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How ostracism and early regulatory capacities shape 8-month-old infants' disengagement from faces

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Introduction: The ability to orient attention toward social stimuli emerges early in life and plays a crucial role in supporting social, communicative, and cognitive development. Adverse experiences, such as ostracism, have been shown to bias these attentional processes. While this phenomenon has been investigated in adults and older children, little is known about how similar in-person experiences influence attentional processes in infancy.
Methods: The present research investigated whether being included or ostracized in a live triadic ball-tossing game affects 8-month-old infants' (N = 54) attentional disengagement from social vs. non-social stimuli. This study also explored the role of temperament-based, attention-mediated regulation in modulating the effects of social exclusion on such attentional mechanisms. Firstly, a live ball-tossing game was implemented where infants were either included or ostracized, and their behavior and emotional responses were recorded and coded. Following the game, infants completed a disengagement task involving centrally presented structured and scrambled faces, while their eye movements were recorded with an eye-tracking system.
Results: Data indicated that ostracized infants were slower to disengage from structured faces; however, those with higher orienting/regulation scores disengaged more quickly. Behavioral results showed reduced positive emotionality, increased negative emotionality, and more active engagement behaviors in ostracized infants compared to included ones.
Discussion: Overall, these findings show that ostracism influences infants' behavioral reactivity and attentional disengagement from social cues as early as 8 months, and that, in turn, this effect is modulated by infants' temperamental traits, highlighting the interplay between adverse environmental experiences and individual predispositions in early social development.

KEYWORDS
ostracism, infants, attentional disengagement, faces, temperament

1 Introduction

Faces are among the most pervasive and socially relevant stimuli in infants' early visual environment (Fausey et al., 2016; Jayaraman et al., 2015) and preferential attention toward facial configurations is already present at birth (Macchi Cassia et al., 2004; Umilta et al., 1996). This attentional preference develops considerably over the first year of life, with infants showing increasingly selective and sustained orienting to faces within complex visual scenes, approaching adult-like patterns by around 6 months of age (DeNicola et al., 2013; Di Giorgio et al., 2012; Gliga et al., 2009; Gluckman and Johnson, 2013). Such early attention to faces is functionally significant, as it supports the development of both social and cognitive capacities, including joint attention and vocabulary acquisition (Farrant and Zubrick, 2012; Senju et al., 2004). Therefore, investigating how the social interactive context can modulate this basic attentional mechanism is of great interest for the field.

Within the complexity of everyday visual environments, the ability to disengage and shift attention enables humans to interact effectively with their surroundings by selecting salient objects and locations (De Zwart et al., 2025; Moyano et al., 2023). Disengagement of attention refers to the process of withdrawing focus from a currently attended stimulus in order to redirect attention to a different stimulus at another location (Posner and Petersen, 1990). This ability is present since birth and undergoes substantial development in the 1st year of life (Valenza et al., 2015). For example, neurophysiological studies have suggested that the frontal cortex is already engaged in controlling attention shifts from central stimuli as early as 6 months (Csibra et al., 1998). As attentional disengagement improves, it also begins to show differential patterns depending on the type of stimulus. Arioli et al. (2025) found that while newborns did not show differential attentional disengagement based on rhythm, 2-month-old infants exhibited faster saccadic latencies (i.e., quicker attention shifting) when central stimuli were presented in a rhythmic-predictable or static pattern rather than non-rhythmic. In addition, 6- to 9-months-old infants exhibit longer disengagement latencies for faces compared to non-face patterns when a novel competing stimulus appears in the visual periphery (Pyykkö et al., 2019), and 7-month-old infants disengage more slowly from fearful faces than from happy or neutral faces (Peltola et al., 2008). Other studies have highlighted the developmental significance of this ability, showing that by 14 months, infants at elevated familial likelihood for developing autism who later receive a diagnosis exhibit longer disengagement latencies from the central stimulus than both other peers at elevated familial likelihood who do not receive a diagnosis and infants at typical familial likelihood (Elsabbagh et al., 2013). While infants' attentional disengagement and orienting have been extensively studied, more recent research has increasingly examined how early attentional patterns interact with individual and environmental factors. For example, 6-month-old infants who disengage more easily from the central stimuli showed reduced frustration, increased positive affect (McConnell and Bryson, 2005) and greater soothability (Nakagawa and Sukigara, 2019). In addition, it was also shown that 12-month-old infants with higher parental report of regulatory capacity were faster to disengage from the central stimulus (Nakagawa and Sukigara, 2013) and that higher levels of negative affect were related to slower disengagement from fearful faces (Conejero and Rueda, 2018).

Extending this line of research, existing literature has also investigated the role of environmental experiences in shaping infants' social attention. For example, Forssman et al. (2014) showed that, in infants, variations in genes related to the serotonin system interact with maternal depressive symptoms to predict greater difficulty in disengaging attention from fearful faces, highlighting the role of gene-environment interplay in shaping early attentional processes. Early social-interaction experiences have also been associated with subsequent attentional processes. Evidence indicates that the total duration of mutual gaze measured at 5 months during mother-infant interaction predicted disengagement performance at 11 months (Niedzwiecka et al., 2018), and social support through affective touch modulated infants' attentional bias toward fearful facial expressions at 7 months (Addabbo et al., 2025). Although the mechanisms underlying these associations remain to be fully clarified, these findings suggest that early social-interaction experiences shape infants' attentional processes in meaningful ways.

Previous studies also suggest that situations involving social inclusion or exclusion may influence attentional processes. Findings from adults and older children indicate that social exclusion can modulate attentional orienting, disengagement, and processing of social stimuli, though the direction of these effects is not always consistent. For example, it was shown that being ostracized from an online ball-tossing game, where the ball is thrown between the participants and two controlled avatars (i.e., Cyberball; Williams et al., 2000), modulated adults' gaze-cueing effect, that is, the tendency to orient attention toward the location another person is looking at (Capellini et al., 2019). Excluded adults showed a reduced gaze-cueing compared to included ones, a difference that was specific to social rather than non-social cues such as arrows (Capellini et al., 2019), and was even more pronounced when the face belonged to the excluder (Yang et al., 2024). Consistent with the view that social exclusion does not uniformly enhance attention to social information, it has also been reported that overt visual attention to social signals was not reliably associated with participants' subjective feelings of exclusion (Beffara et al., 2026). By contrast, other studies have noted that exclusion appears to heighten sensitivity to social cues. For example, adults increased fixations toward the interaction partner who could re-include them during exclusion (Böckler et al., 2014), and accepted a wider range of slightly averted gaze directions as still being directed toward themselves, consistent with enhanced monitoring for salient social cues (Lyyra et al., 2017). In addition, both adults and children showed longer disengagement latencies from the central gaze cue after ostracism, suggesting heightened attention to socially relevant stimuli (Basset et al., 2025). Interestingly, in another study, social inclusion, but not social exclusion, elicited longer response times for direct compared to downward eye gaze in an attentional disengagement task (Syrjämäki and Hietanen, 2020), suggesting that affiliative contexts may selectively increase attentional capture by socially relevant stimuli. Overall, these findings suggest that social inclusion and exclusion can influence attentional processing of social information, although the direction of these effects appears to vary across studies and task contexts. This variability highlights the need for further research to clarify how different social experiences shape attention to social cues.

Emerging evidence suggests that the effects of ostracism on attentional processes seem to extend also to the younger population. Infants show sensitivity to social exclusion as early as 8 months of age (Basset et al., under review; Quadrelli et al., 2023), and their processing of social signals can be affected by such experiences. For example, it was shown that being ostracized (i.e., ignored and excluded) in a live ball-tossing game influenced the processing of emotional social stimuli, with excluded infants displaying enhanced attention to emotional faces (happy, fearful, and angry) compared to their included peers at 13 months of age, but showing reduced neural activity in sensorimotor regions—as indexed by μ rhythm desynchronization—in response to all emotions (Quadrelli et al., 2025). These findings highlight the impact of social exclusion on infants' processing of emotionally salient information, which is essential for effective social engagement, and suggest that sensitivity to social adverse experiences in shaping the processing of social cues emerges early in development. Nevertheless, it remains unclear whether the effect of ostracism on attentional processes extends to earlier phases of development. Orienting and disengagement are crucial for effectively interacting with the surrounding environment during development (De Zwart et al., 2025), yet substantially less is known about how social exclusion shapes these processes in younger infants. Addressing this gap in the literature is therefore of particular importance.

The first aim of this study was to assess how being ostracized from a live ball-tossing game can affect 8-month-old infants' attentional disengagement from social (i.e., structured faces) and non-social (i.e., scrambled faces) stimuli. Attentional disengagement was assessed using the well-established Overlap Task (e.g., Blaga and Colombo, 2006; Cousijn et al., 2017; Hunnius and Geuze, 2004; Peltola et al., 2008), where infants' attention was first attracted to a centrally presented social (i.e., structured face) or non-social (i.e., scrambled face) stimulus. A peripheral target was then introduced while the central stimulus remained visible (overlap condition). This paradigm requires infants to disengage their attention from the centrally presented stimulus in order to shift and orient to the peripheral target. The overlap condition is widely used to assess infants' attentional disengagement abilities, as well as their flexibility in modulating orienting responses according to stimulus characteristics (Arioli et al., 2025; Peltola et al., 2008). We hypothesized that ostracized infants would show longer latencies when disengaging from structured faces, but not from scrambled ones. This prediction is grounded in evidence that ostracism increases infants' attentional engagement with faces regardless of their emotional valence (Quadrelli et al., 2025), suggesting enhanced sensitivity to socially relevant cues following exclusion. This is consistent with the broader view that, after exclusion, individuals show enhanced monitoring and sensitivity to socially salient cues (e.g., Böckler et al., 2014; Lyyra et al., 2017). Related evidence further extends to attentional disengagement in both adults and older children (Basset et al., 2025). We expect these effects to be specific to structured faces, which convey social meaning, whereas scrambled faces lack such meaning (Capellini et al., 2019).

The second aim was to explore the interplay between individual predispositions (i.e., temperamental traits) and environmental experiences, as it was shown not only that temperament seems to impact attentional disengagement in infancy (McConnell and Bryson, 2005; Nakagawa and Sukigara, 2013, 2019), but also that some children may be more vulnerable than others to social exclusion (Tobia et al., 2017). In particular, we focused on the Orienting/Regulatory Capacity (ORC) as reported by parents in the Infant Behavior Questionnaire—Revised (Gartstein and Rothbart, 2003; Montirosso et al., 2011). ORC is considered a precursor of Effortful Control (Putnam et al., 2008) and measures an infant's capacity to focus attention, enjoy gentle stimulation, and be soothed. Given that it captures a core regulatory dimension of temperament, we included this measure to examine whether it is associated with the effects of social exclusion on attentional performance. We hypothesized that temperamental traits may modulate the effects of ostracism on attentional disengagement from faces. In particular, we expected that, following the ball-tossing game, the impact of exclusion on attentional disengagement from faces would be reduced in infants with higher scores at the ORC temperament cluster. This is consistent with evidence showing that, at 10 months, parent-reported attentional/regulatory capacity predicted infants' negative affect following a mild stressor (Morasch and Bell, 2012).

Finally, we examined whether infants showed different behavioral responses when included in or excluded from the ball-tossing game, in line with previous studies (Basset et al., under review; Quadrelli et al., 2023, 2025). We expected that, at the behavioral level, ostracized infants will show less positive emotionality and more negative emotionality than included ones, possibly supporting and extending to a younger age the hypothesis that a system to detect and respond to social exclusion is present during the first year of life.

2 Methods

2.1 Participants

A total of 54 participants (24 females, M_{age} = 254 days, SD_{age} = 9.07 days, range = 235–271 days) were included in the final sample. Infants were pseudo-randomly assigned to the inclusion (N = 28) or the ostracism condition (N = 26), by alternating their allocation to the experimental conditions before their arrival at the laboratory. To be included in the final sample all infants had to be born full-term (37–42 weeks of gestation), have a normal birth weight (>2,500 g) and have no pre- or postnatal complications, as reported by their caregivers. Thirteen additional participants were tested but excluded from the final statistical analyses. Reasons for exclusion were as follows: not meeting inclusion criteria listed above (N = 6 in the inclusion condition), fussiness (N = 2 in the ostracism condition), not completing the attentional disengagement task (N = 2 in the inclusion condition), technical issues (N = 1 in the inclusion condition, N = 1 in the ostracism condition) and not reaching the cut-off limit of having at least two good trials for each condition at the attentional task (N = 1 in the ostracism condition). Families were recruited from metropolitan and suburban areas of Milan, representing a range of socioeconomic backgrounds; 96% of our sample was of European origin. A sensitivity analysis was conducted in G*Power 3.1 (Faul et al., 2007) for a mixed ANOVA with a within-between interaction (2 face types x 2 conditions), with α = 0.05 and power = 0.80. Given the final sample size of 52 participants, the minimum detectable effect size was f =

0.40. Thus, the study had limited power to detect small-to-medium interaction effects.

The protocol was carried out in accordance with the ethical standards of the Declaration of Helsinki (BMJ 1991; 302: 1194) and approved by the ethical committee of the University of Milano-Bicocca (protocol number: 813). Data collection took place at the Bicocca Child and Baby Lab of the University of Milano-Bicocca. Families were recruited *via* phone calls and/or emails sent to parents based on birth records provided by the Metropolitan city of Milan and some neighboring municipalities. Only participants with informed written consent completed and signed were tested.

2.2 Procedure

All participants were tested individually at the Bicocca Child and Baby Lab. Each infant was accompanied by a caregiver and was involved in one experimental session. Firstly, participants took part in a face-to-face triadic ball-tossing game aimed at manipulating ostracism and were assigned to either the inclusion or ostracism condition (as in Quadrelli et al., 2023, 2025). The ball-tossing interaction was video-recorded for offline coding. Infants then completed an attentional disengagement task with centrally presented structured and scrambled faces (Figure 1). Their eye movements were recorded using an eye-tracking system. The role of temperamental predispositions in modulating individuals' attentional performance after the experimental manipulation was assessed by asking caregivers to complete the ORC scale of the Infant Behavior Questionnaire-Revised (IBQ-R; Gartstein and Rothbart, 2003; Montirosso et al., 2011), which measures temperament-based, attention-mediated regulatory capacity in infancy.

At the end of the session, a short playtime was included to help the infant feel re-included and leave the lab in a positive mood. Caregivers were then debriefed and given the chance to ask any questions.

2.2.1 Face-to-face ball-tossing game and behavioral coding

The face-to-face ball-tossing game took place around a table. Infants were sitting on the parent's lap facing the two experimenters who were seated on the opposite side of the table. Following the procedure developed by Quadrelli et al. (2023, 2025), participants were assigned either to an inclusion or an ostracism condition. The game was composed of 18 ball tosses. The first 6 tosses were defined as the *baseline phase*. They were equally distributed between participants both in the inclusion and ostracism conditions. Experimenters interacted with the participant using verbal prompts and eye contact. The last 12 tosses were defined as the *experimental phase*, as this was the phase where the two conditions differed. As in Quadrelli et al. studies (2023, 2025), in the inclusion condition, infants remained actively involved in the game, receiving and tossing the ball as part of an equitable exchange among the three players, while the experimenters maintained eye contact and smiled at them throughout the task. In the ostracism condition, the two experimenters continued tossing the ball only to each other, maintaining eye contact and smiling with each other while ignoring the infant. Parents were instructed not to interact verbally or physically with the infant during the whole duration of the game. Parents were initially blind to the specific aims of the study.

The ball-tossing game was video-recorded for off-line coding. We followed the same coding scheme of Quadrelli et al. (2023, 2025) resulting in four behavioral scores: (a) Positive Emotionality (including smiling, happy vocalizations, and leaning forward toward other players); (b) Negative Emotionality (including crying, angry vocalizations, negative facial expressions, slumped posture, withdrawal from the game, and seeking help from the parent); (c) Active Engagement (including raising arms to request the ball, pointing toward the ball, and seeking the player's attention); (d) Visual Attention (including looks at the ball and looks at the players).

The videos were segmented into 2-s long intervals. Behaviors were coded as present (1) or absent (0) for each segment. For both baseline and experimental phases, behavioral scores were summed and then normalized by dividing the total by the number of observed behaviors. The resulting values were multiplied by 100 to obtain percentage scores (Quadrelli et al., 2023, 2025). A research assistant, who was unaware of the hypotheses of the study, coded infants' behavior during the ball-tossing game. Approximately 25% ($N = 13$) of the videos were additionally coded by a separate coder unaware of the study hypothesis. Intraclass correlation coefficients (ICCs) were calculated *via* R statistical software (R Core Team, 2023, version 4.3.2), employing "irr" package (Gamer et al., 2019), and found to be excellent for all indexes in the two phases, with values ranging from 0.982 to 1 and a mean ICC of 0.989 (all *ps* < 0.001).

2.2.2 Disengagement task

The central stimuli of the Overlap task consisted of three adult, white and female faces selected from the Radboud Faces Database (RaFD; Langner et al., 2010). The image size was 10.7° wide and 13.6° high. Faces were presented either in a structured version, with a neutral expression and facing forward (direct gaze toward the observer), or in a scrambled version. The scrambled stimuli were created using a Fast Fourier Transformation procedure (e.g., Peltola et al., 2008) with an *ad hoc* Matlab script (R2023b, The MathWorks Inc., Natick, MA, USA). This procedure preserves low-level visual properties while disrupting configural facial information. Stimuli did not differ in terms of luminance, either within structured faces, Kruskal-Wallis H test $\chi^2(2) = 2$; $p = 0.368$; $\varepsilon^2 = 0.1$, within scrambled faces, Kruskal-Wallis H test $\chi^2(2) = 2$; $p = 0.368$; $\varepsilon^2 = 0.1$, and overall Kruskal-Wallis H test $\chi^2(5) = 5$; $p = 0.416$; $\varepsilon^2 = 0.1$.

A peripheral target stimulus was presented on the left or right side of the screen at a distance of 13.3° from the center and consisted of a checkerboard whose size was 3.1° wide and 10.7° high. Infants were seated in a child seat positioned approximately 60 cm in front of the stimulus presentation monitor (24-inch screen; resolution 1,920 × 1,080 pixels). Stimulus presentation was programmed using E-Prime 3 (Psychology Software Tools, Pittsburgh, PA) integrated with Tobii Pro Lab (Tobii Technology AB, Stockholm, Sweden). Eye movements were recorded with

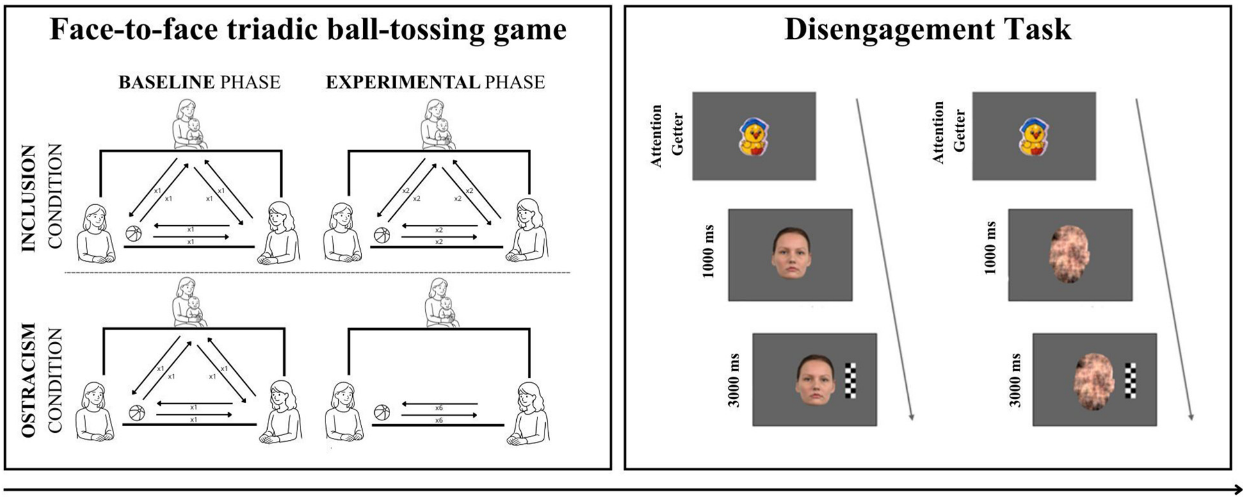

FIGURE 1
Illustration of the procedure of the study.

a Tobii Pro Spectrum 300 (Tobii Technology AB, Stockholm, Sweden), sampling at 150 Hz.

Before the start of the task, a 5-point calibration procedure was administered. During calibration, an animated duck accompanied by a sound was presented sequentially in the four corners and at the center of the screen. The calibration targets were presented one at a time: each time the infant fixated on a target, the experimenter pressed a key to move on to the next, continuing until all targets had been displayed. Once the calibration phase was completed, the overlap task commenced. First, a flickering central attention-getter (i.e., various cartoon images accompanied by sounds) was presented to direct the infant's attention to the screen. Once the infant fixated on the attention getter for at least 500 ms, the central face stimulus (structured or scrambled) was displayed. After 1,000 ms, a peripheral distractor (i.e., the checkerboard) appeared. The distractor was presented randomly and with equal probability on the left or right side of the central stimulus. The checkerboard flickered at a frequency of 10 Hz for the first 1,000 ms and then remained static for the remaining 2,000 ms (as in Addabbo et al., 2025; Peltola et al., 2008). The central face and the checkerboard were displayed simultaneously on the screen for 3,000 ms. The total number of trials was 60. However, the task was terminated when infants reached their maximum level of sustained attention, getting fussy or bored.

2.2.3 Eye-tracker data analysis

The raw data were exported from Tobii Studio and we defined two areas of interest (AOIs), one for the central stimuli and one for the checkerboard. Individual trials were excluded if the infant did not direct gaze toward the checkerboard after its appearance, if there were anticipatory looks within 150 ms of stimulus onset, if infants initiated the saccade after 1,000 ms from the distractor onset and also if the infant was not fixating the central stimulus before starting a saccade toward the distractor, as done in previous studies (Addabbo et al., 2025; Ahtola et al., 2014). In this research we focused on infants' disengagement times (DTs), defined as the interval between the onset of the checkerboard and the moment the infant shifts their gaze from the face to the checkerboard (Addabbo et al., 2025).

To be included in the final analyses participants needed to watch at least 2 trials for each type of stimuli (i.e., 2 structured and 2 scrambled faces), as in previous studies (Addabbo et al., 2025). Following data cleaning, infants contributed a mean of 35 trials, 17 trials for structured faces ($SD = 7$) and 18 trials for scrambled faces ($SD = 7$). There was no significant difference between included and ostracized individuals for the trials seen for either type of stimuli (all $ps > 0.598$). The internal consistency of the Overlap Task was assessed using a permutation-based split-half reliability approach with odd-even splitting (Parsons, 2021), *via* R statistical software (R Core Team, 2023, version 4.3.2). Given that the minimum inclusion criterion for the task was two valid trials per condition, two participants were excluded from this consistency analysis as they did not provide enough trials for the test. Spearman-Brown corrected estimates indicated moderate-to-acceptable reliability across conditions, with values of SB = 0.63 for structured faces and SB = 0.73 for scrambled faces, which is considered adequate given the limited number of trials typically obtained in infant research.

2.2.4 Temperamental traits

The Infant Behavior Questionnaire-Revised (IBQ-R; Gartstein and Rothbart, 2003; Montirosso et al., 2011) is a scale to measure temperament in infancy. It is rated on a 0–7 scale (0 = does not apply, 1 = never, 2 = very rarely, 3 = less than half the time, 4 = about half the time, 5 = more than half the time, 6 = almost always, 7 = always). Items coded as 0 (does not apply) are treated as missing. In this study we focused mainly on the ORC cluster. The ORC includes four sub-scales—cuddliness, soothability, low intensity pleasure and duration of orienting—comprising a total of 60 items.

3 Statistical analysis

Eye tracking data were analyzed via a 2x2 ANOVA with Condition as between-subjects factor (i.e., inclusion vs. ostracism) and type of stimuli (i.e., structured vs. scrambled faces) as within-subjects factor and infants' DTs as dependent variable. The data are reported as marginal means and standard errors (SEs).

To examine the role of temperamental traits and social exclusion exposure on attentional disengagement from structured faces, we conducted a General Linear Model (GLM), with disengagement times (DTs) from structured faces as the dependent variable, and ORC and condition (included vs. ostracized) as predictors, including their interaction term to test for potential moderation of the condition effect by ORC.

In addition, to assess whether the ball-tossing game elicited different behavioral reactivity in included vs. ostracized infants, consistent with sensitivity to exclusion, we conducted a 2x2 ANOVA with Condition as between-subjects factor (i.e., inclusion vs. ostracism) and Phase (i.e., baseline phase and experimental phase) as within-subjects factor on all behavioral reactivity indexes (i.e., Positive Emotionality, Negative Emotionality, Active Engagement, Visual Attention). As this study is part of a broader research project, and some of the behavioral data included are also being reported in a related manuscript currently under review in another journal, these analyses are reported in the Supplementary Materials of the Manuscript.

For all analyses, when the ANOVAs yielded significant effects, pairwise or independent sample comparisons were performed. All statistical analyses were performed on Jamovi 2.6.44 (https://jamovi.org) using a two-tailed 0.05 level of significance.

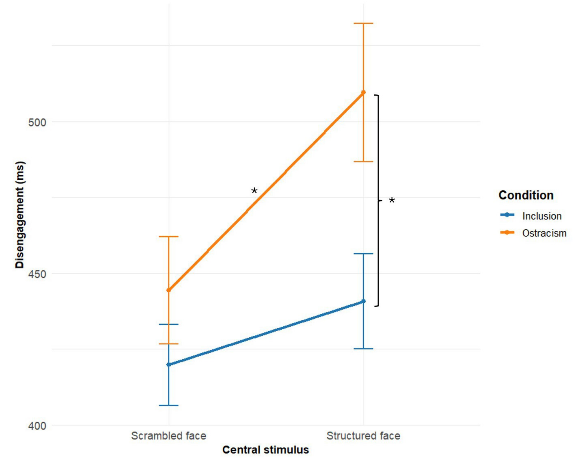

FIGURE 2
Results from the 2x2 ANOVA with Condition as between-subjects factor (i.e., inclusion vs. ostracism) and type of stimuli (i.e., structured vs. scrambled faces) as within-subjects. *$p < 0.05$

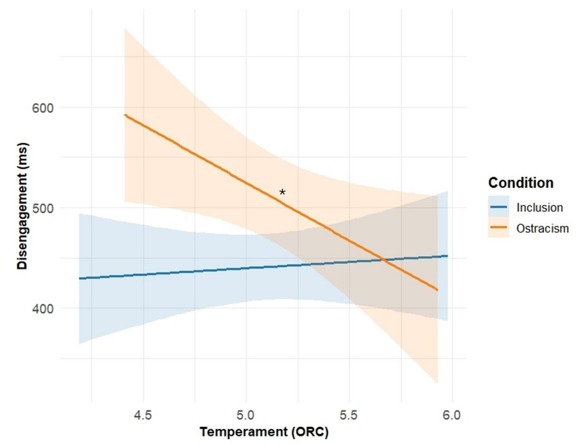

FIGURE 3
Results of the interaction between condition and IBQ-R ORC on infants' DTs from structured faces.

4 Results

4.1 Attentional disengagement task

The 2x2 ANOVA with Condition as between-subjects factor (i.e., inclusion vs. ostracism) and type of stimuli (i.e., structured vs. scrambled faces) as within-subjects factor revealed a main effect of type of stimuli on DTs, $F(1, 52) = 22.40$, $p < 0.001$, $\eta^2 p = 0.301$. In particular, all infants were slower to disengage from structured faces ($M = 475$ ms, $SE = 13.7$ ms) rather than scrambled ones ($M = 432$ ms, $SE = 11.0$ ms). In addition, analyses showed a significant main effect of Condition, $F(1, 52) = 4.09$, $p = 0.048$, $\eta^2 p = 0.073$. Ostracized infants were significantly slower to disengage from the central stimulus ($M = 477$ ms, $SE = 16.6$ ms) when compared to included ones ($M = 430$ ms, $SE = 16.0$ ms). Moreover, analyses highlighted a significant interaction between type of stimuli and Condition, $F(1, 52) = 5.89$, $p = 0.019$, $\eta^2 p = 0.102$. Planned comparisons revealed that ostracized infants were slower to disengage from structured ($M = 510$ ms, $SE = 19.7$ ms) rather than scrambled faces ($M = 444$ ms, $SE = 15.8$ ms), $t(25) = 4.70$, $p < 0.001$, $d = 0.90$, and that ostracized infants were slower to disengage from structured faces than included ones ($M = 441$ ms, $SE = 19.0$ ms), $t(52) = -2.52$, $p = 0.015$, $d = -0.69$ (Figure 2).

4.2 Temperamental traits

A General Linear Model (GLM) was conducted with disengagement times (DTs) from structured faces as the dependent variable, Condition (inclusion vs. ostracism) as a categorical predictor, IBQ-R ORC scores as a continuous predictor, and their interaction. The model explained a significant portion of variance, $F(3, 50) = 4.52$, $p = 0.007$, $\eta^2 p = 0.213$. A significant main effect of Condition was observed, $F(1, 50) = 7.34$, $p = 0.009$, $\eta^2 p = 0.128$, with ostracized infants showing longer disengagement times than included infants. A significant interaction between ORC and Condition was observed, $F(1, 50) = 5.04$, $p = 0.029$, $\eta^2 p = 0.092$. Parameter estimates indicated that higher IBQ-R scores were associated with faster disengagement for ostracized infants ($B = -114.9$, SE $= 45.0$, $t(50) = -2.56$, $p = 0.014$), but not for included ones ($B = 12.5$, SE $= 34.7$, $t(50) = 0.36$, $p = 0.720$; Figure 3).

4.3 Emotional reactivity at the ball-tossing game

Behavioral reactivity analyses revealed lower Positive Emotionality and increased Negative Emotionality and Active Engagement for ostracized infants compared to included ones during the experimental phase. These differences were also significant relative to their baseline phase. Full results are reported in the Supplementary Materials.

5 Discussion

Available research has highlighted the crucial role of face processing in infancy and its importance for social and cognitive development (e.g., Farrant and Zubrick, 2012; Farroni et al., 2002; Senju et al., 2004; Umilta et al., 1996). Studies on adults and children have shown that even brief experiences of ostracism can affect social information processing, although results are not always consistent (e.g., gaze cueing; Basset et al., 2025; Capellini et al., 2019; Yang et al., 2024). Recent evidence indicates that sensitivity to social exclusion emerges early in life and modulates infants' attention toward emotional faces (Basset et al., under review; Quadrelli et al., 2023, 2025). However, it remains unclear whether these phenomena extend to younger infants at ages when an attentional bias for faces is clearly documented (Leppänen, 2016). The present study examined whether being ostracized or included in a live ball-tossing game affected 8-month-old infants' attentional disengagement from social (structured faces) and non-social (scrambled faces) stimuli, assessed *via* the Overlap Task, and explored the role of temperamental traits in modulating this response.

Our primary aim was to assess the effects of ostracism on attentional disengagement. Our results revealed that ostracized infants were significantly slower than included ones to disengage from centrally presented social stimuli, whereas no such effect was observed for non-social ones. These findings indicate that ostracism did not induce a general attentional impairment; rather, its effects seem to emerge specifically for socially salient cues. This result is consistent with evidence that social exclusion modulates attention selectively for social stimuli in adults (Capellini et al., 2019). Heightened sensitivity to social stimuli following exclusion has been interpreted as reflecting the activation of a social monitoring system that facilitates the detection of opportunities for reconnection (Pickett and Gardner, 2005; Qualter et al., 2015). However, the direction of the effect observed in our research is not univocally reported in the literature. While some studies found that exclusion reduces social attention (Capellini et al., 2019; Yang et al., 2024), others show enhanced sensitivity to social cues (Basset et al., 2025; Böckler et al., 2014; Lyyra et al., 2017; Quadrelli et al., 2025). In the present study, structured faces were presented with direct gaze toward the infant, which previous research has identified as a salient indicator of social interest and engagement (Gibson and Pick, 1963). In this framework, our results align with those previous studies that show increased sensitivity to social stimuli after ostracism. Indeed, ostracized infants may have experienced greater difficulty disengaging from structured faces, which could reflect an increased attention to socially relevant signals following exclusion. In addition, we showed that infants took longer to disengage from structured compared to scrambled faces, consistent with evidence of a preferential attentional bias toward socially salient stimuli across early development (DeNicola et al., 2013; Gliga et al., 2009; Leppänen, 2016; Peltola et al., 2008). These findings support the notion that infants' attentional systems are intrinsically tuned to socially meaningful information, which may serve adaptive functions in early development (e.g., Farrant and Zubrick, 2012; Senju et al., 2004).

In this work we also aimed to explore the interplay between temperamental traits and social experiences. Our results show that, as early as 8 months, infants' regulatory capacity (ORC) influenced their disengagement from structured faces, when ostracized. Within this framework, infants with higher orienting/regulation may have relied on this temperamental trait as a protective factor: the greater their ability to regulate, the more efficiently they disengaged from central structured faces. This pattern may be explained by prior research showing that individual characteristics can make some children more vulnerable than others to ostracism, with downstream effects on cognitive performance (Tobia et al., 2017). Indeed, responses to social exclusion have been shown to vary as a function of individual differences such as self-esteem (Onoda et al., 2010), and ostracism itself has been found to undermine self-regulatory capacities (Oaten et al., 2008). These findings highlight the complex interaction between environmental experiences and individual predispositions in shaping early attentional processes. In this sense, infants with greater self-regulatory abilities may be less susceptible to the cognitive effects of exposure to the social exclusion condition. Supporting this interpretation, evidence from 10-month-old infants indicates that higher (parent-reported) self-regulation is associated with lower post-distress negative affect (Morasch and Bell, 2012), suggesting that regulatory capacities are already functionally relevant in modulating emotional and attentional responses early in development. These results are also in line with previous studies which have shown that infants with higher regulatory capacity are faster to disengage from central stimuli (Nakagawa and Sukigara, 2013), whereas those with lower regulatory capacity exhibit slower attentional processing of faces (Martinos et al., 2012). Taken together, these findings highlight the need to consider both individual differences and developmental context when interpreting how infants allocate attention following exposure to social exclusion.

Finally, as reported in the Supplementary Materials, we showed that ostracized and included infants displayed different behavioral reactivity during the ball-tossing game. Indeed, those infants who were excluded exhibited lower positive emotionality, higher negative emotionality and more attempts to attract the players' attention and request the ball than included ones, especially in the experimental phase (Basset et al., under review; Quadrelli et al., 2023, 2025). The behavioral reactivity coding in our study served as a manipulation check. Indeed, in order to assess whether our experimental manipulation could affect infants' disengagement from structured and scrambled faces, we had to ensure that infants experienced the inclusion and ostracism conditions differently. Since in infancy we can only use indirect measures, we implemented a previously published coding scheme

(Basset et al., under review; Quadrelli et al., 2023, 2025) to assess infants' reactivity to the experimental manipulation. Overall, the observed behavior confirms that the experimental manipulation effectively elicited differential social experiences, leading us to posit that infants, as early as 8 months, are able to detect and respond contingently to social threats like being ostracized from a game. However, alternative interpretations of these behavioral findings cannot be completely ruled out. As suggested in the literature (Vanhollebeke et al., 2023), some responses may reflect characteristics of the paradigm itself, such as expectancies violation, rather than social exclusion *per se*. Indeed, the baseline phase (i.e., first six throws) could have set expectations of equal involvement in the game in our participants, and negative emotionality could reflect distress for object-loss. Nevertheless, the pattern of results observed here (i.e., specifically, increased bids directed not only toward the ball but also toward the experimenters) suggests that infants' behavior cannot be explained solely in terms of object-directed responses. Future studies should further disentangle the respective contributions of object-related constraints inherent to the task and sensitivity to social exclusion.

Some limitations need to be acknowledged and addressed in future research. First, we focused exclusively on the ORC scale of the IBQ-R (Gartstein and Rothbart, 2003; Montirosso et al., 2011). However, previous literature indicates that other temperamental dimensions, such as negative affect, soothability, and positive affect, also influence infants' attentional disengagement (Conejero and Rueda, 2018; McConnell and Bryson, 2005; Nakagawa and Sukigara, 2019) and may modulate sensitivity to ostracism. For instance, infants with higher levels of negative affect may be more vulnerable to social exclusion than those with lower levels. A second limitation concerns the inclusion of a single age group, which may restrict the generalizability of our findings. Previous research has posited age-dependent effects of ostracism (Abrams et al., 2011). Moreover, it has been argued that regulatory abilities in infancy rely on the fronto-parietal network (i.e., the orienting network; Posner et al., 2012; Rothbart et al., 2011) and shown that the brain undergoes rapid structural and functional development during the first years of life (Gao et al., 2015; Gilmore et al., 2012), which may influence the emergence and stability of the observed patterns between temperamental traits and attentional mechanisms. Indeed, even if temperamental traits are considered relatively stable over time, their expressions might change during development (Putnam et al., 2001). Expanding the age range in future studies would allow a more comprehensive understanding of attentional and emotional responses to social exclusion and could also help disentangle the interplay between individual differences and developmental changes in shaping attentional mechanisms. A further limitation concerns the relatively small sample size, which provided adequate sensitivity to detect relatively large interaction effects. Therefore, future studies including larger samples may help to further investigate smaller interaction effects.

6 Conclusions

The present research provides evidence that an experimental manipulation of social exclusion can influence attentional processes as early as 8 months of age. Our findings also suggest that individual differences in self-regulatory temperamental traits may moderate infants' disengagement from social stimuli following an ostracism experience, highlighting the interplay between individual characteristics and environmental social experiences. Our findings show that even brief social manipulations, such as temporary exclusion in a live interactive game, can affect both attentional and emotional responses in infancy. Infants who were excluded from the game were, indeed, slower than included ones to disengage their attention from structured faces (i.e., social stimuli). Importantly, ostracized infants with higher regulatory capacity were more efficient in disengaging from social stimuli, suggesting that self-regulation may serve as a protective factor in the context of social exclusion. Future research should investigate a broader age range, incorporate multiple temperamental dimensions, and assess the long-term consequences of early ostracism. Such work could inform interventions and strategies to foster nurturing and inclusive environments that support healthy social and cognitive development from infancy onward.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethical Committee of the University of Milano-Bicocca (protocol number: 813). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

GB: Data curation, Visualization, Conceptualization, Writing – original draft, Formal analysis, Methodology, Writing – review & editing, Software, Investigation. EQ: Conceptualization, Formal analysis, Project administration, Methodology, Writing – review & editing, Funding acquisition, Supervision. CT: Writing – review & editing, Methodology, Conceptualization, Supervision. HB: Conceptualization, Methodology, Supervision, Writing – review & editing, Project administration, Funding acquisition.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdpys.2026.1901379/full#supplementary-material

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