiment, participants were invited to give their consent to participate and were randomly assigned to one of three target's group membership condition. Participants were instructed to pay attention to the eye region of the stimuli appearing on screen. Then, the trait attribution task started. First, participants were exposed to videos of the eye region of the target stimuli, presented in the center of the screen and varying in pupil size. Right after the presentation of each video, participants were asked to evaluate the target individual on two human and two non-human traits.

1.1.2. Stimuli

1.1.2.1. Pupil size stimuli. The videos of the target stimuli consisted of pictures of 4 men and 4 women and were selected from the Amsterdam Dynamic Facial Expression Set (ADFES) (van der Schalk, Hawk, Fischer, & Doosje, 2011). In line with prior research (Brambilla et al., 2019; Mattavelli et al., 2022; van Breen, De Dreu, & Kret, 2018) only the eye regions were used to ensure that participants attend to the eyes of the stimulus. The videos showed the partner's eye-region at life-size and were selected to be neutral in terms of emotional expression. After static presentation for 1500 ms, the person's pupils dilated or constricted within the normal physiological range of 3–7 mm during another 1500 ms (dilating: from 5 to 7 mm or constricting: from 5 to 3 mm). In the final 1000 ms of stimulus presentation, the pupils remained static. Each video thus was last for a total of 4000 ms, a duration consistent with the facial mimicry literature (Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001).

1.1.2.2. Group membership. Three conditions were included in the experiment. In the ingroup condition, the target stimuli were presented as university students. In the stigmatized outgroup condition, target stimuli were presented as people experiencing homelessness. In the non-stigmatized outgroup condition, target stimuli were presented as Dutch citizens. Prior research has shown that people experiencing homelessness are highly devaluated and stigmatized (Harris & Fiske, 2006) while Dutch citizens are perceived less harshly (Cuddy, Fiske, & Glick, 2008).

1.1.2.3. Traits. The dispositional traits were selected via a pilot test. Forty-two participants (23 females, $M_{age} = 29.71$, $SD_{age} = 10.85$) were presented with a series of 59 traits that were previously selected from a larger list (Caprara & Perugini, 1994). Each trait was presented individually and in randomized order. Participants were asked to rate each trait on valence (i.e., "How positive do you think this trait is?" 1 = very negative; 7 = very positive) and human uniqueness (i.e., "To what extent is this trait uniquely human (not applicable to other species)?" 1 = not uniquely human; 7 = uniquely human). The aim was to select two lists of 4 traits each that were a) comparable on valence and b) distinct on humanity. The four adjectives selected to be high on humanity were reflective (*riflessivo*), passionate (*passionale*), dreamer (*sognatore*), and romantic (*romantic*). The four adjectives selected to be low on the same variable were brave (*coraggioso*), energetic (*energico*), strong (*forte*), and tireless (*infaticabile*). To select those stimuli, we computed the average scores on human uniqueness and then conducted a paired sample *t*-test. We found that the first set of traits received higher scores on human uniqueness ($M = 5.61$, $SD = 1.32$) than the second set ($M = 2.30$, $SD = 0.99$), $t(41) = 12.43$, $p < .001$, $d = 1.92$. Importantly, the difference on valence between high human uniqueness traits ($M = 5.59$, $SD = 0.71$) and low human uniqueness traits ($M = 5.76$, $SD = 0.69$) was not significant and descriptively in favor of low human uniqueness traits, $t(41) = -1.79$, $p = .080$, $d = 0.28$.

1.2. Results and discussion

Data were analyzed in a two-level general mixed model. Target's group membership (ingroup vs. stigmatized outgroup vs. non-stigmatized outgroup) pupil size (dilating vs. constricting), and human uniqueness (uniquely human vs. not uniquely human traits) and the interaction terms were included in the model as fixed factors, whilst individual intercept as random factor. Following Kret and De Dreu (2019) this approach was chosen because it maintains intra-individual variance and it allows for the inclusion of a random intercept. Means and standard deviations are reported in Table 1.

We found a main effect of pupil size, $b = 0.81$, $t(25{,}938.71) = 22.18$, $p < .001$, indicating higher attribution for dilated pupils ($M = 4.28$, $SD = 0.63$) than for constricted pupils ($M = 3.84$, $SD = 0.72$). We also found a main effect of human uniqueness, $b = 0.27$, $t(25929) = 7.51$, $p < .001$, indicating stronger attribution for non-uniquely human traits ($M = 4.15$, $SD = 0.69$) than for uniquely human traits ($M = 3.97$, $SD = 0.66$). The main effects were qualified by a significant interaction between pupil size and human uniqueness, $b = 0.79$, $t(25929) = 15.42$, $p < .001$. Decomposing this interaction showed that the effect of pupil size (i.e., higher scores indicate stronger attribution for dilated pupils) was stronger for uniquely human traits, $b = 0.77$, $z = 33.93$, $p < .001$, than for non-uniquely human traits, $b = 0.13$, $z = 5.56$, $p < .001$.

There was no effect of group membership, $F(2, 195) = 0.83$, $p = .439$, and no significant interaction between pupil size and group membership, $F(2, 25{,}949) = 1.21$, $p = .298$. But the interaction between human uniqueness and group membership was significant, $F(2, 25{,}929) = 3.74$, $p = .024$. Decomposing this interaction revealed that the difference in attribution of uniquely human vs non-uniquely human traits (i.e., stronger effect indicate higher attribution of uniquely human traits) was significant when comparing homeless and Dutch people, $b = 0.10$, $z = 2.57$, $p = .031$, whereas neither the comparison between Dutch people and students nor that between students and homeless people were significant, $b = 0.07$, $z = 2.00$, $p = .091$ and $b = -0.03$, $z = -0.74$, $p = .462$, respectively. The three-way interaction was significant, $F(2, 25{,}929) = 6.19$, $p = .002$. This interaction indicated that the impact of human uniqueness in qualifying pupil size effect was comparable when considering student, $b = 0.58$, $z = 11.16$, $p < .001$, and homeless, $b = 0.54$, $z = 8.88$, $p < .001$. Instead, it showed significantly stronger in the Dutch condition, $b = 0.79$, $z = 15.42$, $p < .001$. In other words, dilated (vs. constricted) pupils led to higher attribution uniquely human (vs. non-uniquely human) traits for all the three groups, and this effect was stronger when faces were presented to participants as belonging to a non-stigmatized outgroup.

Study 1 showed that pupils are used by perceivers to attribute dispositional traits in others: dilated pupils, as opposed to constricted, led to higher attribution of positive traits. Importantly for the purpose of this study, the effect of pupils differed when looking at the type of traits considered: pupil size variation was used as a cue for attributing uniquely human traits, more than for non-uniquely human traits that were balanced on favourability. Thus, pupil size did not impact upon the ascription of any positive traits; it has a specific effect on positive human qualities.

Unexpectedly, results revealed that this interaction between pupil size effect and type of traits was further qualified by the target group being evaluated. Specifically, the difference in the pupil size effect for the attribution of uniquely human traits vs. non-uniquely human traits was stronger for non-stigmatized outgroup targets. Overall, results suggest that pupil size is a cue used to ascribe humanity, and that the link between pupillary signals and humanness is biased by the target being evaluated.

Table 1
Means for uniquely and non- uniquely human traits preceded by ingroup and outgroup targets with constricted vs. dilated pupils (Study 1). Standard deviations are in parentheses.

	Uniquely human traits		Non uniquely human traits	
	Constricted pupils	Dilated pupils	Constricted pupils	Dilated pupils
Ingroup condition	3.64 (0.72)	4.40 (0.71)	4.13 (0.69)	4.30 (0.64)
Stigmatized outgroup condition	3.55 (0.60)	4.29 (0.62)	4.06 (0.72)	4.24 (0.66)
Non-stigmatized outgroup condition	3.57 (0.72)	4.73 (0.60)	4.09 (0.85)	4.10 (0.56)

2. Study 2

Results from Study 1 suggest that pupil size influences the attribution of humanity to social targets (especially when non-stigmatized outgroup members are taken into account). Study 2 was designed to extend and replicate the findings of Study 1, by using an attribution task that combines two types of uniquely human concepts: traits and emotions.

Previous research has shown that pupil size, as a measure of arousal (Bradley, Miccoli, Escrig, & Lang, 2008), is related to emotional states. Specifically, dilated pupils are associated with positive emotions and constricted pupils are associated with negative emotions (Kret, 2018). Importantly, emotions play a central role in dehumanization research. Different models of dehumanization (i.e., infrahumanisation theory, see Vaes, Leyens, Paola Paladino, & Pires Miranda, 2012 for a review, and the model of mind perception, see Gray et al., 2007) highlight the idea that feeling emotions is one of the core dimensions that defines a human being.

Based on the relevance of the eyes in perceiving other's emotions and the special role of emotions on dehumanization, in this study we presented emotions (as well as traits) to explore the role of pupil size ascription of humanness. In line with results obtained in Study 1, we expected an interaction between pupil size and human concept. This would imply stronger attributions for traits and emotions selected to be uniquely human when the target is presented with dilated versus constricted pupils. Besides, such effects should vary as a function of target group membership. Specifically, we compared the effect of pupil size on the attribution of humanness for ingroup membership (i.e., university students) and a new type of social group highly devaluated and stigmatized in the relevant population (Romanians).

2.1. Method

2.1.1. Participants and procedure

We conducted an a-priori power analysis on G*Power (Faul et al., 2007). For a 2x2x2x2 mixed ANOVA, assuming an alpha of 0.05 and power of 0.90 and a small effect size $f = 0.10$, the analyses suggested 116 participants.

Participants were 117 Italian university students participating to the study via Prolific Academic. Participants had a mean age of 24.63 (SD = 3.44), and 45% of the sample consisted of women. All the participants were Italian.

We adopted a 2 (target's group membership: ingroup vs. stigmatized outgroup) x 2 (pupil size: constricted vs. dilated) x 2 (human uniqueness: uniquely human vs. non-uniquely human) x 2 (attribution task: traits vs. emotions) mixed design, with the first factor manipulated between participants. The dependent variables were the attribution of traits and emotions for each target, measured on a 7-point scale (1 = not at all; 7 = very much).

The experiment was programmed in Inquisit 6. Before starting the experiment, participants were invited to give their consent to participate. Participants were randomly assigned to one of two target's group membership condition. In one condition (i.e., ingroup), they were told that the target stimuli they were about to evaluate were university students. In a second condition (i.e., stigmatized outgroup), target was presented as Romanians. Indeed, prior research has shown that Romanians are highly devaluated and stigmatized (e.g. Albarello, Foroni, Hewstone, & Rubini, 2017). Participants were instructed to pay attention to the eye region of the stimuli appearing on screen. Then, the attribution tasks started. Participants were exposed to videos of the eye region of the target stimuli, presented in the centre of the screen and varying in pupil size. Right after the presentation of each video, participants were asked to evaluate the target individual on two human and two non-human word stimuli.

Participants were presented with two consecutive blocks of 16 trials each, the first investigating attribution on traits, the second investigating attribution of emotions. In the first stage of each trial, they saw the eye region of the target. The pupils of the partner's eyes dilated or constricted. The onset of a message asking participants to evaluate the partner signalled that the video was over. For each target stimulus, participants provided four attributions, two made on uniquely human traits/emotions and two on non-uniquely human traits/emotions (i.e., traits: "Please indicate to what extent this person is…"; emotions: "To what extent do you think this person can feel…"). Traits/emotions were randomly selected from two lists of four human and four non-human traits/emotions. For each trait/emotion, participants made their attribution using a 7 points scale (1 = not at all; 7 = very much). For half of the trials (equally distributed across pupil size variation), the first trait/emotion was a uniquely human trait, for the other half it was a non-uniquely human trait/emotion.

2.2. Materials

Pupil stimuli and traits were the same as those used in Experiment 1. The emotional terms were selected via a pre-test from a normative study ($N = 42$, 30 females, $M_{age} = 38.78$, $SD_{age} = 16.06$). Participants were asked to rate each emotion on valence (i.e., "How positive do you think this trait is?" 1 = *very negative*; 7 = *very positive*) and human uniqueness (i.e., "To what extent is this emotion uniquely human (not applicable to other species)?" 1 = not uniquely human; 7 = uniquely human). The four selected positive uniquely-human emotions (i.e., *passion, optimism, admiration, hope*) scored higher ($M = 5.34$, $SD = 1.90$) than positive non-uniquely-human emotions (i.e., *calm, affection, happiness, pleasure*, $M = 2.42$, $SD = 1.79$) on human uniqueness, $t = 16.43$, $p < .001$, $d = 1.27$. The difference on valence between uniquely human emotions ($M = 5.88$, $SD = 1.08$) and non-uniquely human emotions ($M = 6.42$, $SD = 0.86$) was significant in favor of non-uniquely human emotions, $t = -5.63$, $p < .001$, $d = 0.43$.

2.3. Results and discussion

Following the same analytical approach of Study 1, results were analyzed in a general mixed model. Target's group membership (ingroup vs. stigmatized outgroup) pupil size (dilating vs. constricting), human uniqueness (uniquely human vs. not uniquely human) attribution task (traits vs emotions) and the interaction terms will be included in the model as fixed factors, whilst individual intercept as random factor. Means and standard deviations are reported in Table 2.

We found a main effect of pupil size, $b = 0.63$, $t(15988) = 11.71$, $p < .001$, indicating higher attribution for dilated pupils ($M = 4.37$, $SD = 1.39$) than for constricted pupils ($M = 3.89$, $SD = 1.41$). The main effect of attribution task was significant, $b = 0.42$, $t(15988) = 7.77$, $p < .001$, indicating higher attribution on emotions ($M = 4.26$, $SD = 1.48$) than on traits ($M = 3.99$, $SD = 1.34$). We found no effect of human uniqueness, $b = 0.03$, $t(15988) = 0.61$, $p = .544$, and of group membership, $b = 0.26$, $t(169.28) = 1.95$, $p < .053$. We also found a significant three-way interaction between pupil size, human uniqueness and the type of task, $b = 0.46$, $t(15988) = 4.30$, $p < .001$. This interaction showed that the effect of human uniqueness on pupil size was significant for traits attribution, $b = 0.37$, $z = 6.83$, $p < .001$, but not for emotions attribution, $b = 0.08$, $z = 1.47$, $p = .141$. Finally, we found a significant four way interaction, $b = -0.35$, $t(15988) = -2.29$, $p = .022$. On trait attribution only, a significant 3-way interaction revealed that the effect of human uniqueness on pupil size is stronger for participants assigned to the outgroup (vs ingroup) condition, $b = 0.36$, $z = 3.33$, $p < .001$. Instead, the same interaction showed not significant on emotions attribution, $b = 0.01$, $z = 0.09$, $p = .927$. The interaction between pupil size and human uniqueness on traits attribution was stronger in the outgroup condition, $b = 0.55$, $z = 7.19$, $p < .001$, than in the ingroup condition, $b = 0.19$, $z = 2.47$, $p = .013$. There were no other significant interactions ($ps > 0.14$).

Together, results show that pupil size influences the attribution of uniquely human traits to ingroup and outgroup members. In both cases, the attribution of uniquely human traits was higher when the targets

Table 2
Means for uniquely and non- uniquely human traits and emotions preceded by ingroup and outgroup targets with constricted vs. dilated pupils (Study 2). Standard deviations are in parentheses.

	Ingroup condition		Outgroup condition	
	Constricted pupils	Dilated pupils	Constricted pupils	Dilated pupils
Uniquely human traits	3.62 (1.28)	4.14 (1.35)	3.69 (1.40)	4.29 (1.43)
Non-uniquely human traits	3.81 (1.24)	4.14 (1.28)	4.11 (1.32)	4.16 (1.28)
Uniquely human emotions	3.81 (1.32)	4.45 (1.31)	4.08 (1.59)	4.71 (1.43)
Non-uniquely human emotions	3.85 (1.43)	4.41 (1.36)	4.13 (1.58)	4.67 (1.50)

were presented with dilated pupils, compared to constricted pupils. This effect of pupil size varied depending on the type of traits (human vs. non-human), showing that pupil are specifically used for the attribution of humanness, and not generally informative for any positive trait. Besides, the effect for the ingroup and the outgroup indicate that group membership plays a relevant role in the link between pupil dilation and inferring human traits. Interestingly, the effect was not found for uniquely human emotions, indicating that variations in pupil size had a different effect for uniquely human traits and emotions. A potential explanation could be the close relationship between pupil size and emotional states (Kret, 2018).

3. General discussion

The effects of observed pupil size on social perception have mainly focused on interpersonal perception, showing that individuals with large pupils are perceived more positively than those with small pupils (Kret & De Dreu, 2019). Extending and complimenting prior research, here we tested whether pupillary signals may impact upon the attribution of humanity by further adopting an intergroup perspective. Combining research on dehumanization and impression formation, we found evidence for the effect of pupil size on the perception of humanity: compared with constricted pupils, dilated pupils triggered a stronger attribution of humanness to targets belonging to different social groups. To our knowledge, this research is the first to focus on the effects of pupil size on the human perception from an intergroup approach. Overall, the findings confirm the key role of pupil size in social perception of humanness and provides novel evidence on the role of social categorization.

Across two studies, participants attributed uniquely human traits to a higher degree when the targets were presented with dilated pupils, compared to constricted pupils. This result confirms the predominance of pupil size in impression formation found in previous studies. Besides, these results show for the first time that the pupil size effect is extended to humanness.

In the first study, we found that group membership is a significant moderator of the pupil size effect on the attribution of uniquely human traits, since the general effect is stronger when stimuli are meant to belong to a non-stigmatized outgroup (Dutch people). In the second study, the effect of pupil size in the attribution of uniquely human traits was replicated, but this effect was not found with emotions. Additionally, we conducted a couple of studies with emotions, with inconclusive and mixed results (link to the supplementary studies). It is important to consider that pupil size is used largely as an emotional cue (i.e., it tells us whether the target can feel emotions). One could argue that it does not matter whether emotions are uniquely human or not, if they are emotions, and people identify the emotional state of other people in line with their pupil size. In this vein, it is possible that participants used this emotional information to make assumptions about the target humanness in both cases, with dilated as well as constricted pupils. Thus, participants used this information to make assumptions about the target's humanness. Future research is needed to clarify the effect of pupil size in the attribution of emotions to ingroup and outgroup members.

Moreover, we found that the key effect was stronger when stimuli belonged to the outgroup (Romanians), compared with the ingroup. Considering the differential effect of pupil size across groups, one could argue that the effect of group seems to be influenced by the extent to which the target can activate positive feelings of communion (ingroup) or compassion (homeless people). In both cases, people might tend to be sympathetic towards the relevant group. This disposition does not happen by default with outgroups that do not activate such feelings (Dutch and Romanians). For that reason, perceiving members of these social groups with dilated pupils could intensify the potential for inferring humanness. Thus, we advance that the informativeness of pupil size for the attribution of humanness to others should be stronger for targets belonging to groups that do not trigger humanity-relevant feeling in the perceiver. Yet, this interpretation of the current findings remains speculative at this stage and future research should better investigate this hypothesis.

Previous research has focused on the role of pupil size without considering group membership. However, social categorization is particularly relevant in social perception: It determines the way in which people interpret social life, attribute meanings towards actions, and create expectations about others. This research goes beyond the study of dilated pupils in impression formation and moves the topic from an interpersonal level to an intergroup level. Our results highlight the relevance to explore processes implicated in impression formation by adding an intergroup approach; otherwise, conclusions might be incomplete.

Despite in the last years society has become more tolerant towards the explicit expression of prejudice and racism (Kteily, Bruneau, Waytz, & Cotterill, 2015), subtle measures of dehumanization continue to be necessary to explore and capture dehumanization towards a broad variety of targets. In this sense, subtle measures focusing on the uniquely human features, values, and capacities have generated a substantial volume of research and have fostered the development of modern theoretical models of dehumanization (Bain, Vaes, & Leyens, 2014; Haslam & Loughnan, 2014). The differential reaction to dilated pupils could extent and complement the use of uniquely human traits and capabilities to detect dehumanization.

Due to the requirement to keep the experimental design as simple as possible, we presented pictures without a social context. Further investigations should explore the pattern of results we reported by including additional contextual cues that could influences on the way that people interpret and process observed pupil size. Thus, further studies may consider how different social categorizations may moderate the results we found. Despite these limitations, our study reinforces the literature on the role of pupil size in social perception by providing evidence that humanness is also sensitive to pupillary signals.

Open science statement

1

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Data availability

Data and analysis codes are available on OSF (Study 1: https://osf.io/6kpg3/?view_only=4b051d713b0949a9897d5dd7f4c93393; Study 2: https://osf.io/cn4g6/?view_only=bc3a9e3f62f74b26b166573fe0a3c5b2).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jesp.2023.104455.

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