Children track variability in adult attention and plan interventions accordingly

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Abstract

Prior research has shown that children are highly responsive to adults' attention, benefit from its presence, and suffer in its absence. However, not much is known about the extent to which children track other's attention to third parties, or the extent to which children actively make decisions and plans to engage adults' attention. In Experiment 1, we looked at whether children (mean: 5;11 range: 4;0-7;11) distinguished attentive and distracted adults in a minimal contrast where attention to a third party (a puppet) was all that varied and the adults were otherwise matched on affect, contingent responding, and other cues. Six- and seven-year-olds but not younger children predicted that the puppets would prefer the attentive adults. In Experiment 2, we looked at whether children (mean: 5;11 range: 4;0-7;11) tracked the co-variation between an adult's attentiveness and a puppet's topics of conversation. We found that older, but not younger children chose the puppets' next topic according to what the co-variation data indicated would best engage the adults' attention. These results suggest that by ages six and seven, but not earlier, children track adults' attention even in third-party contexts and can plan interventions to engage adults' attention.

Keywords: Social attention; social cognition; development

Introduction

People's time and attention is valuable, and perhaps never more so than in early childhood. Young children rely on adults' attentiveness for their very survival. As we review below, there have been numerous studies on children's sensitivity to others' attention but relatively little work on whether children can plan interventions to engage adults' attention. We investigate this in two experiments to follow. First however, we briefly review the extensive literature suggesting that children track and value adults' attention.

Infants are sensitive to others' attention from birth. Newborns look preferentially at faces that engage them in mutual gaze compared to averted gaze (Farroni, Csibra, Simion, & Johnson, 2002). By three months of age, infants shift their own attention in the direction of shifts in their social partners' gaze (Hood, Willen, & Driver, 1998). Infants also react with distress if an adult looks at them but with no sign of attending to them or contingent responding (i.e., the "still face" paradigm (Weinberg & Tronick, 1996)).

Infants also possess an array of mechanisms that effectively capture adults' attention. Features associated with neotony (e.g., big heads, big eyes, etc.) attract adult attention cross-culturally (Alley, 1981; Borgi, Cogliati-Dezza, Brelsford, Meints, & Cirulli, 2014), as do behaviors infants naturally engage in ranging from crying to cooing (Nakayama, 2015). Fortunately, given that young children rely on responsive caregivers for their developmental and emotional needs, caregivers are often lavish with infant-directed attention. The tendency to talk to infants using slow, melodic, and exaggerated tones is a near cross-cultural universal (Fernald, Barkow, Cosmides, & Tooby, 1992; Broesch & Bryant, 2015) and infants themselves are more attentive to and learn speech sounds and words better from infant- than adult-directed speech (Cooper & Aslin, 1990; Schachner & Hannon, 2011; Ma, Golinkoff, Houston, & Hirsh-Pasek, 2011). Infants are also very responsive to adults' infant-directed songs, which both soothe and promote social engagement (Corbeil, Trehub, & Peretz, 2016; Cirelli, Einarson, & Trainor, 2014).

Starting around nine to ten months, young children start taking a more active role not just in responding to attention, but also tracking it and directing it. Infants begin to follow adults' gaze and points and begin to show objects to adults and point themselves (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998). Showing and pointing are the earliest indices that children will actively intervene to engage adult attention. Critically, however, these behaviors require only that the child can represent the adults' line of sight; they do not require children to represent particular content that may more or less effectively engage the adult.

By nine to ten months, Infants also engage in social referencing, using adults' attention and reactions to guide their own responses in contexts of uncertainty or ambiguity (Campos, 1981). By 12 to 14 months, infants check back and forth to verify that they and the adult are looking at the same thing (Wellman, Phillips, Dunphy-Lelii, & LaLonde, 2004; Moll & Tomasello, 2004). Toddlers can also use the focus of others' attention to disambiguate the referent of utterances (Baldwin & Moses, 1996, 2014). For instance, infants selectively look up to check the direction of a speaker's gaze if the speaker labels an object when two novel objects are present but not if only one object is present. Toddlers can also use shared joint attention to disambiguate word referents, assuming that an adult will react with surprise and a new label only to objects that are new to the adult (Tomasello & Haberl, 2003). Conversely, children learn less well if others' attention is compromised. Toddlers are more likely to learn words when an object is named in a joint attention context than if the label occurs in the absence of mutual eye gaze (Yu & Smith, 2012). Similarly, if a word is labeled but the adult's attention is divided (e.g., by a cell phone), they are less likely

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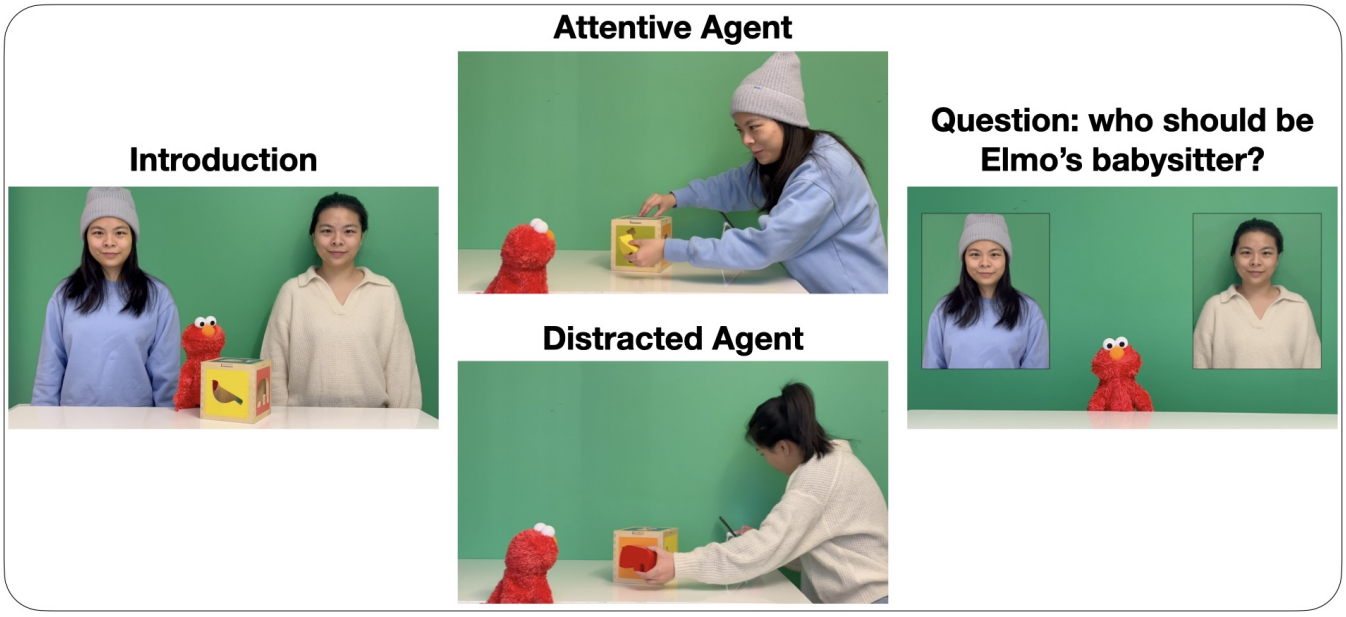

Figure 1: Example Design for Experiment 1. In each trial (two trials in total), two adult characters were introduced as identical twins and were played by the same person with different clothes and hairstyles. Each adult agent interacted with the puppet. During the interactions, one agent paid undivided attention to the puppet; the other looked back and forth at her phone (matched on affect, contingent responding, and other cues). Then, children were asked to help the puppet choose their babysitter.

to learn the word (Reed, Hirsh-Pasek, & Golinkoff, 2017).

Collectively, these results suggest that young children not only track others' attention but use that information for learning. However, despite the abundance of work on attention, few studies have looked at how children actively track the content the adult is interested in and try to engage the adult's attention. To be clear, here we mean something distinct from behaviors we may think of as "attention-getting". Crying, whining, and acting out – and explicit requests like "Pay attention to me!" – may reflect children's distress at not getting the attention they want, and may successfully capture adults' attention, without entailing any specific reasoning or planning on the part of the child. Thus although such attention-getting behaviors are both prevalent and characteristic of childhood, they do more to confirm the fact children find adult attention valuable and are upset by its absence, than provide insight into children's ability to generate intentional plans to intervene in ways that capture adults' attention.

One exception to the paucity of research related to how children attempt to engage adults' attention comes from the work on collaboration. By three, children begin to collaborate with others and they expect their social partners to show sustained attention and commitment to collaborative tasks. When their partner breaks off their joint activity, children will try to regain the adults' attention to the task at hand (Gräfenhain, Behne, Carpenter, & Tomasello, 2009). Again however, such studies do not speak to children's ability to consider sources of variation in others' attentiveness and plan interventions accordingly.

Thus collectively, extensive previous research suggests that children are highly responsive to adults' attention, benefit from its presence and suffer in its absence, and are motivated to seek it. However, we do not know to what extent children make decisions and plans with the specific goal of engaging adult attention. The strongest test of children's ability to intervene on adults' attention may be whether children can propose interventions in a third-party context when the children themselves are not involved in the interaction. If children track and propose actions to engage adults' attention in third-party interactions, this cannot be because the children are merely reacting to being deprived of attention and deploying evolved strategies to regain it (e.g., crying, whining, making noise on the one hand or being cute and winsome on the other).

Here we investigate children's ability to track adult attention in third-party contexts, their understanding that third parties also value others' attention, and their ability to use evidence about the interaction to propose effective interventions. In Experiment 1, we look at whether four to seven-year-olds use differences in adults' attentiveness to make decisions about social partners. Specifically, we ask whether children distinguish between, and expect others to prefer more (versus less) attentive adults. In Experiment 2, we look at whether children reason about the causal relationship between agents' actions and adults' attention such that they can plan effective interventions. Specifically, we show children patterns of covariation in adults' attentiveness to different topics of conversation and ask whether children propose interventions on the

next conversational topic likely to capture adults' attention.

Experiment 1

Methods

Participants Children were recruited through and tested on the asynchronous online testing platform Children Helping Science (Scott & Schulz, 2017). The data was collected in two consecutive stages. First, forty-eight 4-5-year-olds completed the study. Fifteen child participants were excluded from the analysis for failing more than one warm-up trial (n=3), technical difficulties (n=4), parental interference (n=3), and failing to point or the coder not being able to determine the direction of pointing in any test trials (n=4). N = 33 child participants (M = 4.96, range = 4.03-5.84 years) were included in the analysis. Second, Fifty 6-7-year-olds completed the study. Seventeen child participants were excluded from the analysis for failing more than one inclusion trial (n=4), technical difficulties (n=4), parental interference (n=2), and failing to point or the coder not being able to determine the direction of pointing in any test trials (n=7). N = 33 child participants (M = 6.94, range = 6.00-7.97 years) were included in the analysis.

Materials and Procedures The experiment began with four warm-up trials to help child participants familiarize themselves with pointing at the screen. In each trial, the puppet Elmo appeared in the middle of the scene, and two pictures of familiar objects (e.g. a flower, bananas) were presented, one to the left of Elmo and one to the right. Participants were asked to point to one of the objects prompted by the audio.

Each participant received two test trials (See Figure1 for an example). In each trial, participants watched a videotape of two adult agents interacting with a puppet. The adult agents demonstrated a shape-sorter toy, read a story, and had a conversation with the puppet. Each agent engaged in all three interactions and then the second agent was introduced. During the interactions, one agent paid undivided attention to the puppet; the other looked back and forth at her phone. Then, child participants were asked to point to the person that the puppet should choose as their babysitter. The second trial was identical to the first, except that participants saw two different agents demonstrate another toy, read another story, and talk with another puppet. Again, one agent paid full attention to the puppet, while the other looked back and forth at her phone. Then, participants were asked to help the puppet choose their babysitter. After making a choice in the second trial, each participant was asked to explain why they chose that agent. The order in which attentive or distracted agents were introduced was counterbalanced.

Here, we used a minimal contrast manipulation to differentiate the attentive versus distracted agents. The two adult characters in each trial were introduced as twin sisters and were played by the same person with different clothing and hairstyles. We controlled the duration of interaction, affect, facial expression, and speed of conversation across attentive and distracted agents. Thus, the only difference between attentiveness and distraction here is whether the agents maintained eye contact or joint attention with the puppets throughout, or kept shifting their attention away from the puppet and the toy to their phone.

Results and Discussion Children were recruited and tested in two age bins so we report the results for younger (four and five-year-old) and older (six and seven-year-old) children separately. We used a one-tailed binomial test to determine if the proportion of children who chose the attentive agents in both trials was greater than chance (25%). Four and five-year-olds were equally likely to choose the attentive and distracted agents (12/33 children (36.4%); one-tailed binomial: 95%CI=[0.23,1.00], $p = .1$) but six and seven-year-olds did (15/33 children preferred the attentive agent (45.5%); one-tailed binomial: 95%CI=[0.30,1.00], $p < .01$). Collapsing across groups, there was no significant effect of age on children's performance (See Figure2). The mixed-effect logistic regression predicting the choices of attentive or distracted agents from age (in months), with random intercepts for subjects, did not explain significant additional variance (likelihood ratio test $\chi^2(1) = 0.69, p = .41$) compared to the intercept-only model.

Note that although the older children preferred the more attentive agent, the preference was relatively weak: fewer than half the children chose the more attentive agent in both trials. This is perhaps unsurprising given that as noted, we used a minimal contrast here to differentiate the agents. Although the agents differed in the extent to which they made eye contact with the puppets and engaged in joint attention (versus looking at their phones), they were otherwise matched in all respects. Distracted parents might be tempted to take comfort in the fact that merely occasionally glancing at one's phone does not seem to register greatly, especially on younger children.

However, two things are worth noting. First, children here were tested in a third-party scenario where they themselves were not the target of either attention or distraction. Children might be much more acutely aware of when they were and were not being attended to in a first-person interaction. Second of course, our experimental manipulation was a very unrealistic portrayal of how distraction manifests in real life, where inattentiveness is also likely to lead to less contingent responding, reduced affect, and longer temporal delays between responses. Although for experimental purposes, the minimal manipulation was useful in isolating attention and joint attention from other factors, it is perhaps unsurprising that the relatively slight difference in behavior had a correspondingly slight impact on children. However, put another way, it is arguably striking that children as young as six *did* distinguished the agents given that the agents were equally friendly, responsive, prosocial, and prompt to interact with the puppets, and that children were not directly involved themselves but merely observing a third party interaction. Despite the minimal contrast, six and seven-year-olds

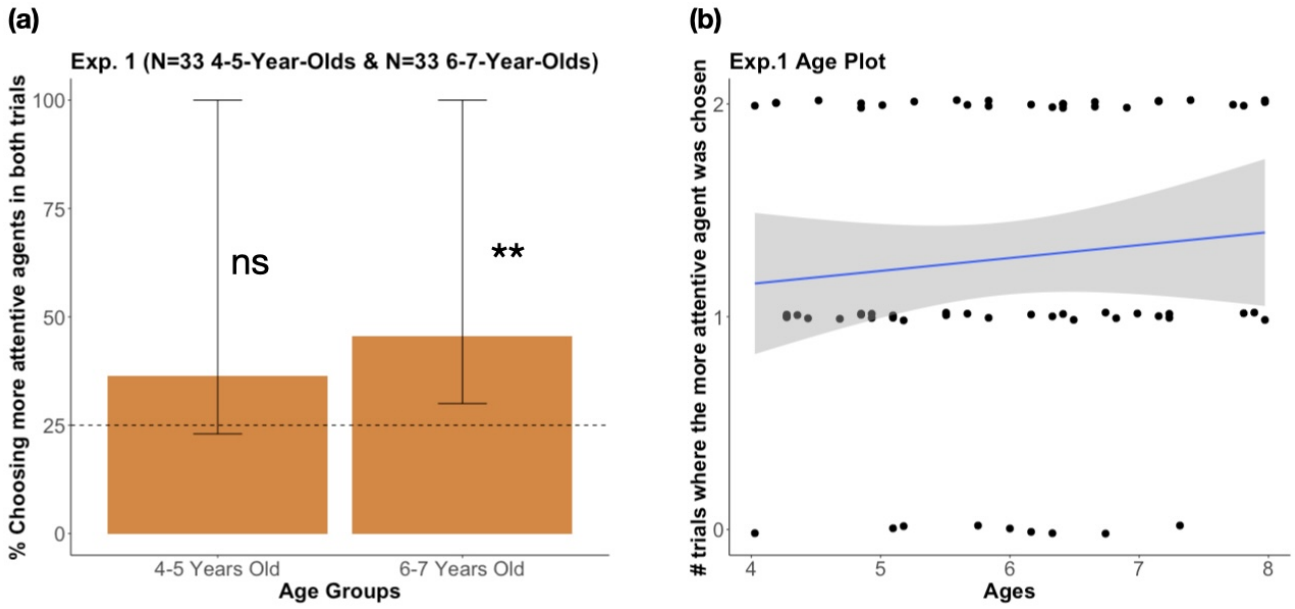

Figure 2: (a) The proportion of children who chose the more attentive agents in both trials, by age groups. (b) Number of trials where participants chose the attentive agent, by age, for each child

expected the puppet involved in each interaction to prefer the more attentive agent.

Experiment 1 thus established that children distinguish the relative attentiveness of agents, even in third-party interactions, and use this as a basis for preference and decision-making. In Experiment 2, we use a more natural contrast between attentiveness and distraction and ask two questions. First, to what extent do children track differences in attentiveness, not just between agents but within a single agent over the course of a social interaction? Second, do children track the content of third-party interactions and the co-variation of the content with the agent's attentiveness, and do they use this information to plan interventions to try to engage the agent's attention?

Experiment 2

Methods

Participants Children were recruited from and tested asynchronously on the Children Helping Science website. The data were again collected in two consecutive stages, four and five-year-olds (N = 33; M = 4.85, range = 4.03-5.84 years) and six- and seven-year-olds (N=33; M = 7.10, range = 6.08-7.97 years). Seven four- and five-year-olds were excluded from the analysis for looking away from the screen or disappearing from videos for longer than 8 consecutive seconds (n=5) and technical difficulties (n=2). Ten six- and seven-year-olds were excluded from the analysis for looking away from the screen or disappearing from videos for longer than 8 consecutive seconds (n=7), parental interference (n=1), technical difficulties (n=1), and being outside the age range (n=1).

Materials and Procedures

Each participant received two trials (See Figure3 for an example). In the first trial, Elmo talked to the adult about two topics: animals and sports, interleaving the conversation so they discussed the topics in an ABAB order. The adult paid undivided attention to the puppet while listening to one of the topics (e.g., sports) but was distracted and flipped through a magazine while listening to the other topic (animals). Then, the adult left briefly. When the adult returned, children were asked to help Elmo decide what to talk about next: animals or sports. Then children received a second trial with a different puppet talking with a different adult about two new topics (baking and taking a trip). As a final manipulation check, participants were asked which topic the agent paid more attention to during the second trial.

In Experiment 2, we use a more natural contrast between attentiveness and distraction. In addition to having the agents flipping through a magazine, the distraction was manifested also by longer temporal delays between verbal and physical responses (e.g., nodding) and reduced affect.

Results and Discussion

Results were analyzed as in Experiment 1. Four- and five-year-olds did not selectively choose topics the adult had attended to (10/33 children chose the more attended topic on both trials (30.3%); one-tail binomial test against 25% chance: 95%CI=[0.17,1.00],$p = .3$), but six- and seven-year-olds did (15/33 children (45.5%); one-tail binomial test against 25%: 95%CI=[0.30,1.00],$p < .01$). Collapsing across groups, there was no significant effect of age on children's performance (likelihood ratio test $\chi^2(1) = 0.32, p = .57$) (See

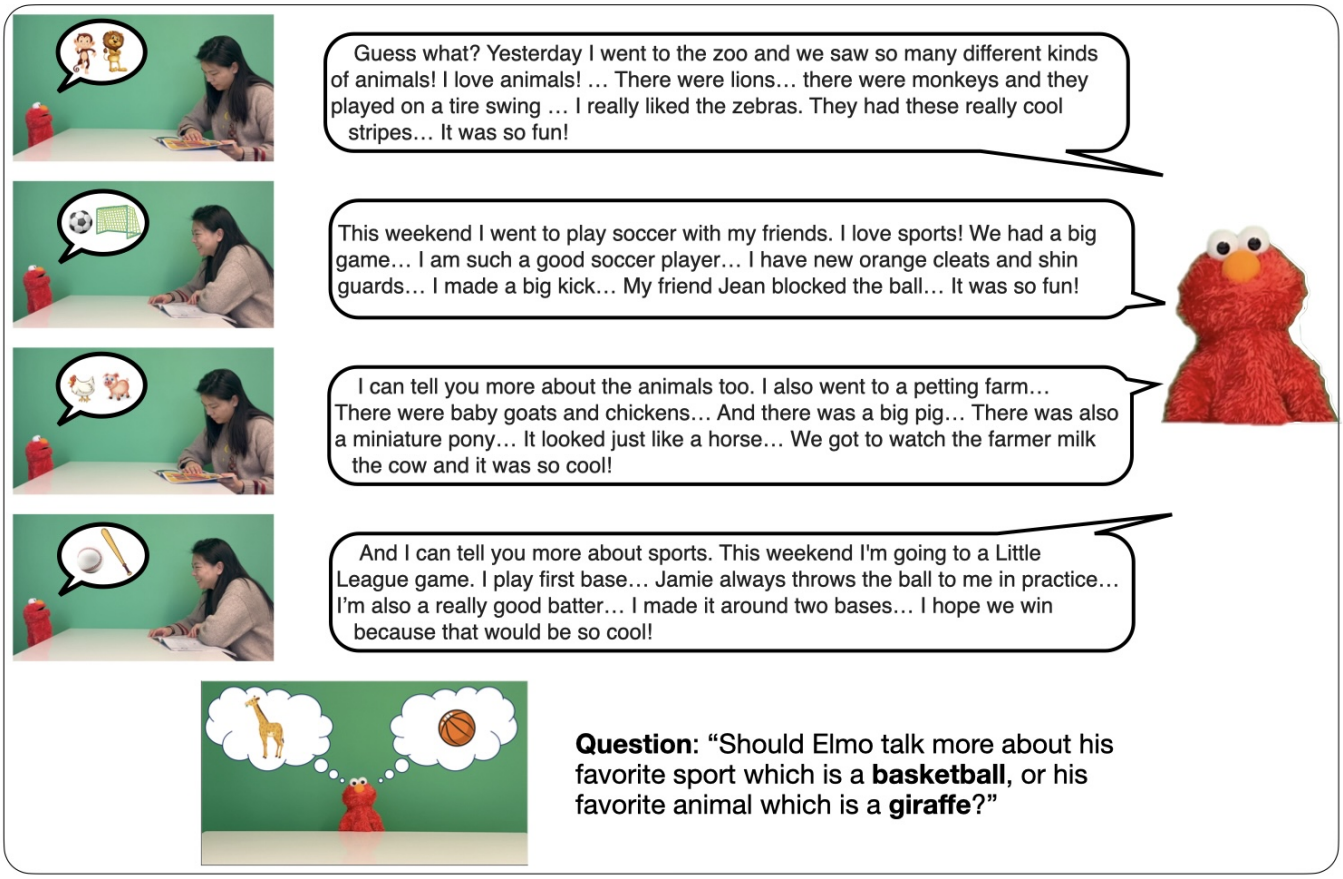

Figure 3: Example Design for Experiment 2. In one trial (two trials in total), a puppet talked to an adult about two topics: animals and sports, interleaving the conversation so they discussed the topics in an ABAB order. The adult paid undivided attention to the puppet while listening to one of the topics (e.g., sports) but was distracted and flipped through a magazine while listening to the other topic (animals). Children were asked to help the puppet decide what to talk about next. The scripts of the puppet are shown in the speech bubbles on the right.

Figure4).

These results suggest that by the age of six and seven, children are beginning to be able to track adult agents' varied attentiveness during a third-party social interaction and are sensitive to the co-variation between the agents' attentiveness and the topics of conversation. They are also able to use this information to plan interventions to attract the agents' attention.

In Experiment 2, the children had more cues to distinguish attentive and distracted behavior (differences in eye contact, contingent responding, and affect). However, children also had to extract the overall conversational topic (e.g., animals or sports) from a natural flow of conversation (see Figure 3) and track the co-variation between these topics and the adult's attentiveness. This might have made the task especially challenging for younger children and future work might look at whether even four- and five-year-olds can plan interventions to engage adult attention in contexts where they both have rich cues to adult attentiveness and it is relatively easy to track the things that engage (or fail to engage) the adult's interest.

General Discussion

Across two experiments, we found that six- and seven-year-olds, but not younger children, track variations in attentiveness between and within agents and can successfully plan interventions to capture adults' attention. Although considerable research suggests that children value adults' attention and experience distress in its absence, to our knowledge, this is among the first studies to show that children actively choose to interact with attentive versus distracted adults and can identify novel interventions (i.e., selecting a specific conversational topic) to seek and maintain adults' attention.

Given that young children are so attentive to attention, why were they unsuccessful in these experiments? In Experiment 1, it is possible that the manipulation was simply too subtle for the children to detect the difference between the attentive and distracted agent. Distracted adults are normally conspicuous in their absences, imposing delays between communicative exchanges and responding with less enthusiasm and affect. Our experiment held these factors constant and varied

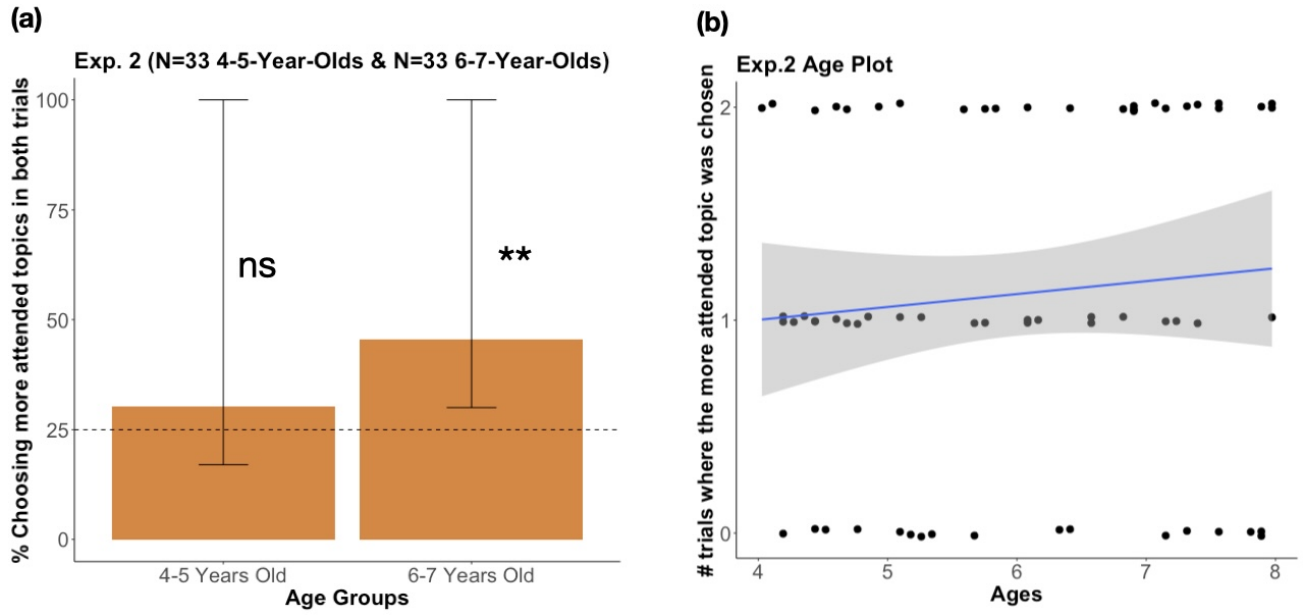

Figure 4: (a) The proportion of children who chose the more attended topics in both trials, by age groups. (b) Number of trials where participants chose the more attended topic, by age, for each child

only attention, and this may either have been too slight a cue for the children to notice, or they may have noticed but been indifferent between the agents given that both were warm, prosocial, and responsive to the puppet.

However, the difficulty with the minimal contrast cannot account for young children's failures in Experiment 2. There the difference between the adult in an attentive and distracted state was marked: the distracted adult not only looked away from her conversational partner but failed to respond promptly to conversational pauses and was more muted in her affective response. If we assume that children did notice (and dislike) these distracted behaviors, why then did they fail to intervene to try to engage the adult?

One possibility is that children could detect the variation in attention but not the reason for it. They may have been unable to use the extended conversational interaction to infer the topic of communication (even though this was articulated at the start of each conversation and used as a prompt during the test trial). Nonetheless, this organizing principle might have been opaque to the younger children; they may have noticed the adults' attention varying but been at a loss to explain and thus intervene on it. A different possibility is that children both detected the adults' varying attention and associated it with the changes in the topics of conversation but may have interpreted the context differently. Younger children might have been more likely to decide that the adults missed important information about the topics being discussed when they were distracted and thus believed the puppet should actually preferentially talk about the topic being discussed when the adult was distracted. This seems possible but unlikely given that no specific content was ever going to be repeated. Additionally, the inference that information could be missed during distraction and the decision to try to compensate for it are relatively sophisticated inferences. If anything, one might assume that these would be more prevalent in older, rather than younger children. Thus, a more likely possibility is that the younger children either failed to extract the cause of the adults' shifts in attention or struggled to use this information for planning and intervention. Younger children might also be more likely to succeed in first-person contexts when they directly experience the adults' attention or distraction. Future research might disambiguate these accounts.

However, the current results suggest at least by the age of six, children both track others' attention and can use it for decision-making and planning. In popular culture, when children seek attention, we may think of the children as being naughty or mischievous. We hope the results of this paper encourage you to think of children's attention-seeking instead as a positive development and a sign of their growing abilities to engage proactively with others.

Open Science

All experiments were preregistered. Here is the project link: `https://osf.io/d65qt/?view_only=bff692e04a8f46d2974cf7e6aaec581c`

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