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# Similar Social Attention, Physiological Arousal, and Familiarity Effect in Autistic and Neurotypical Children: A Real-Life Recreational Eye-Tracking Paradigm

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Social attention is reported to be crucial for the development of social skills, and, according to the social cognitive developmental theory, is fostered by social interactions. Autism is of central importance to the study of social attention, as autism is characterized by atypical social interactions and low social attention, both linked according to the social motivation theory to diminished social interest. Much evidence for positing low social interest in autism comes from eye-tracking studies, which, however, lack ecological validity. Our study documents social attention and physiological arousal, within close to real-life settings, in autistic children, as well as in their neurotypical peers, matched on gender and mental or chronological age. To explore the potential influence of partner familiarity or of the conversational topic, children gaze and electrodermal activity were recorded while they engaged in watercolor activities with, first a familiar and, next, an unfamiliar adult experimenter, who both introduced various topics. Autistic and neurotypical children exhibited comparable attention to their partners' eyes. Notably, across all groups, heightened visual attention was directed to familiar rather than unfamiliar partners. Moreover, parallel arousal patterns emerged, with all children displaying increased skin conductance responses during more engaging topics and when looking at their interactional partner's eyes. These findings underscore the task- and context-dependent nature of social attention and highlight the role of familiarity in an ecologically valid context. The absence of group differences challenges the universality of the social cognitive developmental theory and questions the scope of the social motivation theory of autism.



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Elise Clin served as lead for conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, validation, visualization, writing–original draft, and writing–review and editing. Eleanor Miller served in a supporting role for formal analysis and visualization. Mikhail Kissine served as lead for supervision and served in a supporting role for conceptualization, formal analysis, resources, writing–original draft, and writing–review and editing. Elise Clin and Mikhail Kissine contributed equally to funding acquisition.

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***Public Significance Statement***

This study found that autistic and neurotypical children (with cognitive and linguistic abilities within typical ranges) display comparable eye-gaze behaviors and physiological arousal during a real-life recreational task with an adult. Autistics and neurotypicals were also sensitive in a comparable way to familiarization and familiarity. These findings add nuance to widespread characterizations of autism in terms of insensitivity to social interactions and partners. Our methods also highlight how more naturalistic research may help us better understand the task- and context-dependent nature of social functioning in typical and atypical development. Our results ultimately call into question the universality of the social cognitive developmental theory and the applicability of the social motivation theory.

*Keywords:* autistic and neurotypical children, wearable eye-tracking and real-life social attention, electrodermal activity, social anxiety and alexithymia, conversational topics

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## Terminological Note

Following the preferences expressed by the French-speaking autism community (Geelhand et al., 2023), we will use identity-first language and refer to people diagnosed with autism as autistics and autistic people. Congruently, people without developmental diagnosis (e.g., autism, bipolarity, Down syndrome, etc.) would be referred to as neurotypicals and neurotypical people.

## Social Attention

Orienting and being sensitive to another person's face and eyes, along with experiencing eye contact, are among the earliest social behaviors in infancy (e.g., Farroni et al., 2002). Despite their early emergence, the exact underpinnings of the development of such behaviors in neurotypical children are still the subject of ongoing inquiry, with various theories highlighting different aspects of development and underlying mechanisms contributing to social orienting. One influential perspective is the social cognitive developmental theory, which underscores the pivotal role of social interactions in shaping cognitive development. According to this theory, a child's ability to orient to social stimuli is not solely a product of individual cognitive processes but is intricately linked to the social experiences and interactions that contribute to this child's understanding of the social world (e.g., Vygotsky, 1978). Furthermore, from an evolutionary psychology perspective (e.g., Tomasello, 2010), social orienting is a product of evolutionary pressures, which contributed to render cognitive and attentional processes responsive to socially relevant cues. In line with this evolutionary view, the social motivation theory posits that children are intrinsically motivated to engage in social orienting behaviors due to a biological predisposition that renders such interactions rewarding (Chevallier et al., 2012).

These socioevolutionary models predict that (neurotypical) children should pay more attention to other people than to objects, thanks to both a biological predisposition and environmental stimulation through social interactions. This increased attention to social stimuli is taken to be part and parcel of the typical developmental trajectory, contributing to the formation of meaningful social connections in childhood (e.g., Elsabbagh et al., 2015) and facilitating the acquisition of crucial social skills, such as face and emotion processing (e.g., Black et al., 2017; Grelotti et al., 2005; Quinn et al., 2019), language development (e.g., Bastianello et al., 2022; Cox et al., 2022; Çetinçelik et al., 2021), imitation (e.g., Brubacher et al., 2013; Wang & Hamilton, 2014), perspective-taking (e.g., Furlanetto et al., 2013; Kuhn et al., 2018), or turn-taking in conversation (e.g., Kendon, 1967).

The eye-tracking literature has consistently reported that, from early infancy, neurotypical children demonstrate a remarkable proclivity for attending to social stimuli, particularly faces and eyes (e.g., Simion et al., 2011). Infants as young as a few months exhibit preferential gaze patterns toward faces, showcasing an inherent bias toward socially relevant information (e.g., Reid & Striano, 2007). As development progresses, eye-tracking studies in neurotypical children have unveiled the nuanced dynamics of social orienting, delineating the subtle shifts in gaze patterns during different social interactions and contexts (Gharib & Thompson, 2022; Jurkat et al., 2023; Kim et al., 2023; Meaux et al., 2014). Not only do these findings confirm the early emergence of social orienting, they also highlight its adaptive nature in navigating the complex social world.

## Autism

In the realm of neurotypical research, autism is frequently regarded as a paradigmatic departure from neurotypical development (e.g., Tomasello, 2010). Atypicalities in social interaction and communication are inherent in and central to the diagnostic criteria for autism (American Psychiatric Association, 2013). From the perspective of the social cognitive developmental theory such atypicalities in social interaction should be expected to yield an overall reduction in social attention. This prediction has consistently been vindicated in eye-tracking studies. For instance, atypically low orientation toward others and reduced attention to the eye region are robustly documented early-onset characteristics of autism (W. Jones & Klin, 2013; Zwaigenbaum et al., 2015). Numerous experimental studies, spanning the lifespan of individuals with autism, consistently report atypical—often diminished—attention to social stimuli (for reviews, see Papagiannopoulou et al., 2014; Setien-Ramos et al., 2023). This pattern of social attention is so distinctive in autistic children that it serves as a key feature in widely used clinical assessments, such as the autistim diagnostic observation schedule (ADOS—Lord et al., 2012) or the autism diagnostic interview-revised (ADI-R—Rutter et al., 2003), and is singled out as a potential biomarker of autism (e.g., Murias et al., 2018; Shic et al., 2022). Such reduced social attention in autism has further fueled the assumption that autistics exhibit a diminished motivation to engage with others, aligning with the tenets of the social motivation theory (e.g., Chevallier et al., 2012; Over, 2016).

## Lab Versus Live Paradigms

Research on social attention is generally conducted in highly controlled lab settings, which raises the issue of generalization to real life. Indeed, there is eye-tracking evidence that neurotypicals and autistics process social stimuli in a different way when engaging in live paradigms, as opposed to computer-mediated experiments. For example, Risko et al. (2016) emphasize that gaze both collects and communicates information. In front of a screen, people are free to watch images of people without worrying about conveying any information to them, so that lab tasks might fail to capture this "dual function" of gaze. This could be why most studies in neurotypical populations report less fixations on people who are (supposed) present, in comparison with computerized stimuli or effective social absence (for a review, see Freeth & Morgan, 2023). Interestingly, Grossman et al. (2019) found significant group differences between autistic and neurotypicals in attention to faces during the screen-based experiment, but not in a live interaction task (i.e., an active conversation), where both groups dwelled a similar amount of time on the face of their interlocutor. Therefore, screen-mediated experiments do not necessarily generalize to attentional behaviors in genuine social contexts, as real and implied presence of another person substantially alter patterns of gaze in social contexts, inter alia because of underlying social norms, mentalizing processes, or expectations in terms of reputation or encounters to come (Freeth & Morgan, 2023). Investigating neurotypical and autistic children's social attention in live settings should therefore shed a new light on the processes at play during real-life encounters.

Unfortunately, naturalistic eye-tracking studies in neurotypical and autistic children are still rare and usually do not control for many variables of the social context. And yet, previous studies highlighted how important the experimental setting is. For instance, McParland et al. (2021) found that, when discussing with adult partners in a classroom, neurotypical children tend to be more socially attentive during dyadic exchanges (an adult and the child) in comparison with triadic exchanges (two adults in addition to the child), a pattern opposite to that displayed by autistics. Similarly, Macari et al. (2021) found that infants and toddlers later diagnosed as autistic displayed, as compared with nonautistics, a reduced social attention during dyadic bids. However, their results also underline that the activities themselves are important. Indeed, autistics and nonautistics seem to display a similar social looking time during toy play (Macari et al., 2021; Perkovich et al., 2022; Yurkovic et al., 2021; Yurkovic-Harding et al., 2022), singing a popular nursery rhyme, "peek-a-boo" anticipatory games (Macari et al., 2021), and conversations (R. M. Jones et al., 2017). However, several live studies also found that autistic children, in comparison with nonautistics, tend to look less at the experimenter's face during cognitive, social communication and story-telling tasks (Falck-Ytter, 2015; Hanley et al., 2014; Noris et al., 2012). In addition to experimental settings and activities, topics involved in the conversation influence the social attention. In Nadig et al. (2010), autistic and nonautistic children payed more visual attention to an adult interlocutor when discussing their specific interests than when discussing generic topics (i.e., siblings, pets, or friends). Discussing about feelings, versus activities, also seems to reduce visual attention to eyes in autistic children (Hutchins & Brien, 2016).

Finally, naturalistic settings could greatly benefit from integrating another variable: familiarity to the interactional partner. Most studies invite children to discuss with strangers. However, in real life, children are most often interacting with adults they already know and characterizing behaviors during encounters with unknown people would not be representative of their genuine interactional profiles. In addition to improving ecological validity and representativity of the experiment, controlling for familiarity also allows to determine the extent to which previous findings could owe to a lack of previous acquaintance with an experimenter. Other studies record real-life interactions with caregivers. Yet, having a familiar partner outside the family circle of the child has a crucial role, allowing a tighter controlled experiment (as a parent may be more likely to unintentionally depart from the script), and, more importantly, ensuring that potential effects of familiarity are not associated with parenting (which is presumably linked to different motivational and interactional mechanisms; e.g., Chevallier et al., 2012). Familiarity to the interactional partner has been mostly studied in experiments showing pictures through a screen; these studies found the same familiarity role on social attention between autistic and neurotypical children (Gillespie-Smith et al., 2014; Nuske et al., 2014). Using a live paradigm with no actual eye-tracking, Dowd et al. (2018) reported no difference in attending to distressed adult partners between autistics and neurotypicals. However, studies using other methods, such as event-related potential components, do suggest that autistics process familiar versus unfamiliar faces in a specific way (e.g., Dawson et al., 2002).

All these studies suggest that neurotypical and autistic children's gaze behaviors in naturalistic paradigms could surprise us, notably by being not that different from each other, and by shedding light on processes inherent in real-life interactions.

## Another Look at Social Interactions

The previous sections raise the question of whether social attention and thus eye-tracking studies are fully informative regarding social interactions in children. The challenges inherent in translating findings from controlled lab environments to real-world scenarios underscore the limitations of relying solely on traditional experimental paradigms. To advance our understanding of social interactions, in autism and in general, one should strive for greater ecological validity, considering the influence of context, familiarity, and diverse social activities on the complexities of social attention.

The similarities that have been found between autistics and neurotypicals in live settings also raise several questions. First, this absence of group differences suggests that reduced social interactions or skills, such as evidenced by autism clinical assessments, do not perfectly predict social attention behaviors. Second, it also implies that social attention is not a perfect construct to describe or distinguish neurotypical and autistic children. Third, it casts doubt on the assumption that autistics lack of social motivation, as they exhibit a social attention similar to neurotypicals' in these contexts (e.g., Chevallier et al., 2012; Over, 2016). In addition to live, better controlled designs, it is thus important to find measures of social interest and interactional involvement other than gaze orientation. This improvement may also benefit more introvert children, do they typically develop or not, who could be misevaluated at school, for example (for a debate on the effect of shyness on school performance, see Spere et al., 2009), or negatively experience interpersonal situations (for stuttering children, see Eggers et al., 2021).

Physiological arousal is a good candidate, where arousal refers to one's vigilance toward internal and external stimuli. Measures of the autonomic nervous system, such as the electrodermal conductance, could be informative about social interaction in children in three complementary ways. First, experienced arousal can document interest and engagement in a situation. For example, neurotypicals usually experience a positive arousal in front of direct gaze (Nuske et al., 2015). Second, experienced arousal can denote distress. For example, autistics have already been reported to experience a negative arousal in socially stressful situations (e.g., Kushki et al., 2014; Kylliäinen et al., 2012; Kylliäinen & Hietanen, 2006; O'Haire et al., 2015). Third, such hyperarousal is opposed to an absence of arousal, hypoarousal, which is considered as a signal of disinterest. However, in older individuals (i.e., adolescents; Mertens et al., 2017), hypoarousal can be interpreted as a dampened physiological response to (di)stress because of an inhibitory coping effect following chronical stress (also see Panju et al., 2015).

These oppositions are particularly interesting because of an important debate between two autism theories (for reviews, see Arora et al., 2021; Cuve et al., 2018; Lydon et al., 2016). On the one hand, the hypoarousal model suggests that autistics do not pay attention to social stimuli because such stimuli provoke (as compared to the neurotypical experience) only a weak emotional reaction. Hypoarousal would lower the rewarding value of social stimuli and thus the propensity to pay attention to them. On the other hand, the hyperarousal model suggests that autistics do not attend to social stimuli because they provoke a strong emotional reaction. Hyperarousal would render social stimuli highly uncomfortable and increase the propensity to avoid them. Currently, the eye-avoidance—hyperarousal—model seems to gather the most evidence (for a review, see Stuart et al., 2023). Coupling measures of physiological arousal and of gaze processing during naturalistic encounters should provide interesting evidence to adjudicate between hypo- and hyperarousal models of autism.

## Variables That May Influence Social Attention

To be sure, other variables need to be considered when studying social attention: social anxiety (viz., fear of negative evaluation that leads to an excessive concern about social situations) and alexithymia (viz., difficulties in identifying and describing own emotions).

Socially anxious children are reported to behave in a hypervigilance-avoidance way. They might pay more attention to what they consider as a threat (Schwab & Schienle, 2017; Seefeldt et al., 2014) and then fast orient away, notably from the eyes (e.g., Kleberg et al., 2017). Moreover, socially anxious children may interpret ambiguous or neutral attitudes as threats (for a review, see Stuijfzand et al., 2018), which could make them more likely to experience distress in casual encounters. Interestingly, one study reported lower looking times in autistic versus neurotypical participants only for those social stimuli that were threatening (e.g., Crawford et al., 2016). Overall, autistic children and adolescents exhibit high rates of social anxiety—overall mean is estimated at 17% but it can reach up to 49% (Briot et al., 2020; Burrows et al., 2018; Pearcey et al., 2021; Pickard et al., 2020; Varela et al., 2020)—which could have an influence on eye-gaze behaviors (but Jónsdóttir et al., 2023).

As social anxiety, alexithymia has been found (Bird et al., 2011; Clin et al., 2020) to influence visual exploration of faces in autistic adults (but Clin & Kissine, 2023). Such results have led to hypothesize that alexithymia is associated with impaired interoception: Alexithymic individuals—autistic or not—may experience difficulties in perceiving the internal state of their body, disrupting the processing of social cues and leading to difficulties in social cognition skills such as empathy and emotion recognition (Bird et al., 2010; Brewer et al., 2015; Shah et al., 2016). Unfortunately, alexithymia is far less studied in children, even though preliminary results suggest that alexithymia might be as much present in autistic children as in adults. In autistic adults, prevalence rates are estimated between 65% and 85%, while only 10% of the general population might be alexithymic (Bird & Cook, 2013; Brewer et al., 2015; Hobson et al., 2020). Within autism research, alexithymia has been linked to reduced social responsivity, and lower abilities in emotions recognition and regulation in children (for a review, see Vaiouli et al., 2022), which further warrants investigating potential relationships between alexithymia and eye gaze behaviors in both autistic and neurotypical children.

## Current Study

In this study, each participant was engaging in two real-life recreational sessions, each time with an adult experimenter. Children individually met the first experimenter (henceforth "familiar partner") 3 times in order to get familiar with her (henceforth "familiarization phase") before the first target session (henceforth "familiar session"). During the second target session (henceforth "unfamiliar session"), children played with an adult experimenter they have never met before (henceforth "unfamiliar partner"). Participants were wearing eye-tracking glasses and were equipped with electrodermal sensors to monitor their social attention and experienced arousal. During both familiar and unfamiliar sessions, the interactional partners introduced three general topics and a topic specific to the child, based on interests they showed during the familiarization phase. The rationale was to provide children with as many opportunities as possible to engage in interaction and express themselves.

Based on the literature reviewed above, we address two research questions. First, we ask whether there are group differences in the proportion of fixations on the experimenter's eyes and whether they are predicted by the familiarity of the partner or by the conversational topics. We expect to find a main group difference; in comparison with their neurotypical peers, autistics should look less at the eyes of their partner, notably because of the dyadic setting. We also expect a similar effect of partner familiarity on both groups: Autistics and neurotypicals should gaze more at the familiar experimenter's eyes, in comparison with the unfamiliar one. Moreover, children's social attention should be correlated to topics; they all should fixate more their partner when discussing topics of interest.

Second, we ask whether there is a relation between the experienced physiological arousal and the proportion of fixations on the partner's eyes, and whether this relationship is influenced by the participant's group, the familiarity of the partner, or the conversational topics. We expect more skin conductance responses (SCRs) in neurotypicals when looking at the experimenter's eyes, as it would denote interest. We might expect more electrodermal activity also in autistic children when looking at the eyes, because eye gaze might be uncomfortable to them. We have no directional hypothesis as to whether potential differences in electrodermal activity between neurotypical and autistic children depending on the familiarity to the interactional partner. Regarding the influence of topic on electrodermal activity when looking at the partner's eye region, only tentative predictions can be formulated. For instance, more personal topics might provoke relatively more arousal, as discussing about one's private life while looking at someone's eyes could both elicit more interest or cause some distress. However, we do not know if familiarity and topics will provoke a similar electrodermal activity in autistics and neurotypicals.

Due to the novelty of our paradigm, investigating social anxiety and alexithymia roles as well as potential correlations between variables (such as groups, familiarity, and conversational topics) is exploratory.

# Method

## Participants

The autistic group was composed of 18 children (15 boys, three girls), aged 6–9 years (chronological age: $M = 95$ months, $SD = 14$), with no intellectual delay (mental age: $M = 94$ months, $SD = 62$). The neurotypical group consisted of 36 children (30 boys, six girls), aged 6–9 years (chronological age: $M = 93$ months, $SD = 13$), with no intellectual delay (mental age: $M = 128$ months, $SD = 69$). The autistic group was groupwise matched on family economic status ($M = 6$, $SD = 2$) to the neurotypical group ($M = 6$, $SD = 1$). The neurotypical group was divided into two subgroups: chronological age (CA), 18 pairwise matched children by gender and chronological age to autistics (chronological age: $M = 100$ months; $SD = 12$; mental age: $M = 154$, $SD = 52$); mental age (MA), 18 pairwise matched children by gender and mental age to autistics (chronological age: $M = 86$ months, $SD = 11$; mental age: $M = 102$, $SD = 76$). Tables 1 and 2 display descriptive statistics of our participants by groups. Data collection took place in Belgium where data on race or ethnicity cannot legally be collected. Parents were asked about their child's gender during a phone call, allowing diversity reporting. Note that, in the article, we use "girls" and "boys" to refer to gender, understood as a social construct (World Health Organization, 2021). In the current study, no participant reported, at recruitment time (2017–2018), a difference between gender identity and sex assigned at birth. However, with gender debates having gained in audience, recruiting the very same participants today (and asking perhaps more fine-grained questions) could lead to more diversity self-reporting.

Participants were recruited in schools and specialized institutions, and thanks to flyers published on social media and associations websites. Inclusion criteria were being a native French-speaker, being verbally fluent, presenting no intellectual delay, and having normal or corrected-to-normal vision and audition. Intellectual quotients were assessed with the Leiter International Performance Scale, third edition (Roid et al., 2013).

All autistic participants received a clinical diagnosis of autism or Asperger syndrome from multidisciplinary teams (composed of medical doctors, speech therapists, psychologists, and social workers) specialized in diagnosing autism and officially licensed to do so by the Belgian State. The autism diagnosis was confirmed through the ADOS (Lord et al., 2012; $n = 9$), the ADI-R (Rutter et al., 2003; $n = 1$), or the combination of both ($n = 4$) by accredited assessors from our team, when the original diagnosis had been based on other assessment tools. To ensure that null results could not be attributed to our sample, we checked, for every autistic participant, detailed scoring on the ADOS, the ADI-R, or the Échelle de la Communication Sociale Précoce (ECSP—this scale assesses social interactions, joint attention, and behavior regulation; Guidetti & Tourrette, 2009; scores were collected for another study within our lab). All children, even when their social interaction scores were close to the threshold, were reported either to display infrequent or unusual visual contact, or not to use it in order to regulate the interaction. Several autistic participants are excluded from the sample analyzed here due to IQs lower than 75 ($n = 4$), current language delays preventing from taking part to the experiment ($n = 5$), and aggressive behaviors toward the material ($n = 5$).

To be included in the neurotypical group, participants needed to have no history of developmental delays, psychiatric diagnoses, or neurocognitive impairments, and not exceeding the ADI-R threshold for autism spectrum. Three children were not involved in the study because of ADI-R scores above the threshold. Eleven neurotypical children completed the entire experiment but were not included in the final sample because of the matching process (children of the same chronological/mental age and gender were then selected on the basis of their economic status, in order to best match their autistic pair).

**Table 1**
*Participant Characteristics for Autistic and Neurotypical Chronological Age Groups*

| | Autistic group ($n = 18$; $F = 3$) | | | CA group ($n = 18$; $F = 3$) | | | |
|---|---|---|---|---|---|---|---|
| Measures | *M* | *SD* | Range | *M* | *SD* | Range | *F* |
| Age (years) | 7.8 | 0.8 | 6–9 | 7.5 | 1.1 | 6–9 | 1.3 |
| Age (months) | 95.3 | 14.3 | 72–115 | 99.5 | 12.3 | 75–119 | 0.8 |
| Nonverbal intellectual quotient | 92.7 | 15.2 | 71–133 | 112.6 | 10.4 | 97–129 | 20.6*** |
| Mental age (months) | 94.4 | 61.6 | 40–324 | 153.5 | 52.4 | 81–252 | 9.6** |
| Economic status | 5.5 | 1.9 | 2–9 | 5.5 | 1.3 | 3–8 | 0.01 |
| Parental education | 2.7 | 0.8 | 1–4 | 4 | 1 | 2–5 | 18.2*** |
| Total anxiety | 28.5 | 12.6 | 9–63 | 20.3 | 12.5 | 5–44 | 3.7 |
| Social anxiety | 2.9 | 2.5 | 0–9 | 5.2 | 3.1 | 1–9 | 6.1* |
| Alexithymia | 42.9 | 11.6 | 20–62 | 24.7 | 7.1 | 13–38 | 31.9*** |

*Note.* *F* values come from one-way ANOVAs on the two groups with Tukey post hoc multiple comparison tests. CA = neurotypical children matched on chronological age; ANOVA = analysis of variance.
* $p < .05$. ** $p < .01$. *** $p < .001$.

**Table 2**
*Participant Characteristics for Autistic and Neurotypical Mental Age Groups*

| Measures | Autistic group ($n = 18$; $F = 3$) *M* | *SD* | Range | MA group ($n = 18$; $F = 3$) *M* | *SD* | Range | *F* |
|---|---|---|---|---|---|---|---|
| Age (years) | 7.8 | 0.8 | 6–9 | 6.7 | 0.8 | 6–8 | 4.4* |
| Age (months) | 95.3 | 14.3 | 72–115 | 86.3 | 11.4 | 72–103 | 4.3* |
| Nonverbal intellectual quotient | 92.7 | 15.2 | 71–133 | 99.1 | 13.9 | 81–147 | 1.7 |
| Mental age (months) | 94.4 | 61.6 | 40–324 | 101.5 | 75.8 | 59–396 | 0.09 |
| Economic status | 5.5 | 1.9 | 2–9 | 5.8 | 1.2 | 4–9 | 0.2 |
| Parental education | 2.7 | 0.8 | 1–4 | 3.8 | 1.5 | 0.5–5.5 | 7.3* |
| Total anxiety | 28.5 | 12.6 | 9–63 | 18.2 | 8.6 | 4–30 | 8.1** |
| Social anxiety | 2.9 | 2.5 | 0–9 | 4.1 | 2.2 | 0–9 | 2.1 |
| Alexithymia | 42.9 | 11.6 | 20–62 | 22.4 | 9.8 | 4–41 | 32.6*** |

*Note*. *F* values come from one-way ANOVAs on the two groups with Tukey post hoc multiple comparison tests. MA = neurotypical children matched on mental age; ANOVA = analysis of variance.
* $p < .05$. ** $p < .01$. *** $p < .001$.

## Power Analysis

To our knowledge, our paradigm is the first to simultaneously measure eye gaze behaviors and physiological arousal, while controlling for familiarity to the partner and conversational topics, in autistic children matched on gender, chronological and mental age with neurotypicals, during naturalistic, recreational interactions. This makes it particularly challenging to find a study to a priori estimate the required sample size. The main effect we predict is that of topic; accordingly, the closest study to our is probably Nadig et al. (2010). Nadig et al. (2010) report a main effect of topic, $F(1, 21) = 7.25$, but not of group, on time spent looking at the conversational partner with a group of 23 participants (11 autistics). A power estimation (using G*Power; Faul et al., 2007) indicates that a total sample of 40 participants should suffice to replicate ($\alpha = .05$; $\beta = .9$) an effect of the conversational topic, independently of children's group.

## Questionnaires

Our participants' parents filled in three questionnaires. (a) The Spence's Children Anxiety Scale—SCAS, parent version (Nauta et al., 2004), is composed of 38 items, related to six subscales, each tapping a specific aspect of child anxiety: social phobia, separation anxiety, obsessive-compulsive disorder, panic attack and agoraphobia, generalized anxiety, and fear of physical injury. The internal consistency for the subscales is satisfactory to excellent in nonanxious (coefficients for social phobia: Cronbach's $\alpha = .74$; corrected Spearman–Brown = .90; total scale: Cronbach's $\alpha = .89$) and anxious (coefficients for social phobia: Cronbach's $\alpha = .77$; corrected Spearman–Brown = .92; total scale: Cronbach's $\alpha = .89$) children. The scale also shows good convergent validity: It correlates both with another parent measure (child behavior checklist; Achenbach, 1991), and with the child measure of anxiety symptoms (parent–child agreement for total scale: anxious children = .51; nonanxious children = .49). Within the scale, the parent or the caretaker is asked to rate the degree to which the child experiences each symptom on a 4-point frequency scale, from *never* (0) and *sometimes* (1) to *often* (2) to *always* (3). The total score is the sum of these six subscale scores; the maximal score is 114. Threshold is at 30 for total anxiety, and at 7 for social phobia. In our sample, 14 children met the cutoff for social anxiety: two autistics, nine neurotypicals matched on chronological age, and three neurotypicals matched on mental age. When the study was conducted, no autism-specific scale designed for children was available; some recent studies question the relevance of SCAS, parent version, for autistic children (den Houting et al., 2019; Glod et al., 2017).

(b) The Observer Alexithymia Scale (OAS) (Berthoz et al., 2005; Haviland et al., 2000, 2001, 2002) is a 33-item questionnaire encompassing five aspects of alexithymia: distant, uninsightful, somatizing, humorless, and rigid. Scores are reliable (clinical sample: $\alpha = .90$; nonclinical sample: $\alpha = .86$, .88, and .89), stable (2-week test–retest reliability = .87), and valid because they allow to distinguish clinical from nonclinical samples and correlate with the modified Beth Israel Questionnaire (.69), an observer measure of alexithymia, and the Toronto Alexithymia Scale (.31), the most used self-reported scale of alexithymia. An individual's relatives or acquaintances answer to the items on a 4-point Likert scale: *never, not at all like the person* (0); *sometimes, a little like the person* (1); *usually, very much like the person* (2); *all of the time, completely like the person* (3). The total score is the sum of the subscale scores; the maximal score is 99. The OAS does not include any cutoff, as it is conceived as a continuous measure of alexithymia. Alexithymia is barely measured in (autistic) children and there is no data on the OAS use with autistic children.

(c) Our lab questionnaire (adapted from the revised Family Affluence Scale; Currie et al., 1997, 2008; Hartley et al., 2016; Torsheim et al., 2016) provides a proxy for the participant's socioeconomic background by collecting data on parents. The education score is a 0- to 6-point scale (0 corresponding to *no primary school achieved*; 6 to *a doctoral degree*), and the economic status score is a 0- to 9-point scale (0 being *very low*; 9 being *very high*). The mean of the two parents' scores is calculated for each index. This questionnaire also documents bilingualism statuses. There was a minority of simultaneous bilinguals in the autistic group (two children use another language in addition to French; four are exposed to another language at home but do not speak it) and many more in the neurotypical group (24 bilinguals; two exposed to another language they do not speak). There are two possible reasons for this difference. First, most neurotypical children came from the inherently multilingual city of Brussels. Second, many parents of autistic children still likely feel (or are advised) that they should not raise an autistic child in a bilingual environment, despite growing evidence that exposure to diverse languages is not harmful to children's development, be they autistic or not (Gilhuber et al., 2023; Trelles & Castro, 2019).

## Experimental Setting

Elise Clin individually met all the children 5 times, in a place familiar to them, such as their school (autistic $n = 7$; neurotypical $n = 35$) or home (autistic $n = 11$; neurotypical $n = 1$). The familiarization phase was composed of three first sessions (lasting each between 30 and 60 min), based on games (the IQ test was administered during the second session), with the objective to foster familiarity between the experimenter and the children.

Children were not informed that the study was focusing on social attention and physiological arousal during naturalistic interactions. Instead, "playing with children" was introduced as Elise Clin's job. Autistic children were used to one-to-one recreational activities and did not ask further questions. A few neurotypicals discussed about the study and its apparatus, mainly because their parents talked about it with them, but all were fast satisfied with data collection being a mandatory part of Elise Clin's job. Parents were told that it was a study on "the role emotions play during discussions" (this was congruent with the completion of questionnaires about anxiety and alexithymia). Participants were offered a little gift based on their interests (e.g., coloring book, figurine, construction game, etc.) after ending (entirely completing or not) the study.

The fourth session was the familiar one, as it took place with the experimenter the child met 3 times before during the familiarization phase. The familiar session was always followed, 1 week later, by the unfamiliar session. The new experimenter was briefly introduced to the child by the familiar experimenter at the beginning of the unfamiliar session, as a friend of Elise Clin who enjoys very much painting and was willing to watercolor with the child. After that the familiar experimenter remained out of the child's view, busying herself without making movements or sounds to keep out of the interaction. Otherwise, the activities in the familiar and unfamiliar sessions had an identical structure. Session lengths are reported in Table 3.

Three trained research assistants took the unfamiliar partner role. They were all females (Chapman et al., 2018, for a discussion about the impact of the experimenter's gender) aged between 20 and 25, and they followed the same script, adopting the same friendly and open-to-dialog attitude. The rationale for manipulating familiarity was to elicit interest in the recreational sessions for both groups, as well as to increase the validity of the observations, as explained in the introductory part. Only a few interruptions occurred during the target tasks ($n = 18$), and there were mainly parents passing by or people entering the room by mistake. These very short sequences were discarded from the analyses.

Wherever the experiment took place, the children and experimenters sat at the corner of a table in the same configuration (see Figure 1). The experimenter always sat on the child's nondominant hand side. To ensure reliable electrodermal data collection (Cartaud et al., 2018, 2020), the interpersonal distance was comfortable and similar between children and sessions.

**Table 3**
*Session Lengths per Group*

| | Autistic group | | CA group | | MA group | | All groups | |
|---|---|---|---|---|---|---|---|---|
| Session (min) | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Familiar | 27.03 | 13.36 | 30.57 | 6.22 | 28.84 | 9.07 | 28.81 | 9.91 |
| Unfamiliar | 13.53 | 5.19 | 14.64 | 5.14 | 18.62 | 6.6 | 15.6 | 5.99 |

*Note.* CA = neurotypical children matched on chronological age; MA = neurotypical children matched on mental age.

## Experimental Task

We designed an interactional task based on two recreational sessions. In both sessions, the child and the experimenter were watercoloring predesigned drawings. Each child was invited to pick a drawing among a selection of six; this selection was kept constant across both sessions. Each session officially begins when the experimenter asks, "Which drawing do you want to color?" and ends when the experimenter asks, "Do you want to sign your painting?" We used this leisure context as a way to make participating children more comfortable, and thus more prone to engage in a genuine interaction, but also because 6- and 13-year-old autistic children are reported to particularly enjoy coloring activities (Eversole et al., 2016). Moreover, this activity itself might not elicit different visual attention between our groups, as Yurkovic et al. (2021) found that autistic and neurotypical children pay similar attention to their environment during a naturalistic toy play.

During this recreational task, the experimenter introduced four different topics: three common topics that were identical between the children (Christmas, circus show, and beach holidays), and one that was especially selected based on the interests they showed during the familiarization phase (e.g., Pokémon, cooking, music, etc.). Common topics were selected because of their expected pervasiveness in children's lives, to ensure that every child could have something to say. Christmas was mostly considered as the holiday period during Belgian school year, potentially including snow, Christmas trees, gifts, family moments, songs, and so on. Circus has been discussed in different ways: In addition to live circus shows, several children

**Figure 1**
*Picture of the Experimental Setting*


*Note.* Screenshot of a video shot during the familiar session of the experiment, by Elise Clin, 2017. See the online article for the color version of this figure.

had been engaged in circus courses, others saw TV shows with circus acts, others talked about clowns or animals they had met in various places, and still others preferred to talk about popcorn and candyfloss. Beach holidays encompassed beach activities and summertime, and several children ended by talking about swimming pools.

The three common topics were always introduced 2 times, and in the same way across the children. The experimenter first began with a little (true) anecdote about her experiences of the topic followed by an open question to the child, allowed to talk about it as long as they wanted (e.g., "Every summer, we go to the beach with my parents and sister. My favorite thing to do is to dig a big hole for my sister to stand in. Then I put sand back into the hole, with just her head sticking out. That way, afterwards, I can tease her and tickle her nose without her being able to escape! What about you? What do you prefer to do at the beach?"). After the child's answer, the experimenter introduced another anecdote about the very same topic. After this second child's reaction and a silent moment (providing the child with the opportunity to spontaneously say something), the experimenter introduced another common topic with an anecdote, after a short transition (e.g., "You know, I like summer holidays, but I prefer Christmas holidays!"). The familiar and unfamiliar experimenters told different anecdotes per common topics, but they told the same across the children.

The experimenters were allowed to spontaneously react and ask follow-up questions to the children, as in a natural interaction, but prevented from initiating other topics or introducing more than 2 times a topic that received minimal answer. To introduce the conversation in a natural way, the drawings were illustrating these three common topics. The fourth topic was introduced by the familiar experimenter in the same fashion across children ("I remembered last time that you talked about [topic]. By the way, [little (true) personal anecdote about the topic]"). Usually, children directly engaged in the topic or even did not let her tell the personal anecdote about it. The unfamiliar experimenter behaved as for the common topics: she told a (true) personal story (e.g., "I am playing the piano for 4 years and my teacher asked me to learn a very hard piece. I struggle at practicing it") and asked an open question to the child (e.g., "What instrument would you like to play?") about the specific topic (in this case, the child was playing the violin).

## Data Collection and Treatment

During the experimental task, three data sets were collected. They were then prepared and synchronized in a single data set for further statistical analysis (for details, see methods in the online supplemental materials).

1. Eye-tracking data, namely, participant's eye movements recorded at a 100-Hz rate with a wearable head-mounted eye-tracker. They resulted in a binomial variable which indicated, every 10 ms, whether experimenter's eyes were fixated or not.
2. Interactional data, namely, participants' behaviors recorded with a camera. The videos were used to segment the session into topics discussed by children and experimenters and to label them (e.g., school, video games, animal, friend, etc.). They were then classified into five categories: common topics (Christmas, circus show, and beach holidays); technical aspects (painting in silence, discussion about the experiment and the material); personal topics (the child, their friends, and family); interactional topics (comment on what is going on around them, discussion about the experimenter, jokes, paintbrush fight); and specific topics (topic specific to the child and the ones the child spontaneously introduced such as hobbies, food, etc.). Segmentation and coding in topics were first performed by Elise Clin. A trained master student in Linguistics, blind to participants' diagnosis and to the aims of the study, then reviewed 59.26% of the videos ($n = 64$). If she had any doubt about a segment or a topic label, she and Elise Clin jointly examined it until reaching a consensus. Based on these discussions, Elise Clin then revised the remaining videos ($n = 44$) and got in touch with the other coder when any concern arose. This coding was then synchronized with the eye-tracking data, resulting in binomial variables which indicated, every 10 ms, whether the topics were discussed or not.
3. Electrodermal data, namely, participants' skin conductance (i.e., changes in electrical conductivity in the skin over time; for details, see Boucsein, 2012) was recorded at a 15-Hz rate by sensors attached on children's nondominant hand. These data were then synchronized with the eye-tracking and interactional data, resulting in binomial variables which indicated, every 10 ms, whether there was an SCR (i.e., a skin conductance difference comprised between 0.1 and 1 μ Siemens between two values separated by 1 s and followed by a recovery time) or not.

Children were filmed, and their skin conductance and eye gaze behaviors were recorded during the familiar (fourth) and unfamiliar (fifth) sessions only. All this experimental material could have introduced biases. For example, camera recordings could have induced a social presence or audience effect. Indeed, participants could imagine that someone else would watch (and perhaps judge) the videos, and thus might have not spoken or freely. The eye-tracker itself could also have had an impact on the collected data. On the one hand, by monitoring the eye gaze, it could have inhibited spontaneous exploration. For example, Risko and Kingstone (2011) report that nonautistic adults wearing an eye-tracker tended to avoid looking at particular stimuli (i.e., a provocative swimsuit calendar), and interpret this behavior as a voluntary inhibition effect due to knowing that eye gaze was monitored. On the other hand, by being on the participants' face, the eye-tracking glasses could have influenced the way the experimenters looked at the children (and thus their own reactions). Cañigueral et al. (2018) argue that someone who wears eye-tracking glasses might be less looked at in the eyes than someone without eye-tracking glasses.

To minimize potential biases during the familiar and the unfamiliar sessions (the fourth and fifth ones), we familiarized participating children with the experimental material as follows. The camera was set up from the first session, but was not recording until the fourth session, and the familiar experimenter explained, during the familiarization phase, that the videos were only a precaution, certainly useless, only intended to prove that she was "doing her job" (i.e., playing with children) if whenever her boss would have had wanted to check it out (but without paying attention to what was said), and that nobody else could access them without her consent. As several participants (both neurotypical and autistic) disclosed secrets, the familiarization to the camera might have been effective, at least for a part of the participants. The Shimmer3 GSR + sensors were worn, with no activity recorded, during the second session, and Tobii Pro Glasses 2 were worn, with no gaze data recorded, during the third one. This was intended to compensate for a potential eye-tracker effect, as it has been proven that participants, after less than 10 min, tend to forget about wearing the eye-tracker and seem to stop this "gaze-based impression management" (Nasiopoulos et al., 2015). Regarding the eye-tracker effect on experimenters, we assume that being used to talking to children wearing eye-trackers, experimenters might have been less sensitive to this particularity than naive coparticipants would have been.

## Statistical Methods

All statistical analyses were implemented in R (R Core Team, 2019). The independent variables were group (autistic vs. MA vs. CA), partner (familiar vs. unfamiliar), and topic (common, technical, interaction, personal, or specific). The dependent variables were eyes (fixations on the experimenter's eyes), face (fixations on the experimenter's face), and SCRs. To account for their variability in occurrences by participant (because of different session lengths), variables were converted into proportion data per participant, partner, and topic, so that each participant's variable captures social attention or physiological arousal by participant in each session (familiar vs. unfamiliar) for each topic (common, technical, interaction, personal, or specific).

The variables were analyzed with forward stepwise multilevel linear regressions, with by participants intercepts and partner by participant slopes in the random structure, using the lme4 (Bates et al., 2015) and the lmerTest (Kuznetsova et al., 2017) packages. We started from the null model and incrementally augmented it with group, partner, topic, and their interactions, keeping the random structure unchanged, until we reached the theoretically motivated maximal model. Post hoc comparisons of least-square means were carried out with the emmeans package (Lenth, 2019, Version 1.4) with Tukey adjustment for multiple comparisons. The maximal model was then controlled by independently adding the scores obtained from the social anxiety and the alexithymia questionnaires. Figures were created using the effects (Fox & Weisberg, 2019), the ggplot2 (Wickham, 2016), and the gridExtra (Auguie, 2017, Version 2.3) packages.

To make sure our data could support the null hypothesis, we also conducted Bayesian modeling, implemented using the rstan package in R (Stan Development Team, 2023), which we run using the interface provided by brms (Bürkner, 2017). The independent and dependent variables were the same as in the frequentist models. Independent variables were subgroup (autistic vs. MA vs. CA), partner (familiar vs. unfamiliar), and topic (common, technical, interaction, personal, or specific). Dependent variables were eyes (proportion of fixations on the experimenter's eyes per participant, partner, and topic) and SCRs (proportion of SCRs per participant, partner, and topic). Maximal models were constructed with partner by participant slopes in the random structure. The model priors for each estimate were chosen to be flat and uninformative (priors are available in the online supplemental materials). The full model testing for an effect of eye fixations on SCRs did not converge. We therefore used the next most powerful model, including all fixed effects but no topic interactions. Graphs are reported in the Results in the online supplemental materials.

## Transparency and Openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study, and we follow journal article reporting standards (JARS—Kazak, 2018). Statistical analysis code is available in the online supplemental materials. Research materials are not available because of our ethics committee and general data protection regulation requirements not allowing for diffusion of pseudoanonymized data. The design and analyses of this study were not preregistered.

## Analytic Plan

First, we asked whether there were group differences in the proportion of fixations on the experimenter's eyes and whether they are predicted by the partner or the conversational topics. We further investigated these differences using Bayesian modeling.

Second, we investigated the correlation between the proportion of SCRs and the proportion of fixations on the experimenter's eyes, and whether this correlation is influenced by the group, the partner, or the conversational topics. Here again, we then implemented Bayesian modeling.

# Results

## Fixations on the Partner's Eyes

First, we tested whether group, partner, or topic predict fixations on the experimenter's eyes (see results for face in the online supplemental materials). Interestingly, with the unfamiliar partner, many children did not gaze at the experimenter's eyes at all: 12 in the autism group, eight in the chronological age group, and seven in the mental age group. However, with the familiar partner, there was no child who never looked at the experimenter's eyes. Figure 2 displays the distribution of fixations by group, partner, and topics over the experimenter's eyes.

The model fit was improved by stepwise addition of partner, $\chi^2(1) = 14.31$, $p < .001$, and topic, $\chi^2(4) = 38.49$, $p < .001$; there was no significant effect of group and No Partner × Topic interaction (both *ps* > .42). Post hoc pairwise comparisons indicated that, in all groups, children looked more at the familiar partner's eyes than at the unfamiliar partner's eyes ($\beta = .02$, $SE = .5\mathrm{e}^{-2}$, $p < .001$). There were also less fixations on the partner's eyes during technical versus other topics: common ($\beta = -.02$, $SE = .4\mathrm{e}^{-2}$, $p < .001$), specific ($\beta = -.02$, $SE = .4\mathrm{e}^{-2}$, $p < .001$), and personal ($\beta = -.02$, $SE = .5\mathrm{e}^{-2}$, $p < .001$) topics. Finally, adding social anxiety scores or alexithymia scores as fixed factors to the maximal model did not affect the reported results.

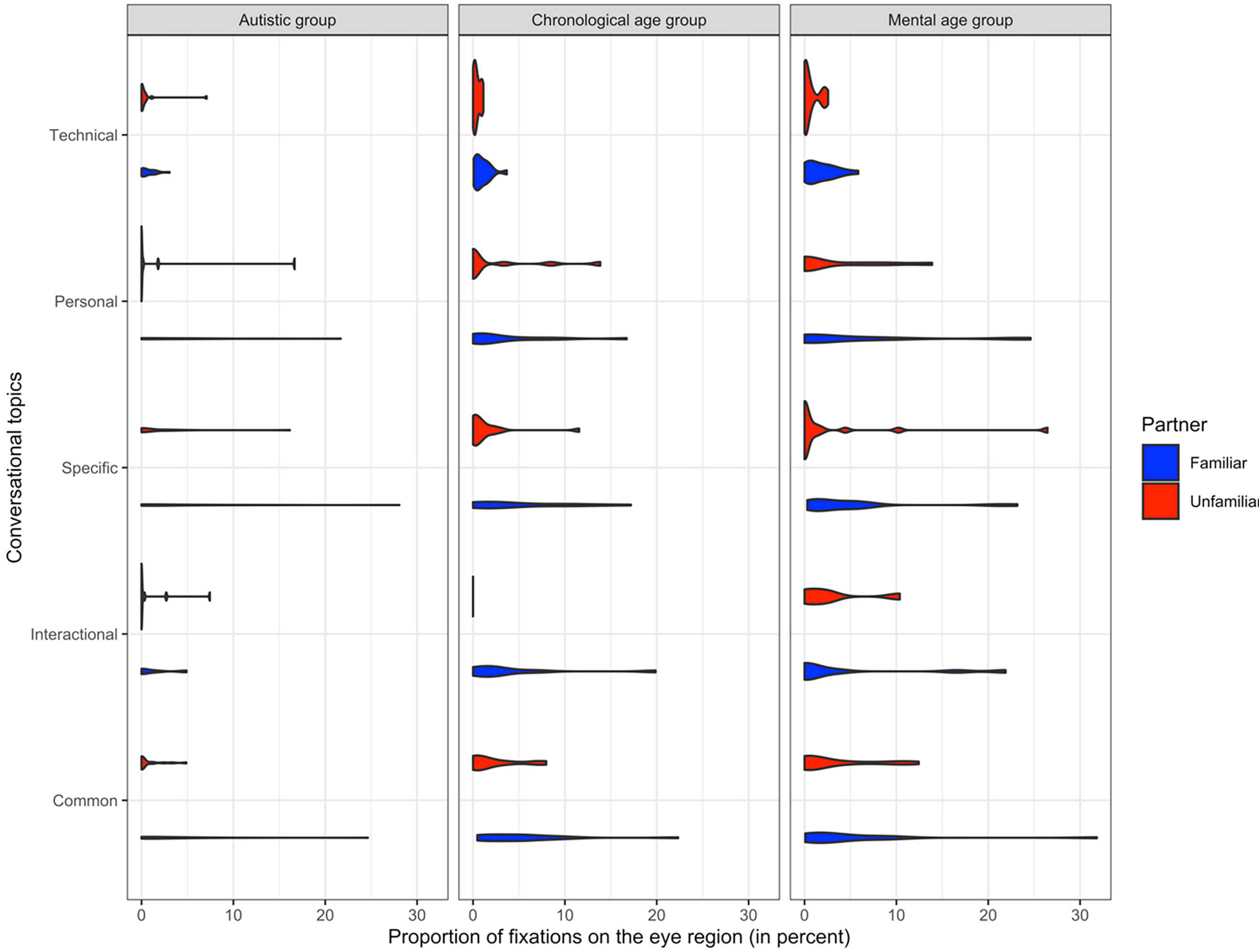
The Bayesian model for eye fixations shows, provided that our data is a good approximation, a significant effect of partner ($\beta = .01$, $SE = .01$, 95% confidence intervals [CIs] [−0.06, 0]), as well as of topic, with less eye fixations in the technical topic ($\beta = -.03$, $SE = .01$, 95% CIs [−0.06, −0.01]) than in the others (all other credible intervals contain 0). The Bayesian model shows no effect of either group (CA: $\beta = .01$, $SE = .02$, 95% CIs [−0.02, 0.05]; MA: $\beta = .01$, $SE = .02$, 95% CIs [−0.02, 0.04]), but is consistent with small negative and positive effects.

## SCRs

Next, we tested whether fixations on the partner's eyes, group, partner or topic predict SCRs. Figure 3 displays the distribution of SCRs by group, partner, and topics.

Stepwise comparisons of multilevel linear models with SCRs as the dependent variable indicated a significant effect of eyes,

**Figure 2**
*Proportions of Fixations on the Partner's Eyes by Group, Partner, and Topic*




*Note*. See the online article for the color version of this figure.



$\chi^2(1) = 23.2$, $p < .001$, and topic, $\chi^2(4) = 17.26$, $p = .001$; there was no effect of group, partner or Eyes × Topic interaction (all *p*s > .279). Post hoc pairwise comparisons revealed that there were less SCRs during common versus interaction ($\beta = -.03$, $SE = .9e^{-2}$, $p = .007$) and specific ($\beta = -.02$, $SE = .6e^{-2}$, $p = .028$) topics. As shown in Figure 4, post hoc slope comparisons indicated that participants' SCRs proportion tended to increase along with their looks at the experimenter's eyes ($\beta = .54$, 95% CIs [0.34, 0.73]). This tendency was especially pronounced in the CA group ($\beta = .97$, 95% CIs [0.62, 1.33]) relative to the MA group ($\beta = .15$, 95% CIs [−0.06, 0.36]), this difference being significant ($p < .001$). Adding social anxiety scores or alexithymia scores as fixed factors to the model did not affect the reported results.

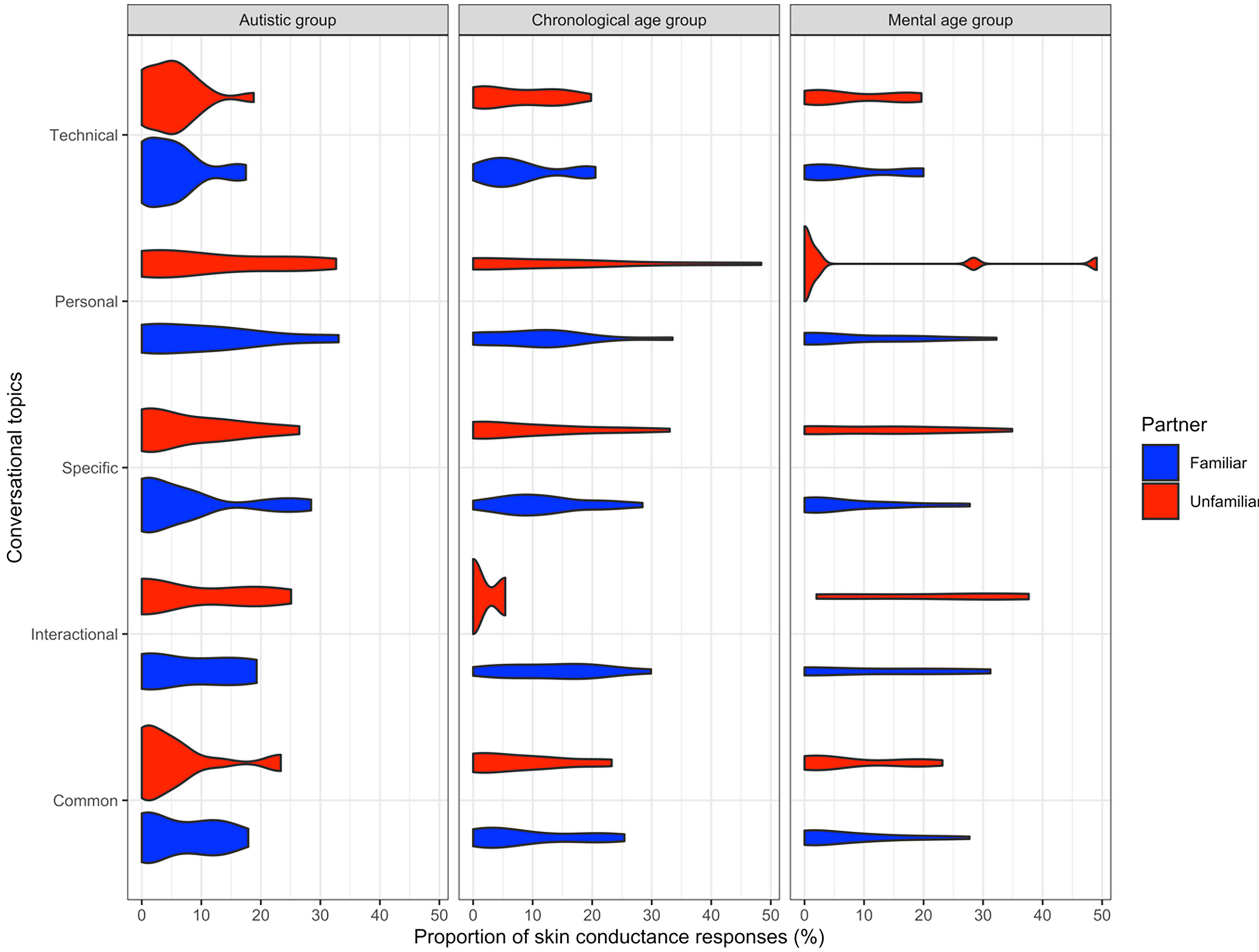
The Bayesian model for SCRs is consistent with a strong effect of eye fixations ($\beta = .79$, $SE = .01$, 95% CIs [0.42, 1.16]). Topic also shows an effect, with larger SCRs during interaction ($\beta = .03$, $SE = .01$, 95% CIs [0.01, 0.05]), other ($\beta = .02$, $SE = .01$, 95% CIs [0.01, 0.03]), and personal ($\beta = .02$, $SE = .01$, 95% CIs [0, 0.04]) topics. The technical topics do not have an effect ($\beta = .01$, $SE = .01$, 95% CIs [−0.01, 0.02]). The Bayesian model for SCRs shows no effect of partner ($\beta = .01$, $SE = .02$, 95% CIs [−0.02, 0.05]) or group (CA: $\beta = .04$, $SE = .03$, 95% CIs [−0.02, 0.09]; MA: $\beta = .02$, $SE = .03$, 95% CIs [−0.03, 0.07]) although they are also consistent with small positive effects. The results from our Bayesian analysis are therefore consistent with the results from our frequentist analysis.

## Discussion

Anchored in a real-life recreational paradigm, our study simultaneously assessed autistic and neurotypical children's gaze behaviors and experienced arousal while discussing diverse topics with an adult to whom they were familiar or not. To our knowledge, this study is the first of its kind with neurotypical and autistic children, combining eye-tracking and electrodermal activity recordings, and displaying a naturalistic yet standardized conversation with familiar versus unfamiliar partners and a great variety of topics (for a review, Laskowitz et al., 2022). Our objective was to design an ecologically

**Figure 3**

*Proportions of SCRs by Group, Partner, and Topic*




*Note.* SCR = skin conductance response. See the online article for the color version of this figure.



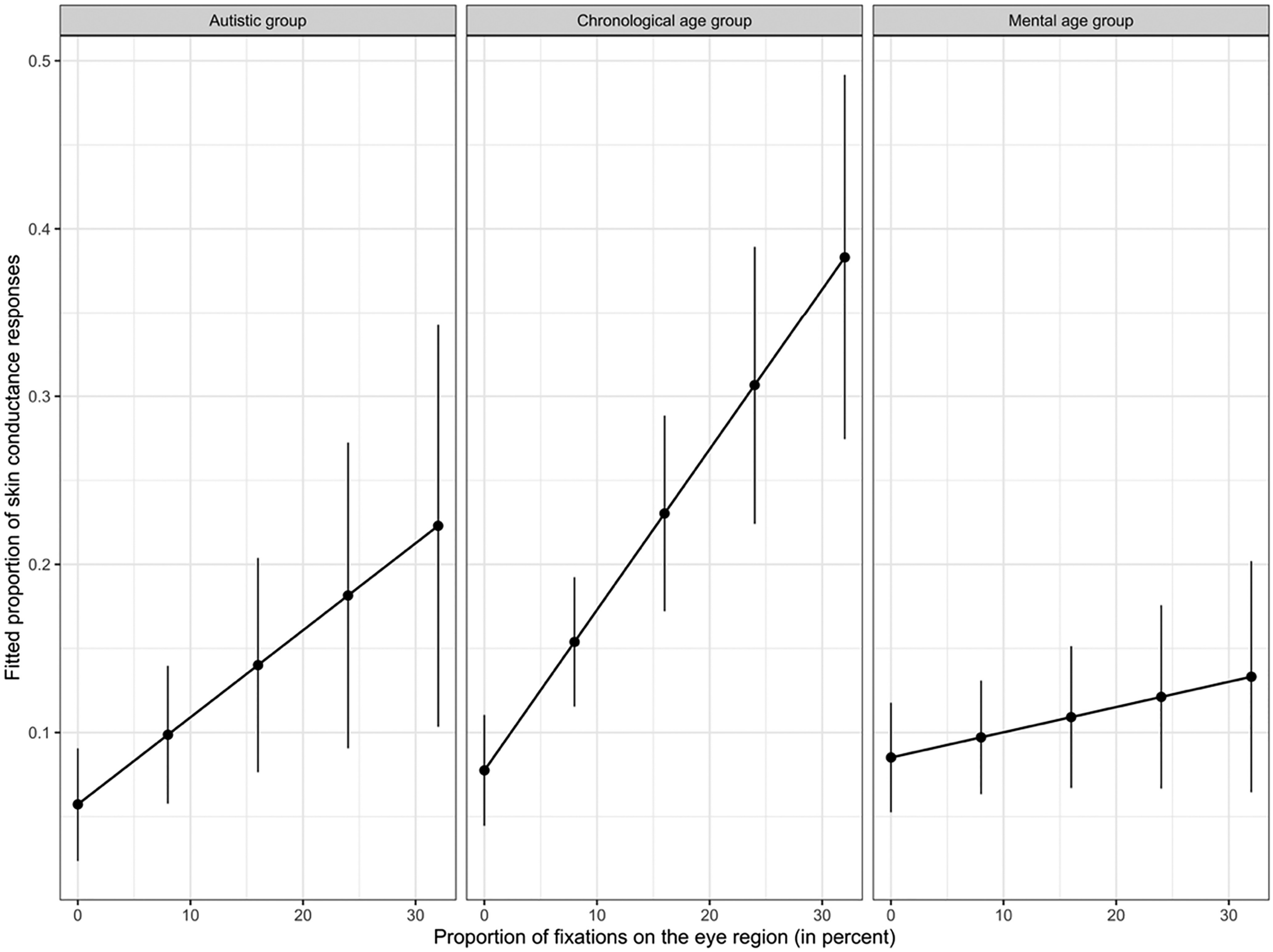
valid paradigm, providing participating children with the opportunity to express themselves and display genuine interactional behaviors within a realistic and reciprocal setting (not passive nor one-way active), all the while collecting rigorously controlled data.

The first research question was to investigate the factors that may influence visual attention to other people's eyes in autistic and neurotypical children. We found that autistics and neurotypicals did not differ in their overall social attention on their interactional partner's eyes. This result contrasts with McParland et al. (2021) who found less attention to faces in autistic children in comparison with neurotypicals, although this group effect was restricted to the contrast between dyadic versus triadic exchanges. At the same time, our results are in line with other live eye-tracking studies that found an overall comparable attention to the interlocutor (e.g., Nyström et al., 2017). Our study thus confirms that social attention, in both neurotypical and autistic children, might be task-dependent (Falck-Ytter, 2015; Hanley et al., 2014; R. M. Jones et al., 2017; Macari et al., 2021; Magrelli et al., 2013; Noris et al., 2012). This result has clear implications for experimental investigations of the processing of social cues and interaction in both typical and atypical populations.

Our study reveals that there is no discernible difference in the extent of social attention between autistic and neurotypical children when they are interacting with an adult partner during recreational tasks, which echoes similar observations in toy play paradigms (Macari et al., 2021; Perkovich et al., 2022; Yurkovic et al., 2021; Yurkovic-Harding et al., 2022). Interestingly, children in our autistic sample were reported to display unusual gaze behaviors based on clinical and research assessments such as the ADOS, the ADI-R, or the ECSP. In this respect, our results question the applicability of the social cognitive developmental theory to autism. According to this theory, social interactions play a pivotal role in shaping cognitive development, predicting, therefore, that reduced social interactions in autism should correlate with an overall decrease in social attention. What our results suggest, however, is that other factors than atypical social interactions may contribute to the social behaviors in autistic children. More broadly, autistic children might develop taking other routes, as recent findings suggest:

**Figure 4**

*Fitted Proportion of SCRs by Proportion of Fixations on the Eye Region per Group*




*Note*. Vertical lines represent 95% confidence intervals. SCR = skin conductance response.



Some autistic children have been found to acquire language via non-socially based channels, such as the Internet or television (Kissine et al., 2023). These results prompt a reconsideration of the universality of theories like the social cognitive developmental theory, suggesting that neuroatypicalities, including autism, may call for more specific theoretical frameworks, rather than being solely perceived as delays or deficits in comparison to neurotypical development.

In addition to the task-dependent nature of social attention, we can hypothesize that specific aspects of this paradigm could have elicited these null results. For example, our study was highly structured, predictable, and reassuring; during this experiment, children have all been familiarized with meeting an experimenter at a specific place and time, and with each session being structured around appealing games. Moreover, the experimenters were positively biased toward children and never put pressure on them to answer their questions, react to their stories, or paint in any specific way. This might have softened a potential mismatch between experimenters' expectations and autistic children's behaviors, maybe limiting the double empathy problem (Milton et al., 2021), and thus leading to more comfort in children, as well as to more interactional reciprocity. Even though our Bayesian modeling indicates supports this null result, new studies, including more participants and collecting specific gaze data within different social contexts, should add to this preliminary finding.

We also found that all children were looking more at the familiar versus unfamiliar interactional partner's eyes. This result highlights two major points. First, it confirms that autistics and neurotypicals are similarly affected by the familiarity status of their interactional partner, as found in lab and preliminary live studies (Dowd et al., 2018; Gillespie-Smith et al., 2014; Nuske et al., 2014). Second, it tells us that three sessions of 30–60 min each (the familiarization phase) are enough to foster familiarity in both neurotypicals and autistics. Altogether, this finding provides an important indication of the length of the acquaintance needed to establish familiarity in neurotypical children. It also suggests that autistic children, at least when they have cognitive and linguistic abilities in the typical range, should not be considered as socially indifferent or unsensitive.

We found comparable social orienting and effective familiarization between autistic and neurotypical children. We controlled for developmental aspects by including two neurotypical groups, either matched on chronological or mental age to the autistic participants. As there were no differences between groups, results regarding social attention and sensitivity to familiarity do not seem to be developmentally constrained. This null result is somewhat at odds with mainstream theories that characterize autism in terms of a deficit in social motivation and orientation (e.g., Chevallier et al., 2012). In our study, all participants developed a social affiliative relationship with an adult who was not a caregiver. Moreover, coders had the subjective impression that all children displayed more enjoyment during the familiar session. This would suggest, in fact, that social bonding extended beyond identity recognition and social orienting. Further research, with measures of social affiliation, should be carried on in order to deepen our understanding of the nonparental bonding phenomenon in neurotypicals and autistics. For instance, it would be informative to know how meaningful, comfortable, interesting, trustworthy, and pleasant the relationship appeared to both interlocutors.

Our study does not replicate the finding that children pay more attention to their conversational partner when discussing their specific interests than when discussing generic topics (Nadig et al., 2010). We only found that children in all groups paid more attention to their interactional partners when discussing personal topics (the child's life), specific topics (the child's interests), and common topics (the three themes introduced by the experimenters with all children), in opposition to technical topics. However, technical topics include discussions about the experiment or the material, painting issues such as color picking, and even silent painting. This limits the scope of this result, as one should expect that a child would gaze less at an interlocutor when being focused on coloring, choosing colors, commenting drawings and material, or keeping silent.

Our second research question was whether physiological arousal could be related to the extent children fixated their interactional partners' eyes, to their group, to the familiarity of the partner, or to the topics they discussed. We found that autistics and neurotypicals did not differ in their overall electrodermal activity. Even though this result does not support the hypoarousal model of autism, suggesting a lack of salience of social stimuli (e.g., Baron-Cohen et al., 1997), it is possible, however, that a combination of hypo- versus hyperarousal profiles in the autistic group blurred potential group differences (Schoen et al., 2008). Furthermore, unlike previous research (Kushki et al., 2014; Kylliäinen et al., 2012; Kylliäinen & Hietanen, 2006; O'Haire et al., 2015), interacting with an unfamiliar partner did not increase experienced physiological arousal nor in all children, nor in autistics in particular. However, we found that children were less aroused during common versus interaction and specific topics. That is, 6- to 9-year-old children are experiencing more arousal when discussing more engaging topics with an adult, independently of their familiarity status. Our results also reveal that all children were experiencing more arousal when looking at their partner in the eyes, as in Nuske et al. (2015). This effect was especially strong in the chronological age group in comparison with the mental age group, suggesting a maturation process in neurotypical children.

SCRs seem to be a sensitive measure in this paradigm. It might be due to our participants' age; children in our sample are relatively young (aged 6–9), contrasting with older participants (aged 8–18) in the studies that suggest a dampened physiological response to a stress that has become chronical in autistics, because of the repetition of negative social experiences (Mertens et al., 2017). However, at this stage, it is impossible to determine the valence of such arousal. On the one hand, arousal could reflect interest, enthusiasm or attention in (some) children when discussing interactive and specific topics or looking at the interactional partner's eyes. Eye contact (i.e., two people looking at each other's eyes at the same time) is known to increase arousal in nonautistics (Nichols & Champness, 1971), but apparently also in autistics within live interactions (Kikuchi et al., 2022), while this arousal is usually attributed to interest or attention. On the other hand, arousal could also mean that (some) children, for instance shy ones, were distressed by more engaging topics and direct gaze. Distress could also be triggered by experimenters' expectations. Indeed, the experimenters' subjective feedback suggests that participants' direct gaze was very often reciprocated because it was an unconsciously desired behavior. The three experimenters who filled the unfamiliar experimenter role, as well as Elise Clin, who acted as the familiar experimenter, experienced frustration when they were looking at the child without making eye contact, or introducing a topic or telling a story without getting any answer or reaction. They consequently realized that they were implicitly expecting for their interactional bids to be responded to. Note that this expectation was present for both autistic and neurotypical groups, and that experimenters were also frustrated in this respect by some neurotypical children. This could have made the experimenters' gaze behavior unwillingly insistent or more intense, and thus less comfortable (Clin & Kissine, 2023). Obviously, both positive and negative valences could coexist in the sample, and even vary within each group. Further measures or investigations are needed to determine the valence of this arousal in each individual.

Finally, as part of an exploratory analysis, we did not find any influence of social anxiety or alexithymia scores on the reported results. While results regarding alexithymia are not surprising (for a review, see Vaiouli et al., 2022), previous studies in autistic adults and socially anxious children did make it likely that social anxiety could have had a role to play on social attention in autistic and nonautistic children (e.g., Clin et al., 2020; Crawford et al., 2016; Kleberg et al., 2017, 2021; Schwab & Schienle, 2017; Seefeldt et al., 2014). We might have also expected an effect of social anxiety on physiological arousal; socially anxious children could have exhibited more SCRs when interacting with an unfamiliar partner or discussing personal topics, as these could have been stressful social situations. This null result could be due to the questionnaire we used to assess experienced social anxiety. This questionnaire was completed by parents, and not by the children themselves, notably because of the age of our participants and the self-consciousness questionnaires expect from the respondents. However, the SCAS-Parent seems to be not that reliable for autistic children (den Houting et al., 2019; Glod et al., 2017). Note that the CA group scored significantly higher on social anxiety than autistic participants (respective means: 5.2 and 2.9). This discrepancy could be due to the need for a higher social awareness in order to score at this scale, as the six items tap both social performance and social anxiety.

All in all, the absence of differences in terms of social attention and physiological arousal between autistics and neurotypicals asks the very important question of what measures are best fitted for the construct we aimed at exploring. Social interest and motivation did not appear problematic during the encounters. However, the unfolding of the interactions seemed to follow different routes, leading to more tiredness and tension in experimenters, hypothetically because it required more adaptation. This unanimous feeling, congruent with the idea that neurotypicals (and experimenters all were) expect different behaviors than the ones autistics do spontaneously adopt (Milton et al., 2021), suggests getting a detailed look at the interactional profiles of autistic and neurotypical children. This most of all require far more complex analyses than basic eye-tracking measures, such as number of fixations or dwelled time on social stimuli. Actually, using such measures underestimates the limitations inherent in eye-tracking (based on focal vision) and takes for granted that neurotypicals and autistics use the very same gaze cues in the very same way (e.g., to gather and convey the same information), while, for instance, autistics have been reported to rely on peripheral vision to a greater extent than neurotypicals (Mottron et al., 2007; Noris et al., 2012).

To conclude, our study clearly shows that more naturalistic research should be carried out in order to better delineate and understand the specificities of social functioning in children, and to provide autistic individuals with adequate support (see Wass & Jones, 2023 for a recent plea in this direction). Our naturalistic, live paradigm holds substantial implications for the broader understanding of social attention in neurodiverse populations, highlighting the crucial role of social context, and, more particularly, of the task participants are engaged in and the familiarity between interactional partners, in studying social attention. Notably, our results suggest that autistics are sensitive in a comparable way to familiarization and familiarity than neurotypicals, contradicting the indifference-unsensitivity view of autism. It also warrants further fine-grained studies of real-life interactions between autistic and nonautistic individuals. For example, a close investigation of the relationship between social attention and linguistic and nonverbal behaviors could provide further cues as to how children navigate in social interactions, and as to what meaning social attention gets within such an interactive social context.

## Limitations and Future Directions

Our study sample only comprised autistic children with linguistic and intellectual profiles within the typical range. Moreover, because of the very costly and fragile material needed to implement naturalistic experiments, we could not include children with highly frequent and potentially harmful externalized behaviors, and ended up with a relatively small sample size per group. Moreover, our sample was gender-matched but not gender-balanced. Yet, autistic girls versus boys might pay in a more typical way attention to social stimuli (Harrop et al., 2018, 2019, 2020). Furthermore, in this study, there is an overlap between gender and sex assigned at birth, contrary to one might have expected based on the literature (Bölte et al., 2023; Corbett et al., 2023). However, gender diversity in autistic children was less discussed at data collection time and we might not have asked the right questions to gather precise gender information. For these reasons, our results should not be extended to the whole autism community.

Several limitations are inherent in our experimental design. The familiar session always came first. This was intended to maximize the similarity of all participants' experimental conditions and the surprise effect of the last session, and also to reduce the potential distraction the unfamiliar session could have been during the familiar session (introducing another topic of discussion). However, this implies that the familiar and unfamiliar sessions were not counterbalanced, so that this order could have had an impact on the results. The repetition of the same task and topics could have elicited boredom in participants. For instance, two older neurotypical participants were dissatisfied about painting a second time. Yet, these two participants in particular have been very polite with the unfamiliar experimenter (more than with the familiar one who heard for the whole session how much they disliked painting) and only complained about renewing the activity to the familiar experimenter. Unexpectedly, no participant at all pointed out that the topics were the same between the two sessions. Perhaps discussing the topics illustrated by the six drawings made this repetition seem natural and plausible. The fact that all the experimenters introduced differently the same topics, based on their own personal anecdotes, could also explain that the second target session did not look like an identical repetition. Children did not always tell their same stories within the topics, which denotes an adaptation to their interlocutor. In fact, even some neurotypicals reused the familiar experimenter's anecdotes as being their own, probably because they liked them. This could also illustrate how invisible the familiar experimenter became, as they did not fear to be overheard and "denounced" (it did not appear as a teasing or testing of the familiar experimenter).

Moreover, the unfamiliar experimenter was briefly introduced by the familiar one, who then silently stayed in the room. The rationale was to alleviate a potential overwhelming distress, and thus to address ethical concerns, but it is possible that results would have been different if the familiar experimenter would have been absent. For practical reasons, the familiar experimenter was also always the same person across participants. Even though the unfamiliar experimenters were selected based on their similarities to the familiar one, their personality (more or less open or fun), interactional attitudes (more or less smiling or talkative), and positionality toward (autistic) children (more or less positive or comfortable) might differ in some respects. Furthermore, the experimenters were not blind to participants' group. The familiar one recruited them, and the unfamiliar ones were informed of children's group. Keeping the diagnosis undisclosed for the latter experimenters would have created an unbalance between experimenters and, in any event, would have been useless as experimenters met the participants in places that clearly revealed their status (e.g., ordinary vs. specialized schools). Future studies should carefully reflect on the experimenter's role on the unfolding of the interactions to best shape their paradigms on this critical point.

Interactions took place between child participants and adult experimenters. Future research might consider studying peer interactions among children with and without diagnoses, within more or less structured paradigms (see Kuhlen & Brennan, 2013 for a discussion on experiments with confederates). This is a key issue for understanding autistic children's behaviors and improve their inclusion in mainstream settings. Furthermore, we did not monitor partner's social attention, while mutual influence (also at the brain level) has been found in previous studies (Behrens et al., 2020; Cañigueral et al., 2018, 2021; Cañigueral & Hamilton, 2019; Hessels et al., 2018, 2019; Laskowitz et al., 2022; Noah et al., 2020). Note also that, even though children were familiar with the experimental material at the time of the target sessions, it remains possible that some of them did not forget about the camera or the eye-tracker.

Our analysis was quantitative: Being involved in a topic does not predict how interactional turns were shared out, how (much) children discussed with the experimenter, nor how appropriate their conversation was. Fine-grained analyses of the interactional content in relation to eye-gaze behaviors (as in Dindar et al., 2017) should be carried out in further research.

Finally, future studies should include reports of social anxiety and alexithymia based on multiple respondents and autism-specific scales designed for children, in order to better capture the feelings and thoughts participants do experience (den Houting et al., 2019; Glod et al., 2017). As well, they could include a standardized debriefing session with the children, to ask them and gather what and how they felt during the experiment.

## Constraints on Generality

This article results and interpretations are based on a study with two target populations: autistic children, aged 6–9, with intellectual and linguistic profiles within the typical range, and neurotypical children, aged 6–9, matched on mental or chronological age to the autistic participants. This sample was selected because autistic children with these profiles could more easily be candidates for inclusion in mainstream schools and activities, yet still face many obstacles. Better knowledge of interactional profiles in live situations of both parties (inclusive neurotypicals and included autistics) could help in designing inclusion policies.

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