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Predicting infant social attention: The role of temperament and mother-child interaction

Nena V. Kohl [a,1], Jonathan A. Schmidt [a,1,*], Anne Henning [b], Gisa Aschersleben [a]

[a] Department of Developmental Psychology, Saarland University, Saarbrücken, Germany
[b] SRH University of Applied Sciences Heidelberg, Campus Gera, Germany

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ABSTRACT

The origins of individual differences in infant social attention are not yet well understood. Two prominent lines of research identified different predictors. One points to differences with varying experiences in parent-child interaction styles while another focuses on differences in infant temperament. There is a lack of research integrating these two approaches in a single sample. The goals of this study were to test whether mother-child interaction as well as infant temperament at the age of 6 months are able to predict later social attention at the age of 12 months and whether social attention at 12 months is associated with shy temperament at 18 months. Data from a longitudinal sample of 64 mother-child dyads from a mid-sized city in Germany were being investigated. Mother-child interaction was measured using the EAS. Infant temperament was assessed with the IBQR and the ECBQ. A habituation paradigm was employed to measure infant social attention at 12 months. Several regression models showed that infant involvement in mother-child interaction positively predicted social attention, while a fearful temperament negatively predicted social attention. Moreover, the observed interaction between infant involvement and fearfulness in the sample of emotional available mothers may indicate that fearful infants who are already able to search for help by involving their mothers do not show any disadvantages in social attention. Shy temperament at 18 months was not correlated with infant social attention. Overall, our results provide further evidence on the influence of both the social context as well as individual traits on social cognitive outcomes.

1. Introduction

The developing ability to understand the goals of others is a milestone in infant socio-cognitive development and a significant predictor of later social competencies, such as Theory of Mind in preschool years (Aschersleben et al., 2008; Wellman et al., 2008). Although a substantial body of research has focused on the long-term effects of early social attention on the understanding of goal-directed actions and later socio-cognitive outcomes, the origins of individual differences in social attention remain unclear. The present study aims to address this gap by considering both individual (infant temperament) as well as dyadic social behavior (mother-child interaction) as potential predictors of infant social attention.

* Correspondence to: Campus A 1.3, Room 2.20, Saarbrücken 66123, Germany.
E-mail address: jonathan.schmidt@uni-saarland.de (J.A. Schmidt).
[1] First authorship is shared equally

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1.1. Social attention

In the first year of life, infants learn to understand intentional behavior (Woodward et al., 2009). As early as six months, they are able to interpret certain actions as goal-directed (Woodward, 1998) and at the end of the first year they begin to anticipate actions based on gaze cues (Phillips et al., 2002) and to anticipate the goals of failed actions (Brandone et al., 2014). These early abilities are typically investigated using habituation paradigms, where infant looking times are measured in response to a series of repeated stimuli during the habituation phase and then novel stimuli in the test phase. A decline in looking time during the habituation phase reflects attentional processing, while an increased looking time during the test phase indicates surprise and suggests a violation of expectation (Kavšek, 2013; Poli et al., 2024). This violation of expectation regarding a goal-directed action is assumed to reflect infants' novelty preference and implies some degree of social understanding (Bertenthal & Boyer, 2015; Wellman et al., 2004).

The decrement in looking time during habituation, when applied to social stimuli, is often referred to as social attention (Wellman et al., 2008) and is considered an indicator of how efficiently infants process social information (Salley & Colombo, 2016). Infants who exhibit a stronger decrement of attention are thought to more effectively assess goal-directed actions and respond more sensitively to social cues (Wellman et al., 2008). Individual differences in social attention are discussed as predictors of far-reaching socio-cognitive developmental steps (Hunnius, 2007). For example, Wellman et al. (2004) found that social attention at 14 months of age correlated with performance on the Theory of Mind Scale three years later. Aschersleben et al. (2008) demonstrated that decrement of attention to goal directed actions at six months of age predicted the ability to solve false-belief tasks at the age of four. Similarly, Wellman et al. (2008) found that decrement of attention at 10–12 months predicted the ability to solve false-belief tasks at the age of four, even after controlling for IQ, verbal competence and executive function, which indicates a degree of developmental continuity in social cognition.

Taken together, these studies suggest that individual differences in social attention, which already crystallize in the first months of life, are able to meaningfully predict developmentally relevant outcomes at least until preschool age. However, the underlying mechanisms that give rise to these individual differences in social attention are still not fully understood. On the one hand, several studies have demonstrated that the quality of parent-child interaction, especially the mother-child interaction, is related to social attention and social understanding (e.g. Dunphy-Lelii et al., 2014; Hofer et al., 2008; Hohenberger et al., 2012; Licata et al., 2014). On the other hand, some studies point to the role of infant temperament to account for differences in social attention (e.g. LaBounty et al., 2018).

1.2. Mother-child interaction quality

A considerable body of research highlights the significance of a sensitive and responsive maternal interaction style, which plays a crucial role in the socio-cognitive development of infants and children (e.g. Carpendale & Lewis, 2004; Ruffman et al., 1999; Symons & Clark, 2000; Tamis-LeMonda et al., 2014). Dunkel et al. (2023) reported a substantial correlation between maternal supportiveness at 14 months of age and a child's general intelligence at age 10, indicating longitudinal effects of maternal interaction quality on cognitive development. Maternal sensitivity appears to be associated not only with children's language or academic outcomes (Hirsh-Pasek & Burchinal, 2006), but also with verbal and performance intelligence in adolescence (Dunkel & Woodley of Menie, 2019). With regard to socio-cognitive development, Licata et al. (2016) found that the emotional availability of the dyad at 7 months of age predicted the child's ToM at 4 years of age, even when controlling for child temperament and cognition.

Moreover, effects of mother-child interaction quality can already be observed in infancy. Bornstein and Tamis-Lemonda (1997) reported a relationship between maternal sensitivity and responsiveness and the infant's attention span and information processing skills. Fonagy (2002) describes mother-infant interaction as vital for understanding and interpreting human actions and behavior, linking it to social understanding. Empirical evidence from Hofer et al. (2008) supports these assumptions: They found that 6-month--old infants of mothers that were modestly controlling yet also sensitive were more likely to interpret unfamiliar human actions as goal-directed compared to infants of those mothers that were less controlling and either sensitive *or* unresponsive. Their results challenge the general findings that it is particularly a sensitive maternal interaction style that supports social development, suggesting instead that an interaction style characterized by structuring and providing clear and directive social input that may enhance early understanding of goal-directed actions. Hohenberger et al. (2012) replicated these findings and extended them longitudinally. While infants of modestly controlling mothers outperformed others at six months, these differences were no longer present at 10 months. Both Hofer et al. (2008) and Hohenberger et al. (2012) employed the Back of Hand task, which constitutes a complex social event that most infants older than 10 months are able to properly process (Király et al., 2003).

Licata et al. (2014) as well as Dunphy-Lelii et al. (2014) also examined the relationship between mother-child interaction and infant understanding of goal-directed actions while controlling for infant temperament. Licata et al. (2014) assessed the relationship quality at 7 months of age, based on 10-minute videotapes of a free-play situation in a laboratory setting using the emotional availability scales (EAS; Biringen, 2008) and presented infants with a goal-encoding task by Woodward (1998). A sum score across all EA-dimensions significantly predicted 7-month-old infants' goal-encoding ability, even when controlling for child temperament, working memory and maternal education. Infants of emotionally available mothers were better at encoding human actions as goal-directed than infants with less emotionally available mothers.

While Licata et al. (2014) reported a significant effect for infants' understanding of goal-directed actions in test trails, Dunphy-Lelii et al. (2014) found an effect for the decrement of attention during habituation. In their study, 10–12 months old infants participated in a structured play session with their mother and an intentional action looking time paradigm (Phillips et al., 2002). They captured mother-child interaction, maternal mind-mindedness, infant social temperament as well as object-centered attentiveness using the

16 min videotapes from the play situation in a laboratory setting. Unlike maternal mind-mindedness, infant activity level and infant object-centered attention, only mother-child interaction quality predicted infant decrement of attention. Dunphy-Lelii et al. (2014) state that these findings underline the relationship between mother-child social interaction and infant social attention. But they also state that the direction of the effects remains unclear. While mother-child interaction quality predicted the child's habituation, a reverse or reciprocal relationship is also conceivable. For example, the subtle interplay of infant socio-cognitive skills and sensitive mother-child interaction could also be responsible for the correlation, and even a reverse effect could be postulated. It is, for example, possible that children with higher socio-cognitive skills show more responsivity and engagement in mother-child interactions. However, the claim that mother-child interaction, being a relatively stable factor since birth, is capable of supporting the child in developing later socio-cognitive skills is more common in the literature (e.g., Licata et al., 2014, 2016; Paulus et al., 2018). Nevertheless, there remains a lack of longitudinal studies that focus on the relationships between mother-child interaction and decrement of attention to social stimuli in the first year of life.

1.3. Infant temperament

In contrast to social contextual factors, such as mother-child interaction, infant temperament reflects more endogenous differences in reactivity and regulation that could influence how infants engage with their environment. Temperament, with its emotional, attentional and motoric components, can play a decisive role in the way infants react to different stimuli and situations, including those

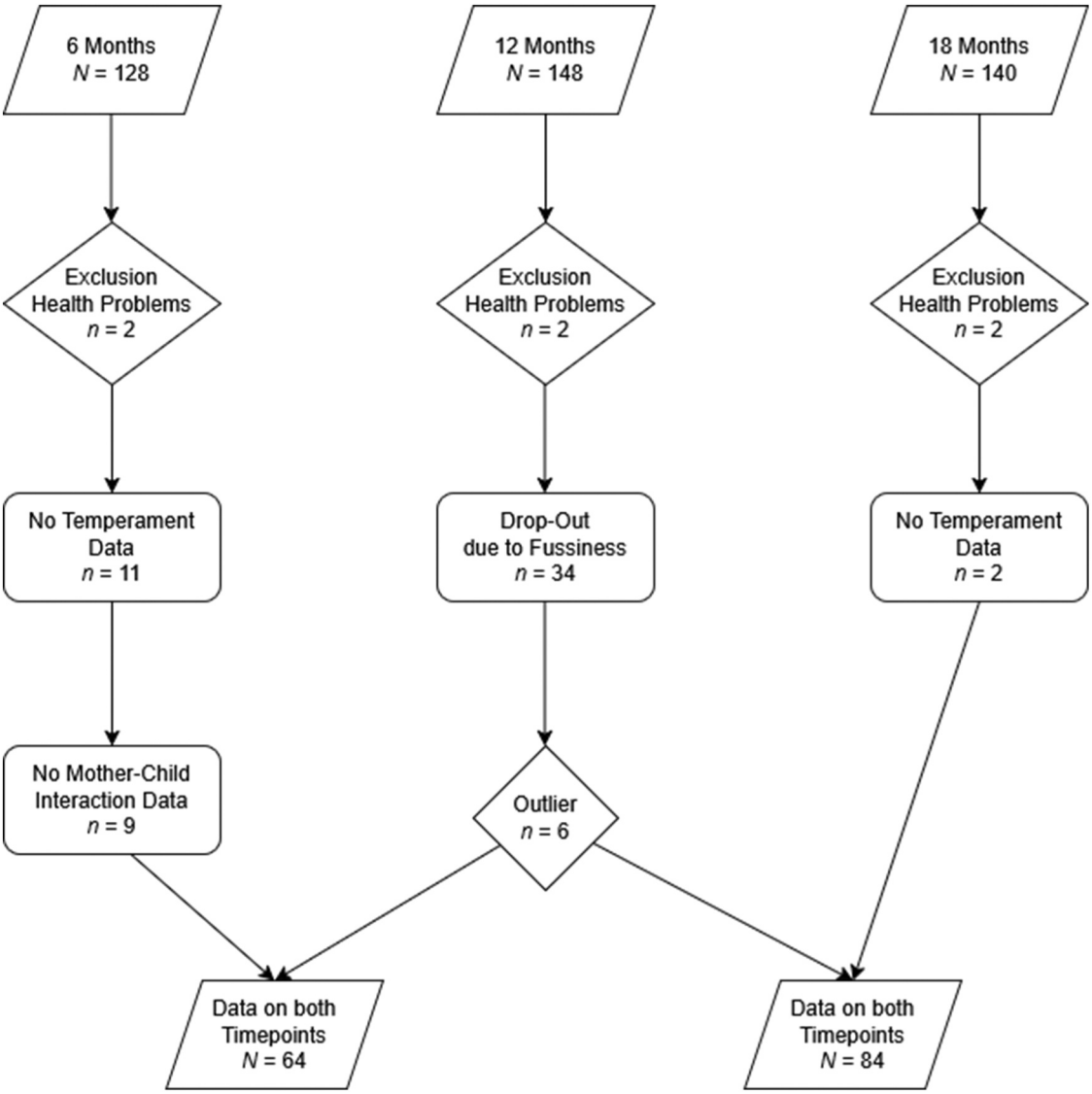

Fig. 1. *Drop Out and Data Exclusions. Note:* Additional mother-child dyads were recruited for the second assessment.

within a social context (Rothbart & Bates, 2006).

The emotional reactivity hypothesis by Wellman et al. (2011) assumes that a shy, observant temperament goes along with a better theory of mind development. As a precursor ability of ToM, social attention may be similarly influenced by shyness. This alternative approach for explaining the development of individual differences in infant social attention is explored by LaBounty et al. (2018), using parent-report items based on Rothbart's biopsychological model of temperament (Rothbart, 1981, 2011). LaBounty et al. (2018) included several scales adapted from the Infant Behavior Questionnaire (IBQ-R; Gartstein & Rothbart, 2003) and the Child Behavior Questionnaire (CBQ; Rothbart et al., 2001) that they theorized might describe more social aspects of temperament such as fear, shyness, cuddliness, low-intensity pleasure and high-intensity pleasure, as well as a habituation paradigm based on Woodward (1998). They found evidence for an association between both shy and fearful temperament and habituation performance on goal-directed action tasks in their sample of 10–11-month-old infants, even after controlling for general cognitive development. Performance was not related to other temperament scales. The authors suggest that these findings indicate that shy children are particularly efficient at social processing due to their tendency to observe the actions of others and passively learn from their behavior. Their choice of measure, however, presents a sort of limitation when it comes to the interpretability of their results: Because the IBQ-R did not include a scale representing shyness, LaBounty et al. (2018) employed an ad-hoc scale for their assessment of this temperamental trait, using modified items from the CBQ – which was designed for children 3 years of age or higher and uses a somewhat dissimilar approach to item construction compared to the IBQ-R (Gartstein & Rothbart, 2003; Rothbart et al., 2001). While these first results are promising, further testing is required to ensure the validity of measuring shyness at such a young age. Retroactively investigating the potential link between shyness and social attention by employing properly validated items in their intended age range of 18–36 months could therefore provide additional clarity, assuming that temperamental traits remain stable throughout the first years of life (Schmidt et al., 2024).

1.4. Aim of the study

The aim of our study was twofold. The first aim was to include infant temperament traits and mother-child interaction quality in a longitudinal design to investigate the predictive qualities of both constructs. We expected that infant social attention at the age of 12 months could be predicted by both the quality of mother-child interaction, especially maternal sensitivity, maternal structuring and maternal non-intrusiveness, as well as infant temperament at the age of 6 months.

A secondary aim was to replicate the findings of LaBounty et al. (2018), who measured shyness with an ad-hoc temperament scale and found it to be related to infant social attention. We therefore investigated a possible link between infant social attention at 12 months and shyness at 18 months using a well-established and age-appropriate scale.

2. Method

2.1. Participants

Originally 128 infants participated in the study at the age of 6 months, 148 infants at the age of 12 months and 140 infants at the age of 18 months. The sample sizes fluctuated due to drop-out and the inclusion of new mother-child dyads for the second assessment. A power analysis for our main hypothesis using a significance level of $p < .05$ and a power of.80 indicated that 68 participants were required to detect a medium effect, as was found by LaBounty et al. (2018) and Licata et al. (2014). Fig. 1 shows drop-out and data exclusions. In total, data from $N = 64$ infants (age at 6 months in weeks: $M = 27.36$, $SD = 1.10$, range [24.57–30.43]; age at 12 months in weeks: $M = 52.31$, $SD = 1.58$, range [49.29–56.71]; 26 female) were included in the following main analyses. Data from 84 infants were available for the analyses concerning the 12- and 18-months old infants (age at 18 months in weeks: $M = 79.02$, $SD = 1.72$, range [76 – 86.71]; 25 female).

At the time of mother-child interaction mothers were on average 32.86 years old ($SD = 5.03$) with a range from 19 to 42 years and most mothers had an academic degree (56%). Families were recruited from the work unit's database, as they had expressed interest in volunteering to take part in research and were contacted via telephone. All families lived in or near a mid-sized city in Germany. At each measurement point parents received compensation for travel expenses and a small gift for the children.

2.2. Procedure and measures

The study is part of a broader longitudinal study of the socio-cognitive development of infants and children. Each visit to our laboratory lasted approximately one to one and a half hours and included several tests as well as a brief sociodemographic questionnaire filled out by either parent. The relevant measures conducted at the measurement points of 6, 12, and 18 months are described in greater detail below.

2.2.1. Social attention – back-of-hand task

Infants' social attention at 12 months was assessed using the Back-of-Hand task (BoH), an adaptation of the Woodward paradigm (Jovanovic et al., 2007; Woodward, 1999). The BoH task is a well-established instrument in the literature on infant social habituation (e.g., Hohenberger et al., 2012; Jovanovic et al., 2007; Király et al., 2003) and is generally viewed as a social task because of its involvement of a human hand as an actor. In contrast, tasks that show similar events but with a mechanical agent as opposed to a human one appear to be interpreted differently by infants (Hofer et al., 2005; Jovanovic et al., 2007).

The same video clips as in Hofer et al. (2008) and Mink et al. (2014) were used. Infants sat on their parent's lap in front of a table, facing a monitor. Video recordings of the infants and the running clips were made simultaneously with two cameras. The habituation paradigm started after a blue curtain appeared on the screen for 3 s and a female voice saying "Schau mal" ("Look!"). Infants first saw two objects, a duck and a tower, positioned side-by-side on black cardboard at the front side of the stage for about 2.5 s. Then an arm appeared from behind the curtain at the right side of the stage and lowered its hand with the palm facing up onto one of the two objects. The palm of the hand pushed the target object slowly to the back of the stage, which lasted about 4 s, and then came to a halt until infants looked away for at least 2 s or after 60 s. The blue curtain appeared again, and the action started all over. In sum, the habituation task took about 10 min of testing time, with infants seeing a minimum of 6 and a maximum of 14 habituation trials. The target object and the position of the toys were counterbalanced across infants. Habituation time was coded online by a total of six observers trained in the procedure, using the program Habit 2000 and three trained research assistants reviewed the habituation data for accuracy afterwards. Social attention was calculated using the decrement of attention to social stimuli as defined by Wellman et al. (2008) and LaBounty et al. (2018): the sum of infant looking time at the fifth and sixth trial was subtracted from the sum of infant looking time of the first two trials, which is referred to as the unweighted habituation score.

2.2.2. Mother-child interaction

Mother-child interaction at 6 months of age was assessed during a 5-minute free play sequence at a laboratory setting. Mothers were instructed to play with their infants as they would at home. The same three toys were given for every dyad, and mothers were free to use them however they saw fit. The interaction was videotaped and scored by two trained coders using the Emotional Availability Scales (EAS, 4th Edition; Biringen, 2008). Interrater reliability of about 20% of all cases ($n = 29$) was calculated to ensure reliability. A first comparison revealed an interrater reliability of ICC = .64, $p < .001$ indicating a moderate reliability. Afterwards, reliability cases were compared, inconsistent cases were discussed, and an agreement on what the final scores should be was reached. A second comparison showed a good ICC = .86, $p < .001$. Only then were the remaining cases coded, with each coder scoring half of the cases. Other EAS dimensions showed similarly moderate to good reliability (Structuring: ICC =.78, $p < .001$; non-Intrusiveness: ICC =.62, $p < .001$; non-Hostility: ICC =.70, $p < .001$; Responsiveness: ICC =.90, $p < .001$; Involvement: ICC =.89. $p < .001$).

The EAS consist of six dimensions measuring the quality of the interaction between parents and children. Four dimensions address the parent's side, two dimensions address the child's side of emotional availability. Due to the dyadic nature of the EAS, parental behavior cannot be rated independently of the child and vice versa. Each dimension is assigned a direct score ranging from 1 to 7, with higher values indicating more optimal behavior. Maternal sensitivity focuses on maternal affect and the mother's awareness of signals and emotional responsiveness towards the child. A highly sensitive mother interacts in genuine, warm, and sensitive ways and enjoys the interaction with her child. Structuring describes the mother's ability to structure the interaction and to guide and support the child without being too controlling. A highly structuring mother is active in the interaction, makes an effort to guide the child and provides adequate scaffolding. The dimension of non-intrusiveness focuses on the adults' intrusive behavior. A highly non-intrusive mother is neither physically nor psychologically intrusive and lets the child lead the interaction, while being able to follow the child's lead. Non-hostility describes the lack of negativity in the interaction. A non-hostile mother shows no covert or overt hostility or negativity and is emotionally well-regulated. On the child's side, child responsiveness focuses on the child's affect and the willingness to respond to the mother's suggestions. A highly responsive child shows genuine and positive affect, enjoys the interaction and shows age-appropriate emotion-regulation. As the last dimension child involvement describes how much a child is able to positively involve the mother in the interaction. At a young age, involvement on the child's side can be rather subtle. Infants scoring high on this dimension typically involve their parents through looking or smiling or engaging with the parent verbally or via touch.

2.2.3. Infant temperament

Infant temperament was assessed using German translations of both the revised version of the Infant Behavior Questionnaire (IBQ-R; Gartstein & Rothbart, 2003; German translation by Kristen and Eisenbeis, 2007) at 6 months and the Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006; German translation by Nikolaizig, 2007) at 18 months of age. The structure of both questionnaires is similar: caregivers are asked to rate how frequently specific kinds of child behavior are occurring within the last two weeks. Each item is embedded in a situational context, such as during feeding or when meeting a stranger (e.g. "During feeding, how often did the baby squirm or kick?") and is affiliated with one particular scale. Responses are graded on a Likert scale ranging from 1 ("never") to 7 ("always"). Caregivers are given the option to rate an item as "does not apply" as well.

The IBQ-R consists of a total of 191 items belonging to 14 different scales, while 201 items and 18 scales make up the ECBQ. Scales are formed by calculating the mean of every affiliated item, excluding items that were rated as "does not apply" or not rated at all. If more than half of the items belonging to a scale were rated as missing this way, the entire scale was treated as missing. Based on the findings of LaBounty et al. (2018), four scales from the IBQ-R and the shyness scale from the ECBQ were selected for analysis. The IBQ-R's Duration of Orienting scale was additionally selected due to its conceptual similarities to performance on habituation tasks. Internal consistency of these scales was generally good, with Cronbach's Alpha values of.91 for Fearfulness,.82 for Duration of Orienting,.79 for High-Intensity Pleasure,.84 for Low-Intensity Pleasure,.86 for Cuddliness and.83 for Shyness.

2.3. Data analysis

We calculated several regression models with social attention as the criterion to test our main hypotheses. Our first model included maternal sensitivity, structuring and non-intrusiveness as predictors. Our second model included the temperament scales of Fearfulness, Duration of Orienting, High-Intensity Pleasure, Low-Intensity Pleasure and Cuddliness as predictors. A third model included

child involvement and responsiveness. We also planned a fourth model for testing the incremental validity of maternal EAS dimensions over those temperament scales with a significant main effect on social attention. The pearson correlation coefficient between infant social attention and shyness at 18-months was used as indicator for the relationship between those two variables. All relevant study variables were added into correlation matrices to explore our dataset further.

2.4. Open science statement

We preregistered our research goals, hypotheses, and analytic strategies for this study. Exploratory non-preregistered analyses are stated as such. Preregistration documents are available on the Open Science Framework (https://osf.io/9qtbw/?view_only=9a8575d418e54598b8f204fa10aa579e). Data, script, and materials are available via request.

3. Results

3.1. Descriptive data

For the sample of 64 infants in the main analyses, a *t*-test revealed a significant decrease in looking time of the Back-of-Hand task ($t(118.79) = 6.02$, $p < .001$) from the sum of the first two trials ($M = 38.22$ s, $SD = 12.13$) to the sum of the fifth and sixth trial ($M = 26.66$ s, $SD = 9.43$). Decrement of attention was 11.56 s ($SD = 11.35$) on average with a range from –18.40–40.88 s. Boys and girls did not differ in the decrement of attention ($t(41.38) = 0.68$, $p = .499$) nor did they on any of the EAS dimensions or relevant temperament scales. Table 1 lists the descriptive statistics for the EAS dimensions and relevant temperament scales.

3.2. Mother-child interaction and social attention

Contrary to our expectations, the maternal scales sensitivity, structuring and non-intrusiveness at six months of age did not predict infant decrement of attention at 12 months; neither did maternal non-hostility nor child responsiveness (all $p > .465$). A linear regression revealed that child involvement significantly predicted decrement of attention ($\beta = 3.38$, $SE = 1.12$, $t(62) = 3.02$, $p = .004$).

3.3. Temperament and social attention

For temperament, fearfulness at 6 months significantly predicted decrement of attention at 12 months as expected ($\beta = -4.22$, $SE = 1.98$, $t(56) = -2.13$, $p = .038$). No other temperament scale was correlated with decrement of attention (see Appendix), including infant shy temperament at 18 months of age ($r = .08$, $p = .451$).

3.4. Mother-child interaction, temperament and social attention

Because none of the expected mother-child interaction scales predicted decrement of attention, we elected to not test their predictive value alongside fearfulness within a single model. Instead, we exploratively put child involvement, the only EAS dimension found to predict decrement of attention, and fearfulness at 6 months in a multiple regression model. This model was significant ($F(2, 58) = 6.50$, $p = .003$) and explained 18.3% variance in decrement of attention. Child involvement stayed significant ($\beta = 3.33$, $SE = 1.12$, $t(58) = 2.98$, $p = .004$), while the effect of fearfulness did not ($\beta = -3.07$, $SE = 1.84$, $t(58) = -1.67$, $p = .101$). As our main analyses included a total of 64 participants as opposed to our required 68 participants, our study can be considered slightly underpowered with a power of $\beta = .78$.

Table 1
Means, Standard Deviations, and Range for EAS Dimensions and Temperament Scales at 6 Months.

	M	SD	Range
Sensitivity	5.07	1.19	2.00–7.00
Structuring	5.17	1.15	2.00–7.00
Non-Intrusiveness	4.71	1.50	2.00–7.00
Non-Hostility	5.97	1.15	2.00–7.00
Responsiveness	5.03	1.21	2.00–7.00
Involvement	4.23	1.32	2.00–7.00
Fearfulness	2.14	0.75	1.00–3.92
Low Intensity Pleasure	5.16	0.88	3.08–6.83
High Intensity Pleasure	5.59	0.75	3.56–7.00
Cuddliness	5.96	0.64	3.76–7.00
Duration of Orienting	3.45	1.01	1.38–6.00
Shyness	3.19	0.98	1.36–6.00

Table 3
Interaction Between Child Involvement and Fearfulness.

$N = 61$	*B*	*SE*	*t*	*p*
Fearfulness	-2.18	1.83	-1.20	.239
Involvement	3.00	1.09	2.75	.008**
Fearfulness*Involvement	3.28	1.53	2.14	.036*

Note. $^{*}p < .05$, $^{**}p < .01$.

3.5. Exploratory analyses

We carried out further exploratory post-hoc analyses to investigate this finding. Since the predictors appeared to be unrelated to each other ($r = -.11$, $p = .263$), an additional model was tested to determine whether their interaction contributes to the prediction of the criterion beyond the main effects. The model including both predictors as well as their interaction term was significant ($F(3, 57) = 6.13$, $p = .001$) and explained 24.4% variance in infant decrement of attention. As can be seen in Table 3, the main effect of involvement as well as the interaction term were significant, indicating a moderating effect of child involvement (see Fig. 2).

Based on the conjecture that high-involving children might only benefit from their initiative if mothers are able to respond to their efforts in kind, we split our sample into two subsamples, based on mothers' sensitivity scores and calculated the same model again. The interactive effect was present only when the infants' mothers were classified as sensitive and emotionally available (Direct Score Maternal-Sensitivity ≥ 5.5). For mothers classified as non-sensitive, only the main effect of involvement remained significant (see Table 4).

4. Discussion

4.1. Summary

The aim of the present study was to explore the role of mother-child interaction and infant temperament at 6 months for social attention at 12 months. Our results showed significant associations of fearfulness and infant involvement with infants' decrement of attention when observing goal-directed actions involving a human actor, but no main effects from other EAS dimensions or temperament scales. Additionally, exploratory analyses revealed further intricate relationships between these constructs: fearful infants appear to process these goal-directed actions more slowly unless they are able to involve their sensitive mothers.

4.2. Maternal sensitivity, structuring and non-intrusiveness

First, we analyzed the influence of maternal sensitivity, maternal structuring and maternal non-intrusiveness on the decrement of attention as an indicator of social attention, based on previous findings in the literature (e.g. Hofer et al., 2008; Licata et al., 2014). Contrary to our expectations, maternal EAS did not predict infant social attention. One possible explanation for this is the role age might play in the link between emotional availability and social attention. In comparison with the samples studied by Hofer et al. (2008) and Licata et al. (2014), infants in our study were older when social attention was measured. Social attention and understanding develop within the first year of life, while infants in our study were about 12 months old and should therefore be able to already understand the BoH task. While some form of rudimentary understanding of social events is a necessity for our task to work, it could also have led to lower variance between individuals and their social processing abilities. The results obtained by Hohenberger et al. (2012) may also shed further light on this idea: infants of moderately controlling mothers showed a better performance of social understanding at 6 months of age, but not at 10 months of age in the same sample. They state that social understanding develops during sensitive phases early in life and emphasize the importance of maternal interaction styles in fostering its growth. Early social attention might go through similar sensitive phases of increased susceptibility to the influence of the mother. It is thus conceivable that administering the BoH task at an earlier age would have revealed the expected relationship between the EAS and social attention that an assessment at 12 months failed to show.

4.3. Infant involvement

Our results indicate that infant involvement predicts social attention: Infants who involve their mothers more at 6 months of age show faster social processing at 12 months. Even at an early age, infants show remarkable variability in their involvement of the mother. Some have already learned how to invite their mother into an interaction through smiling, looking towards the mother, touching her or involving the mother verbally. This involvement could be a benefit as it encourages the mother and maybe even other people to engage more with the child and through this engagement, teach the very basics of social interaction. Therefore, these infants may have an advantage regarding the processing of social stimuli.

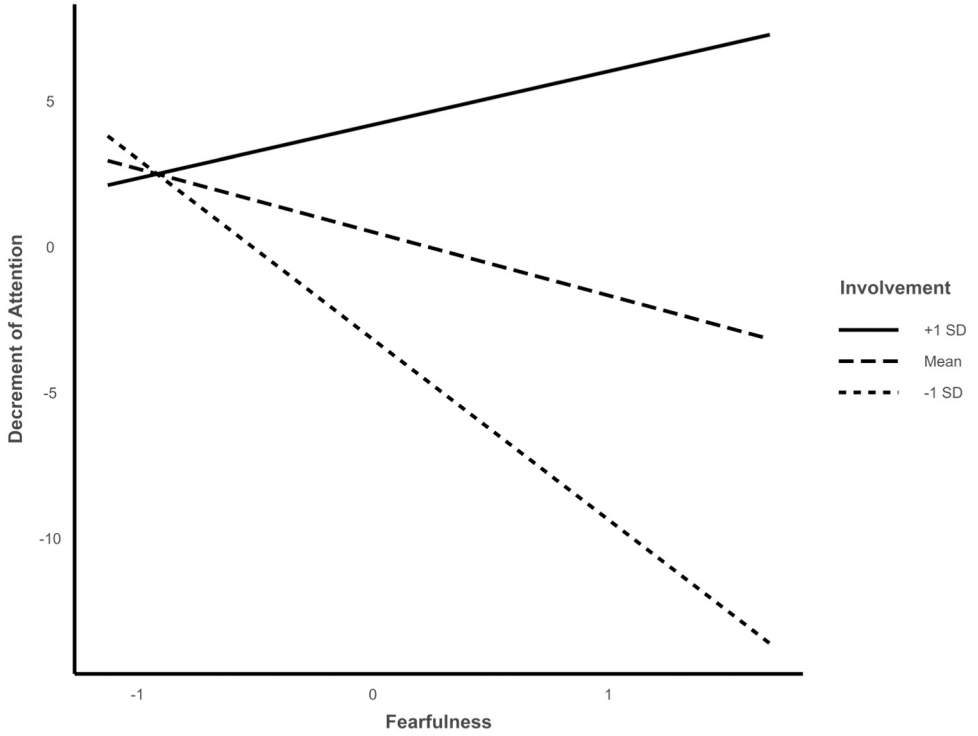

Fig. 2. *Interaction Effect of Involvement and Fearfulness on Decrement of Attention. Note.* Variables were mean-centered before analysis.

Table 4
Interaction Between Involvement and Fearfulness for Sensitive and Non-Sensitive Mothers.

Sensitive mothers				
N = 28	*B*	*SE*	*t*	*p*
Fearfulness	-3.60	2.90	-1.24	.226
Involvement	2.84	1.40	2.05	.052
Fearfulness*Involvement	5.27	2.03	2.60	.016*
Model	$F(3, 24) = 4.99$	$p = .008$**	$R^2 = .38$	
Non-sensitive mothers				
N = 33	*B*	*SE*	*t*	*p*
Fearfulness	-0.40	2.32	-0.17	.863
Involvement	6.07	2.02	3.01	.005**
Fearfulness*Involvement	3.27	2.50	1.31	.202
Model	$F(3, 29) = 4.25$	$p = .013$*	$R^2 = .31$	

Note. *$p < .05$, **$p < .01$.

4.4. Infant temperament

Second, we analyzed the relation of infant temperament and social attention, focusing on the scales of fearfulness, high intensity pleasure, low intensity pleasure, perceptual sensitivity, and cuddliness. Only fearfulness predicted infant social attention: more fearful infants at 6 months show poorer performance in social processing at 12 months of age. This is unsurprising as fearful infants are often described as clinging to an action or person they know while showing fear and discomfort when changes occur. Furthermore, our findings are in line with the attention control theory of Eysenck et al. (2007), which assumes that anxiety affects efficient processing of the goal-directed attentional system in a negative way, especially as personal resources are needed to regulate one's own emotions. Fear hinders effective processing, which may result in longer and more stable looking times. Fearful infants might thus observe the social situation longer, which could have a negative impact on their processing speed.

Then, we focused on the relationship between shy temperament and social attention. Contrary to the findings by LaBounty et al. (2018), social attention at 12 months was not related to shy temperament at 18 months in our sample. This null finding may be related to the ways the ECBQ and CBQ each measure shyness: the ECBQ asks about specific behavior shown in specific situations (e.g. "When approaching unfamiliar children playing, how often did your child watch rather than join in?"), while the CBQ asks more generally

about shyness on a more abstract level (e.g. "My child acts shy around new people."). It is possible that the CBQ items used by LaBounty et al. (2018) – adapted for a younger age group – do not measure the same construct as the ECBQ items. Shyness has a distinct social component that may not have emerged yet in the first year of life or may be indistinguishable from fearfulness at that age range.

4.5. Exploratory analyses

In our exploratory, non-preregistered analyses we examined potential interactions between fearfulness and involvement, based on the possibility that fearful infants who are already able to involve their parents might be able to seek out others for the help they need in regulating their emotions in anxiety-inducing situations. These infants may thus be able to compensate for the disadvantages in social processing that come with increased fearfulness. A high degree of involving the parent could therefore be seen as a protective factor in infancy. Indeed, fearful infants with a *higher* involvement did not differ from less fearful infants in their social attention, while fearful children with *lower* involvement showed slower processing of the social stimuli.

It is important to note that the involvement scale of the EAS does not account for reciprocity by the parent, meaning it would be entirely possible for an infant to show high involvement without actually having their efforts result in a successful interaction with their mother. Would the infant's capacity to involve still be beneficial in such a case? We theorized that, if infants at this young age are already able to look for help by involving their mothers, mothers must be able to recognize and answer their needs for them to benefit from their initiative. To investigate this further, we divided the sample into sensitive mothers vs non-sensitive mothers. After doing so, the moderation effect disappeared completely for the group of non-sensitive mothers, implying that involving infants benefit only from their efforts if their mothers are sensitive enough to adequately respond to their attempts. Both models explained a large amount of variance. These results show that maternal sensitivity, while seemingly not affecting social attention directly, could still be an important condition for allowing infants to benefit the most from their own initiative.

Our findings underscore that individual differences in infant social attention emerge from the interplay of individual dispositions and relational contexts rather than being determined by either factor alone. In other words, infant behavior such as involvement does not exist in isolation, but gains significance through the dynamic interaction with temperament and caregiver behaviors. These interrelated effects are consistent with an interactional perspective, which emphasizes context-dependent pathways of development.

4.6. Limitations

Although our results provide interesting insights into the possible influence of infant temperament and quality of mother-child interaction on infant social processing, there are some limitations that have to be considered when interpreting the results. The sample was generally highly educated, with most participating mothers having obtained an academic degree. It should therefore not be considered representative of the German population. Due to necessary exclusions (see Fig. 1), a post-hoc power analysis revealed our study to be slightly underpowered. The exploratory findings on involvement and fearfulness also require further preregistered studies to ensure their validity.

Furthermore, our data cannot show with complete certainty that these effects are specific to social attention in particular. They might also reflect more general results of learning or information processing as infant habituation is often thought to represent some of the earliest forms of learning in life (Colombo & Mitchell, 2009). However, there are other studies linking the BoH task specifically to social events, while tasks involving non-human actors produce different results (see Hofer et al., 2005; Jovanovic et al., 2007). This difference implies the presence of some social element to human goal-directed actions that the BoH task is tapping into.

4.7. Implications for research and practice

There are several other potentially fruitful avenues for future research. For one, our setup could be replicated employing objects without agency to test whether temperament and maternal interaction quality play a role in individual differences in object-centered attention as opposed to social attention. This could help answer the question whether the effects found in this study reflect social attention specifically or more general learning processes. Additionally, measuring social attention at an earlier age, as was done by Hohenberger et al. (2012), could help identify potential sensitive phases in the development of social processing, during which infants are particularly susceptible to the influence of their caregiver's interactive behavior.

The complex interplay of an individual's own traits, experiences and environment yields unique sources of risk and resilience which may have long-term impacts on development. Our results further emphasize that caregivers and practitioners in childcare should not merely pay attention to individual traits of a child but also their social environment. The consequences of certain potential risk factors such as a more fearful temperament can be dampened or perhaps even negated by competencies on both the child's and the mother's side. In our study, this is made apparent by the way the negative effects of fearfulness on social attention were compensated by the child's ability to involve their mother - if that mother was also sensitive in their interaction. This also demonstrates the significance of early intervention, which can both inform caregivers of the possible variations in infant temperament and train them in sensitively responding to their infants' attempts at involvement.

5. Conclusion

All in all, our results show that the relationship between temperament, maternal interaction quality and social attention is multi-faceted and complex. The infant's early temperament and capacity to involve their mother seem to predict social cognitive processing.

While maternal sensitivity at 6 months does not seem to directly affect infant social attention at 12 months, it still seems to provide infants with the kind of supportive environment they need to successfully process relevant information in potentially frightening situations. However, the precise mechanisms that lead to these striking individual differences still remain unclear. Further research is required to disentangle the exact nature of the connections between these different constructs.

Ethics statement

This research was conducted in accordance to the APA ethical standards. The present study was part of a research project entitled "*Einfluss der mütterlichen Sensitivität in der frühen Kindheit auf den Grundschulerfolg"* which was approved by the ethic committee of the faculty for human and business sciences of Saarland University (protocol number: 19–22), Germany.

CRediT authorship contribution statement

Kohl Nena Viktoria: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Schmidt Jonathan Arthur:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Anne Henning:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition. **Gisa Aschersleben:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

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Appendix A

Table A.1
Correlations Between Decrement of Attention and 6 Months Temperament Scales

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Decrement of Attention	1														
2. Activity Level	-.05	1													
3. Distress to Limitations	-.02	.30***	1												
4. Smiling and Laughter	-.05	.03	-.24**	1											
5. Soothability	.13	-.11	-.34***	.21*	1										
6. Falling Reactivity	.12	-.15	-.41***	.15	.35***	1									
7. Perceptual Sensitivity	-.14	.19	.14	.27**	.05	.04	1								
8. Sadness	-.08	.24**	.51***	-.18	-.28**	-.40***	.16	1							
9. Approach	-.03	.10	.13	.33***	.02	.07	.59***	.06	1						
10. Vocal Reactivity	-.07	.32***	.01	.52***	.00	.13	.36***	-.03	.39***	1					
11. Fear	-.21*	.14	.24	-.08	-.09	-.12	.05	.35***	-.05	-.01	1				
12. Duration of Orienting	-.12	.03	-.27**	.27**	.17	.02	.31**	-.03	.17	.25*	-.04	1			
13. High Intensity Pleasure	-.11	.04	-.01	.45***	.15	.22*	.40***	-.13	.53***	.38***	-.06	.34***	1		
14. Low Intensity Pleasure	-.05	-.08	-.30**	.42***	.37***	.28**	.37***	-.28**	.38***	.30**	-.11	.36***	.44***	1	
15. Cuddliness	-.10	-.26**	-.25**	.38***	.25*	.28**	.13	-.22*	.03	.08	-.07	.31**	.27**	.46***	1

Note. *** $p < .001$, ** $p < .01$, * $p < .05$.

Table A.2
Correlations Between Decrement of Attention and 18 Months Temperament Scales

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Decrement of Attention	1																	
2. Activity Level	-.06	1																
3. Attentional Focusing	.01	-.22**	1															
4. Attentional Shifting	.07	-.03	.44***	1														
5. Cuddliness	.09	-.15	.20*	.35***	1													
6. Discomfort	-.13	-.03	.02	-.01	.13	1												
7. Fear	-.05	-.04	-.02	-.14	.09	.50***	1											

(*continued on next page*)

Table A.2 (*continued*)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
8. Frustration	.01	.40***	-.22*	-.25**	-.32***	.11	.25**	1										
9. High Intensity Pleasure	-.08	.41***	-.19*	-.03	.04	.19	-.00	.10	1									
10. Impulsivity	-.09	.33***	-.10	.08	-.03	-,01	-.03	.15	.34***	1								
11. Inhibitory Control	.06	-.15	.32*	.30*	.13	-.03	-.25	-.45***	.00	-.30	1							
12. Low Intensity Pleasure	-.03	-.20*	.43***	.44***	.44***	.24	.08	-.41***	.16	.10	.21	1						
13. Motor Activity	.10	.25**	-.19*	-.18	-.13	.43***	.24**	.15	.31***	-.03	-.04	-.03	1					
14. Perceptual Sensitivity	-.05	.08	.14	.38***	.15	.45***	.14	-.10	.26**	.21*	.15	.38***	.24**	1				
15. Positive Anticipation	-.15	.25**	-.17	-.01	-.10	.19	.11	.08	.33***	.36***	-.23	.14	.24**	.26**	1			
16. Sadness	.09	.10	-.10	-.22**	-.13	.19	.44***	.48***	-.06	.03	-.29*	-.14	.19*	-.12	.04	1		
17. Shyness	.08	-.06	-.06	-.31***	-.05	.11	.52***	.19*	-.08	-.07	-.05	-.03	.10	.02	-.01	.28**	1	
18. Sociability	.12	.17	.10	-23*	.17	.01	-.05	-.10	.24**	.25**	-.21	.24**	.04	.14	.32***	-.15	-.30***	1
19.Falling Reactivity	.00	-.23**	.25**	.36***	.27**	-.10	-.27**	-.42***	.07	.04	.29*	.30***	-.30***	.11	-.08	-.43***	-.21*	.24**

Note. *** $p < .001$, ** $p < .01$, * $p < .05$.

Appendix A.3

Correlations between Temperament Scales at 6 and 18 Months

6 Months	Activity Level	Distress to Limitations	Smiling and Laughter	Soothability	Falling Reactivity	Perceptual Sensitivity	Sadness	Approach	Vocal Reactivity	Fear	Duration of Orienting	High Intensity Pleasure	Low Intensity Pleasure	Cuddliness
18 Months														
Activity Level	.32***	.36***	-.01	-.10	-.07	.14	.18	.21*	.20*	-.03	-.07	.21*	-.07	-.12
Attentional Focusing	-.03	-.27**	.18	.28**	.07	.07	-.20*	.04	.08	.02	.29**	.21*	.29**	.28**
Attentional Shifting	-.03	-.18	.25*	.29**	.25*	.45***	-.34***	.28**	.15	-.19	.31**	.37***	.42***	.27**
Cuddliness	-.14	-.15	.38***	.29**	.21*	.13	-.27*	.19	.15	-.19	.18	.28**	.50***	.28**
Discomfort	.09	.03	.02	-.11	.07	-.01	-.03	-.03	.09	.13*	-.02	.08	.01	-.18
Fear	.03	.04	.12	-.21*	-.04	-.09	.16	-.09	.04	.29**	.21*	.01	-.02	-.04
Anger	.34***	.30**	-.25**	-.29**	-.26**	-.04	.34***	-.08	-.02	.08	-.10	-.11	-.28**	-.16
High Intensity Pleasure	.13	.12	.12	-.05	.18	.25*	.16	.24*	.21*	.03	-.02	.33***	.03	.10
Impulsivity	.14	.31**	.05	-.07	.13	.30**	.15	.30**	.28**	.08	-.06	.23*	.08	.01
Inhibitory Control	.00	-.29**	.22**	.42***	.17	.21	-.25	.21	.07	-.06	.09	.30**	.22**	.33*
Low Intensity Pleasure	-.20*	-.28**	.42***	.37***	.23*	.29**	-.24*	.29**	.24*	.02	.30**	.38***	.58***	.32**
Motor Activity	.18	-.04	.13	-.02	-.00	.03	.09	-.01	.21*	.07	.07	-.03	.00	-.11
Perceptual Sensitivity	.04	-.10	.14	.20*	.15	.36***	-.16	.20**	.15	.04	.20*	.29**	.39***	.18
Positive Anticipation	.14	.19*	-.03	-.25*	-.09	.27*	.18	.19	.27*	.10	-.00	.12	-.00	-.25*
Sadness	.18	.19*	-.09	-.29	-.07	-.13	.28**	-.12	-.04	.15	.04	-.12	-.13	-.17
Shyness	.09	-.01	.01	.04	-.03	-.16	.06	-.12	-.07	.32**	.09	-.06	-.13	.02
Sociability	.05	.13	.18	-.21*	-.00	.36**	.04	.19	.26*	-.04	.06	.25*	.28**	-.01
Falling Reactivity	-.20*	-.26**	.19*	.32***	.23*	.25*	-.20*	.14	-.01	-.16	.28**	.28**	.32***	.30**

Note. *** $p < .001$, ** $p < .01$, * $p < .05$.

Data availability

Data may be made available from the corresponding author upon request.

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