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Social reward predicts false belief understanding in Namibian Hai||om children

Roman Stengelin[1,2] | **Ljubica Petrović**[1] | **Maleen Thiele**[1] | **Robert Hepach**[3] | **Daniel B. M. Haun**[1]

[1]Department of Comparative Cultural Psychology, Max-Planck-Institute for Evolutionary Anthropology, Leipzig, Germany

[2]Department of Psychology and Social Work, University of Namibia, Windhoek, Namibia

[3]Department of Experimental Psychology, University of Oxford, Oxford, UK

Correspondence
Roman Stengelin, Department of Comparative Cultural Psychology, Max-Planck-Institute for Evolutionary Anthropology, Deutscher Platz 6, 04103 Leipzig, Leipzig, Germany.
Email: roman_stengelin@eva.mpg.de

Funding information
Department of Early Child Development and Culture at Leipzig University & Max-Planck-Society

Abstract

Social motivation is theorized to promote Theory of Mind development in childhood, but research testing this link is scarce and largely limited to urban middle-class milieus of the Global North. Here, we investigated the link between social motivation (i.e., social reward responsivity) and Theory of Mind (i.e., false belief understanding) among $N = 59$ Hai||om children (Age_{Range} = 2.3–8.0 years) from rural Namibia, an indigenous community where children's social experience with peers and adults differs much from urban middle-class milieus typically sampled in developmental science research. Children's preference for adult, but not peer faces predicted their false belief performance. Moreover, their false belief performance increased with age, showing mastery of the current false belief task by the preschool years. These results accommodate universalist claims on the link between social motivation and Theory of Mind while suggesting a particular contribution of the social reward responsivity to adult social partners.

KEYWORDS
culture, false belief, social motivation, social reward, theory of mind

1 | INTRODUCTION

To efficiently coordinate social interactions, humans need to understand and predict others' actions in the light of their desires, beliefs, and intentions utilizing a Theory of Mind (Premack & Woodruff, 1978; Rakoczy, 2022). By around age four, children take a leap in understanding others' minds as they start to consider others' actions based on subjective beliefs, even if those are objectively wrong (i.e., false beliefs; Wimmer & Perner, 1983). False belief understanding is considered a critical milestone in socio-cognitive development as it indicates that children understand behavior not as driven by the objective reality, but subjective representations thereof. This developmental step has been identified and replicated in numerous societies, denoting false belief understanding as a universal and "genuine conceptual change in the preschool years" (Wellman et al., 2001, p. 656; see also Barrett et al., 2013; Callaghan et al., 2005; Rochat et al., 2009).

1.1 | Cultural variation in childhood theory of mind

Universalist claims concerning children's Theory of mind development have recently been challenged by research demonstrating that false belief understanding in urban, industrialized societies does not necessarily generalize to children outside this cultural niche. In some studies, children from more rural, subsistence-based communities have been found to solve false belief and other Theory of Mind tasks only at much later ages (De Gracia et al., 2016; Dixson et al., 2017; Kuntoro et al., 2017; Mayer & Träuble, 2015, 2013; Stengelin et al., 2020b; but see Avis & Harris, 1991; Callaghan et al., 2005).

For example, research among indigenous communities in the Pacific has found late onsets in children's false belief understanding compared to their urban, industrialized communities. This pattern has been attributed to cultural norms regarding mental state talk and thought (Brandl, 2021; Dixson et al., 2017; Mayer & Träuble, 2015, 2013; Wassmann et al., 2013), such as *opacity of mind doctrines* prevalent in this region but also other indigenous communities (Duranti, 2015; Robbins, 2020; Robbins & Rumsey, 2008). Such accounts stress the fundamental inaccessibility of thoughts and beliefs, discouraging introspection and reasoning about others' mental states or considering intentionality in moral judgment (McNamara et al., 2019; Wassmann et al., 2013). As a result, mental state thought and talk is de-emphasized when compared to urban, industrialized societies, where focusing on and reflecting upon children's mental states is idealized as a good parenting practice (Hughes et al., 2018; Meins et al., 2002; Taumoepeau, 2019).

Moreover, socialization goals and parenting practices critically shape children's understanding of themselves and others as mental agents (Kärtner, 2015; Kuntoro et al., 2017). Communities prioritizing children's psychological autonomy, educating them toward becoming self-conscious agents who follow their preferences and desires, are likely to promote children's understanding of their mental states in contrast to those of others. This focus is characteristic of urban, industrialized communities typically studied in developmental science (Kärtner, 2015; Keller, 2016). Conversely, communities valuing obedience and hierarchical relatedness may place less emphasis on subjective mental states but instead consider social roles and relations as determinants of behavior (De Gracia et al., 2016; Kuntoro et al., 2017).

Another socio-cultural variable to consider in cross-cultural research on Theory of Mind development is the context in which the phenomenon is typically studied. Childhood socio-cognitive development is often assessed following standardized protocols relying on children's ability to closely attend to fictive stories provided by adult strangers in one-on-one settings and responding to the adult's rhetorical questions to demonstrate their socio-cognitive skills. This approach mimics children's experience in schools and other educational settings, potentially disadvantaging children from communities where learning occurs through self-directed observation or peer collaboration (Lancy, 2010; Lew-Levy et al., 2017; Odden & Rochat, 2004). It is thus likely that differences in false belief understanding across

communities are partly due to methodological details rather than actual differences in social cognition (Greenfield, 1997; Jukes et al., 2024).

Systematic efforts to study children in currently underrepresented communities are needed to better understand and dissect the contribution of such cultural drivers of Theory of Mind development.

1.2 | Developmental drivers of theory of mind development

To understand how Theory of Mind unfolds across and within cultural communities, developmental psychologists have focused on identifying factors contributing to false belief understanding and other related skills in early and middle childhood (Gopnik & Wellman, 1992; Wellman, 2018). Of particular interest are social attributes, such as a children's social motivations, that provide them with opportunities to engage with and learn from others (Chevallier et al., 2012; Lane & Bowman, 2021).

According to the Social Motivation Theory of Autism (Chevallier et al., 2012), children are intrinsically motivated to orient their attention toward social partners ("social orienting"), seek and like social engagement ("social reward"), and build and maintain long-lasting relationships ("social maintaining"). Interindividual variation in each of these domains of social motivation results in diverse social experiences, providing opportunities to probe and refine their Theory of Mind. While the Social Motivation Theory of Autism initially aimed at explaining neurodivergence in Theory of Mind among individuals with an autism spectrum diagnosis, assumed links apply to developmental science more generally (Chevallier et al., 2012; Nielsen, 2008; Tomasello, 2023). Indeed, a growing body of research indicates that, also in neurotypical children, social motivation and engagement predict social cognition both concurrently (Brink et al., 2015; Burnside et al., 2017; Burnside et al., 2018; Devine & Apperly, 2021; Lane et al., 2013) and longitudinally (Brink et al., 2015; see Lane & Bowman, 2021 for a review; Mink et al., 2014). Notably, links between social motivation and cognition have been established for different domains of social motivation, including children's social orienting (Burnside et al., 2018), social reward (Dubey et al., 2022; Stengelin et al., 2020b), and social maintaining (Devine & Apperly, 2021; Fink et al., 2015; Vonk et al., 2020).

It is important to note that these findings almost exclusively derive from research with urban, industrialized communities in the Global North. This sampling bias heavily restrains generalizations beyond such communities (Nielsen et al., 2017). In line with the "cultural nature of human development" (Rogoff, 2003), children's social tendencies and motivations (Correa-Chávez & Rogoff, 2009; Mejía-Arauz et al., 2007; Stengelin et al., 2020b) and their Theory of Mind (De Gracia et al., 2016; Dixson et al., 2017; Mayer & Träuble, 2015, 2013; Stengelin et al., 2020b) show systematic variation across cultural communities.

To our knowledge, only one study has to date linked children's social motivation and their Theory of Mind cross-culturally. Stengelin and colleagues (2020b) compared three–eight-year-old children from urban Germany with rural Namibian Hai||om and Ovambo children in their social motivation for peer collaboration. The authors assessed two aspects of children's social motivation, focusing on social reward: their positive emotional expressions during collaboration as compared to an individual activity (i.e., their *liking* of peer collaboration) and their preferences choosing between both activities (i.e., their *seeking* of peer collaboration). Children's Theory of Mind was assessed using a culturally-adapted task in which children theorize about the mental states of fictive story characters (Wellman & Liu, 2004). Urban German children expressed more positive emotions selectively during collaboration than Namibian children, and these children also scored higher on the Theory of Mind scale. Interestingly, independent of the community-level variation in these measures, in all three societies children's *liking* of collaboration predicted their Theory of Mind. Links between children's *seeking* of peer collaboration and their Theory of Mind were smaller when both proxies for social reward were analyzed in parallel. As such, this study suggests mixed support for universalist's claims on the link between social motivation and Theory of Mind in the context of peer collaboration: while children exhibit notable cultural variation in both social reward and Theory of Mind, links between the two phenomena recurred across diverse cultural communities.

1.3 | The two social worlds of childhood social cognition

Social interactions with adults and peers provide children with often complementary opportunities for social learning and cognitive development, forming "two distinct social worlds" (Tomasello & Gonzalez-Cabrera, 2017, p. 283; referring to Piaget, 1965). Adults are central sources of physical and emotional care in early and middle childhood. Moreover, parents' use of mental state talk and their goals and practices predict their children's false belief (Kuntoro et al., 2017; Laranjo et al., 2014; Meins et al., 2002). Notably, parental mind-mindedness accounts for variation in Theory of Mind both within and across urban cultural communities (Hughes et al., 2018). In Germany, toddlers have been found to understand pointing gestures from adults before they understand similar cues from peers, highlighting that adult-child interactions are particularly relevant for early socio-cognitive development in this community (Kachel et al., 2018, 2021). Adult caregivers crucially shape children's social experience and learning, such that social motivations biasing children to engage with adults can be considered critical for Theory of Mind development.

At the same time, the more egalitarian nature of peer interactions allows children to negotiate and exchange social perspectives on equal footing, providing an alternative yet rich source for socio-cognitive development (Piaget, 1932). Children with siblings often exhibit early-emerging Theory of Mind development (Lewis et al., 1996; McAlister & Peterson, 2007), suggesting that not only adults but also their siblings provide them with important opportunities for refining their socio-cognitive repertoires. Furthermore, children's cooperative play with their siblings predicts their false belief understanding (Dunn et al., 1991), suggesting a promotive causal role of peer interactions in socio-cognitive development. One may thus speculate that also children's social motivation for engaging with peers might foster childhood social cognition. Importantly, the effects of siblings on Theory of Mind development have failed to generalize to children outside the urban Global North (De Gracia et al., 2016; Shahaeian, 2015; Shahaeian et al., 2011), again highlighting the role of sampling diversity to permit generalization of research findings outside the communities under investigation.

In the current study we explored three research questions. First, we tested the link between social motivation and Theory of Mind among Namibian Hai||om children, predicting that children's social motivation, assessed through children's preference for social stimuli (i.e., faces of adults and peers; see Burnside et al., 2018) compared to non-social yet potentially rewarding stimuli (i.e., swings), would predict their false belief understanding. Second, we explored whether such links would be sensitive to the characteristics of the social stimuli. More specifically, we tested whether effects of children's social motivation varied across adult and peer stimuli (Kachel et al., 2021; Stengelin et al., 2022). We were agnostic as to whether children's preference for peers as compared to adults' faces would better predict their false belief understanding. Finally, we addressed methodological concerns of previous work (Stengelin et al., 2020b, 2020c; see also Brandl, 2021) assuming that Hai||om children might better demonstrate their false belief skills when presented with adjusted task demands on response inhibition and production (Setoh et al., 2016; see also Grosso et al., 2019; Scott et al., 2020) compared to standard measures of false belief.

2 | METHODS

2.1 | Participants

We tested $N = 59$ Hai||om children (29 girls) aged 2.3–8.0 years ($M_{age} = 5.45$; $SD_{age} = 1.65$) residing in two small-scale communities in Oshikoto region, Namibia. We tested an additional $n = 6$ children but excluded them from further analyses because they were older than our intended age range ($n = 1$) or because we could only gather data for the social motivation task, but not the false belief task ($n = 5$). We included all children who were available and motivated to participate and whose parents gave their consent during a research stay in Namibia in February and March 2019. We also administered the tasks with children from a neighboring Ovambo community using a similar procedure, but did not obtain usable data from this community due to translation issues. Ethics approval was granted by Leipzig University

(reference number 169/17-ek) with support from the Ministry of Home Affairs and Immigration in Namibia and the Working Group of Indigenous Minorities in Southern Africa (WIMSA).

2.1.1 | Cultural context

The Hai||om are traditionally semi-nomadic foragers living in and around the Etosha Pan in northern Namibia. Along with other San communities, such as the Khwe and Ju|'Hoansi, the Hai||om are the indigenous people of Namibia. In the 1950s, they were expelled from today's Etosha National Park to promote tourism and economic development in the area. Since then, they settled in communities and farms to the south and east of their ancestral lands. They speak a dialect of Khoekhoegowab, which is part of the Khoisan language cluster. The current research forms part of a multi-year, ongoing research collaboration between the hosting communities and the research team (see Dieckmann et al., 2014; Friederich & Lempp, 2014; Widlok, 1999; for further ethnographic detail).

The child participants in this study came from two rural communities in the Oshikoto region of Namibia. Community A hosted about 300 Hai||om individuals on a cattle farm located approximately 50 km from the nearest settlement. Community B was home to around 800 people as part of a governmental resettlement project, focusing on vegetable and animal husbandry. This community is situated about 20 km from the next larger settlement. Social and familial ties between these communities exist, with visitors regularly traveling by foot between settlements—a day's journey by foot through the dry savannah bushland.

The current lifestyle in these communities combines different subsistence strategies, including gathering bush food and hunting small game, although hunting larger animals is legally prohibited. Additionally, some Hai||om engage in occasional wage labor on farms and small-scale gardening. The communities lack regular shops, and transportation to other areas is infrequent and depends on occasional hitchhiking opportunities. Primary schools are present in both communities, but there is no formalized education before the age of six. Reports from teachers at the time the research was conducted indicated low school attendance among older children. Children live in large, multi-generational households with an average of 9.4 individuals, engaging with siblings and peers for the most part of their daily lives (Bohn et al., 2024).

As is typical for the San and other hunter-gatherer communities, the Hai||om emphasize individual autonomy, demand sharing, and egalitarianism as fundamental cultural schemas guiding social exchange (Barnard, 2002; Hewlett, 2016). These schemas are also reflected in childhood socialization (Barry et al., 1959). For example, Hai||om children have been shown to share resources in an egalitarian fashion, placing less emphasis on merit or ownership compared to children from urban, industrialized communities (Kanngiesser et al., 2019; Schäfer et al., 2015). Additionally, these children demonstrate more autonomous and individual social learning strategies compared to their counterparts in the Global North, who tend to emphasize high-fidelity (over-)imitation (Stengelin et al., 2019, 2020a). Ethnographic research indicates a moderate belief in the opacity of the mind among the Hai||om (Widlok, 2009, 2023) and other San communities (Laws, 2023). While reasoning about mental states is not culturally prohibited, individuals often emphasize the inaccessibility of others' motives and beliefs, reflecting a respect for personal autonomy and the subjectivity of behavior and thought. For instance, in Hai||om storytelling, tricksters and deceivers frequently appear as ambivalent "agents of creativity" whose ultimate intentions remain somewhat ambiguous (Friederich & Lempp, 2014; Guenther, 2002; Schmidt, 2018).

Hai||om children have been found to prefer individual activities over peer collaboration when given the choice between the two (Stengelin et al., 2020b). To our knowledge, two studies have investigated Theory of Mind development in these communities with mixed results. On one hand, Hai||om children have been found to struggle with culturally adapted versions of classic explicit Theory of Mind tasks, showing no robust false belief understanding by their late preschool years (Stengelin et al., 2020b). On the other hand, these children demonstrated selective mistrust towards peer competitors from around age five, indicating a sophisticated understanding of false belief by anticipating deception from competitors (Stengelin et al., 2020c).

In summary, the cultural context of the Hai||om provides a valuable contrast to urban, industrialized communities, helping to test the generalizability and universality of developmental research (Amir & McAuliffe, 2020; Norenzayan & Heine, 2005). Moreover, the combination of cultural variables relevant to Theory of Mind development among the Hai||om—such as high levels of psychological autonomy, large household sizes, modest opacity of mind beliefs, and low emphasis on formalized education—offers a unique perspective on socio-cognitive development more specifically.

3 | STUDY DESIGN AND MATERIALS

Children participated in two tasks on the same day. First, they engaged in a social reward task, then in a false belief task reflecting the causal framework motivating the current investigation. Both tasks were assessed in classrooms at local school buildings. Children could sit on their caregivers' laps if they preferred to do so ($n = 22$, mostly younger children) or engage in the study without their caregivers being present ($n = 37$). If caregivers were present, they were instructed to remain neutral and not to affect children's responses. None of the caregivers intervened in their children's behaviors. The study was preregistered on the Open Science Framework (Social Reward Task: https://osf.io/5v72x/?view_only=6470375218ec4088a38ffdbbaba0c2ef; False Belief Task: https://osf.io/vszaw/?view_only=f5ddab7a649e4de9b2ecf17ebfdc1dca), including our aim to link children's performance on both tasks. However, we chose to analyze data using a different approach due to reasons outlined in the Data analyses section. Thus, the current research should be treated exploratory, rather than confirmatory.

We assessed children's social reward using a tablet-based task (see Ruta et al., 2017) in which they were repeatedly given the choice between seeing a social or non-social stimulus by pressing one of two buttons on a touchscreen. This task taps into different aspects of social reward responsivity, including children's liking, seeking, and learning of social rewards. The original task has successfully applied to detect variation in social reward among children with and without autism spectrum diagnosis (Ruta et al., 2017) and relates to children's social skills, thereby indicating validity in tapping social reward responsivity (Dubey et al., 2022). While Hai||om children have little exposure to touchscreens and other electric devices, recent research indicates that stimulus presentation and response collection via touchscreens is intuitive and efficient in this community (Bohn et al., 2024). We used a Huawei MediaPad T3 (9.6″) with an android application (code available at: https://gitlab.com/SCR_TAG/social-reward-public). The tablet was placed on a tripod on a table such that children could easily attend and operate the touchscreen. As social stimuli, we used portrait photos of unfamiliar Hai||om adults and children from neighboring communities. All social stimuli depicted individuals with neutral facial expressions. Children were always presented with same-gender stimuli. We used two different stimuli per combination of stimulus age and gender and counterbalanced these stimuli across children. As non-social stimuli, we used two photos of swings (one per trial block/condition), assuming that this would carry reward value for children of the tested age range as a culturally-appropriate, non-social stimulus. As training stimulus, we used a photo of a tree. All images were matched in size and presented in greyscale on a white background. Stimuli were shown for two to four seconds (randomized per trial). The interstimulus interval between button presses and stimulus presentation was also between two and four seconds (randomized per trial).

Children's false belief understanding was assessed using two table-flipcharts on which stimulus materials were presented as a large, double-sided picture book (see also Setoh et al., 2016 for a similar task and set-up). We independently counterbalanced the location of the correct slide for *Practice Trials* and *Test Trials* across children (left vs. right). Following the false belief task, we piloted other similarly structured tasks aiming to tap other Theory of Mind-related concepts, such as diverse desires or knowledge access. These tasks are not detailed out in the current manuscript.

For both tasks, instructions were given in Hai||om by an adult male experimenter. Instructions were independently translated from English into Hai||om by two research assistants (one of them being the experimenter). Disagreements between translated versions were discussed among both research assistants and the first author.

3.1 | Procedure

3.1.1 | Social reward task

Children were invited into the study room with or without their caregivers and were asked to sit down on a chair or on their caregiver's lap, facing a tablet on a table next to them. A local male experimenter directed children's attention to the tablet and started the testing application by pressing a button on the screen. A white button appeared on one side of the screen and the experimenter explained to children that they could watch images by pressing buttons. Then, each child went through two training phases. First, children learned contingencies between button presses and image appearance. During four training trials, a white button appearing on the left- and right-hand side of the screen. Following the children's button press, the button disappeared and a training image of a tree appeared at the same location on screen. In the second training phase, children were introduced to contingencies between button color (red or blue) and stimulus type (social or non-social, contingencies counterbalanced across children). During four trials, a blue (or red) button appeared on one side of the screen and children learned that one button color would predict images of social stimuli (adult faces or peer faces, counterbalanced across sessions) whereas the other color would predict a non-social stimulus (i.e., swings). Each color was presented on either side once during this phase.

In the test phase, children were simultaneously presented with both buttons (blue and red) appearing side-by-side on screen (see Figure 1A). Here, color contingencies from the second training phase were maintained. The experimenter told the child that "Now it's your turn! You can decide which button you want to push". Every child was presented with two blocks (8 trials per block, 16 trials in total). Each block presented a different social stimulus (adult faces or peer faces). The non-social stimulus was semantically similar across blocks, but different swings were displayed across blocks. Within each block, each button appeared equally often on both sides of the screen (location being pseudo-randomized across participants). Every child saw the button of each stimulus category (social or non-social) four times on each position on screen. Between test blocks, children were encouraged to leave the study room for a short break while the experimenter set up the second block of the social reward task (featuring the respective other social stimulus). In total, the social reward task took about 10 min.

3.1.2 | False belief task

After a break, children were re-invited to the study room and sat on a chair where the experimenter stated that "Now we will listen to some stories. Watch carefully!". Children faced a desk on which two flip charts were arranged (Setoh et al., 2016; see Figure 1B). The experimenter flipped the first page, and a photo of a young female adult was presented at the central position (*Story Trial 1*). While flipping the page, the experimenter stated that "This is a story about a girl named Maria—Look! There is Maria!". On the second page, Maria was depicted taking an apple out of a bowl ("Maria finds an apple in a bowl."; *Story Trial 2*). Next, two photos were presented side-on-side depicting an apple and a banana. This *Practice Trial 1* evoked a response from participants without posing any demands on their Theory of Mind, thus serving as a response training.

Story Trial 3 depicted Maria putting her apple in a box ("Maria puts her apple in a box for later."), before she would turn away from the scene holding a ball in her hands in *Story Trial 4* (*"Then she goes outside to play ball"*). Again, two photos were placed next to each other in *Practice Trial 2* depicting a ball and a book, while the experimenter asked the child "Where is Maria's ball?".

Story Trial 5 depicted a second agent, Anna, holding the apple as if she was taking it out of the box ("When Maria is gone, her friend Anna finds the apple and takes it away."). Next, *Story Trial 6* depicted Maria again ("Maria is hungry. She comes home to look for her apple."). In a final *Test Trial*, two photos were presented side-by-side. One photo depicted Maria approaching the bowl, and the other photo depicted her approaching the box. The false belief test question at this stage was "Where will Maria look for her apple?".

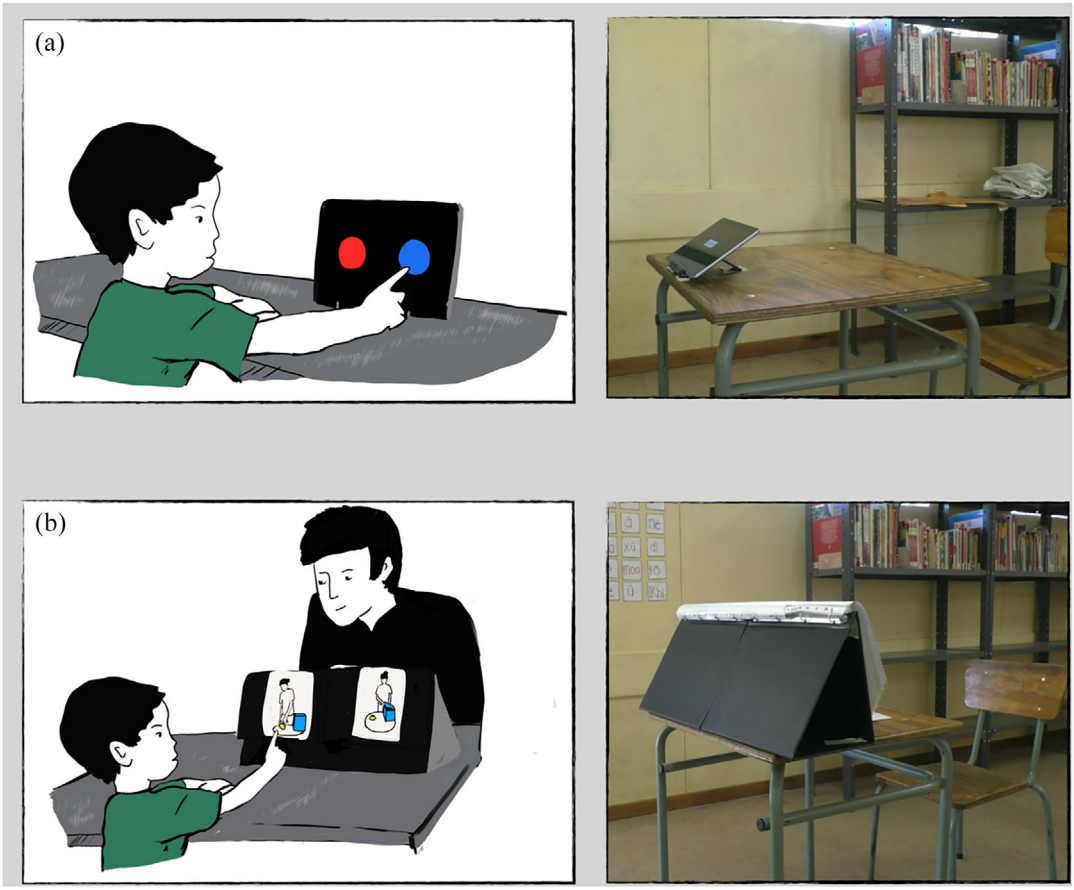

FIGURE 1 Setup during the two study phases with schematic illustrations (left panel) and screenshots of the study setting (right panel); (A) tablet-based social motivation task; (B) picture-book-based false belief task.

3.2 | Coding

3.2.1 | Social reward task

Children's touch responses (social button presses vs. non-social button presses) were automatically recorded. We calculated the number of social button presses per all 8 trials within each block. For statistical analyses, we created a sum score of each child's social button presses throughout all 8 test trials per block (i.e., social stimulus category: adult or peer). The score could range from 0 (indicating no social button presses) to 8 (indicating social button presses only for a given block/condition).

3.2.2 | False belief task

We coded children's responses to the final trial as either correct or false. To do so, the first author and two Namibian research assistants watched videos together and made a mutual decision. Correct responses could be indicated by children's pointing (i.e., pointing to the corresponding photo), touching (i.e., touching the corresponding photo), or verbal utterances indicating their response (i.e., "in the box" vs. "under the bowl"). All responses were clear, leading to full agreement between coders.

3.3 | Data analysis

In the following, independent (i.e., fixed effect predictors and controls) and dependent/outcome variables are in *italics*. To investigate effects of our predictors *Age and Social Reward* (of both adult and peer stimuli) on the outcome *False Belief Understanding*, we fitted a Bayesian logistic regression using brms (Bürkner, 2017, 2018) in R (R Core Team, 2020). We centered Age around zero and treated Social Reward as a monotonic (i.e., ordinal), rather than metric predictor. We did so to gain more conservative estimates of the effect of this variable, following our visual inspection of the data which indicated that many children converged on similar scores for this variable (i.e., 4 social button presses, which reflects half of trials) whereas only few children scored at the extremes of these variables. Thus, a monotonic predictor allowed us to reduce the leverage of these extreme datapoints on slope estimation while pooling information on the general direction of effects across the range of children's social reward scores. We also included children's Sex (*M, F; centered around zero*) as a control variable. For the intercept, we used a normal prior with a mean of 0 and a standard deviation of 1.5. This assigns about 95% of the prior weight to intercepts such that when all other variables are equal to zero, the probability of *False Belief Understanding* is between .05 and .95, putting most weight on probability values of .50, which makes the model more skeptical of very low or very high probabilities. We applied a similarly conservative strategy to define priors for the fixed effects, using normal priors with a mean of 0 and standard deviations of 1.5 for *Social Reward* in both conditions and *Sex*, and 1.5/4 = .375 for Age (values of which span a range roughly four times wider than the other variables). These assign about 95% of the prior weight to slopes such that any individual variable is able, when varying over its full range, of shifting the *False Belief Understanding* probability roughly half-way along the scale from .05 to .95. We chose these priors rather than using default (flat) priors as a conservative approach since we had not detailed out choices of priors in a preregistration.

To estimate effects of both predictors on children's *False Belief Understanding*, we compared the predictive accuracies of different statistical models. First, a $\text{Model}_{\text{Adult+Age}}$ included the fixed effects of *Age*, *Social Reward* [Adult Condition], and *Sex*. Second, a $\text{Model}_{\text{Peer+Age}}$ comprised of the fixed effects of *Age*, *Social Reward* [Peer Condition], and Sex. At first, these models' predictive accuracies were compared to a $\text{Model}_{\text{Null}}$ comprising of a fixed effect of Sex only. To further distinguish between potential effects of *Age* and *Social Reward on False Belief Understanding*, we then compared these models to a $\text{Model}_{\text{Age}}$ including only fixed effects of *Age* and *Sex*, but not *Social Reward*. To compare predictive accuracies of these models, we compared model WAIC and leave-one-out cross-validation (LOO) weights (Vehtari et al., 2017). Note that weights weigh up to 1, with higher weights indicating better predictive accuracy of the respective model. To further estimate fixed effects of *Age* and *Social Reward on False Belief Understanding*, we plotted posterior means and corresponding 95%-CI for each predictor.

As noted above, this approach emerged after collecting the data and was hence not detailed out in a preregistration document. Consequentially, the following results should be treated as exploratory and require further replication. We had to change our analytic approach as we could not gather data from other cultural communities beyond the Hai||om (data was collected in 2019 prior to the COVID pandemic) and in response to the skewed Social Reward Task data to which we responded with by fitting the corresponding variable as a monotonic, rather than linear predictor. We also explored whether links between social reward responsivity and false belief depended on caregivers' presence following a similar analytic approach of comparing WAIC and LOO weights of models with and without this predictor.

4 | RESULTS

Children's social button presses in the social reward task varied considerably across individuals in both the adult and peer condition. Across conditions, children showed no clear preference for either social or non-social stimuli ($Mode_{Adult\ Condition} = 4, Median_{Adult\ Condition} = 4; Mode_{Peer\ Condition} = 4, Median_{Peer\ Condition} = 4$). Nevertheless, some children in both conditions showed individual-level preferences ($\text{Range}_{\text{Adult Condition}} = 0–8; Range_{Peer\ Condition} = 0–8$), such as

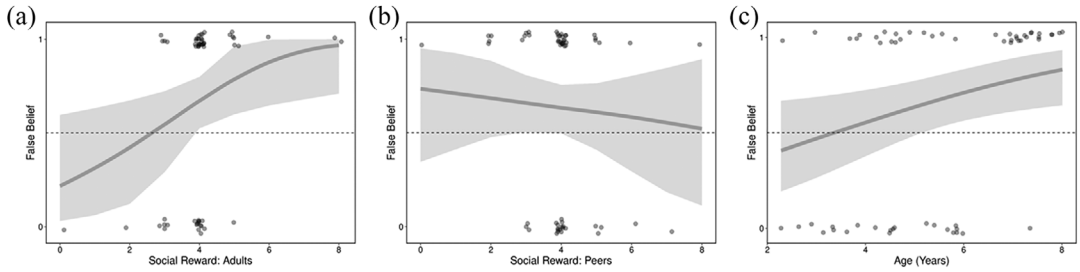

FIGURE 2 Conditional Effects of (A) Social Reward responsivity [Adult], (A) Social Reward responsivity [Peer], and Age (years) on children's False Belief Understanding. Social Reward responsivity scores reflect the number of social button-presses per trial block (0–8). False belief scores of 1 indicate that children solved the task; grey areas indicate 95%-Credible Intervals, horizontal dotted line indicates chance level. Dots represent raw data jittered on the *X*- and *Y*-Axis (A, B) or only on the *Y*-Axis (C) for better visualization.

exclusively pressing cues representing either social or non-social stimuli. With regards to children's false belief understanding, more than half of the children (37/59) anticipated that Maria would look for her apple in the box, thereby ascribing to her a false belief about the true location of the apple (see Figure 2 for an illustration of the raw data).

The $Model_{Adult+Age}$ (WAIC weight: .97; LOO weight: .97) outperformed the $Model_{Peer+Age}$ (WAIC weight: .03; LOO weight: .03) and the $Model_{Null}$ (WAIC weight: .00; LOO weight: .00), indicating that the combined fixed effects of *Social Reward* [Adult Condition] and Age increased the model's predictive accuracy. To tease apart the effects of both predictors, further analyses revealed that the $Model_{Adult+Age}$ (WAIC weight: .94; LOO weight: .94) outperformed not only the $Model_{Peer+Age}$ (WAIC weight: .03; LOO weight: .03), but also the $Model_{Age}$ (WAIC weight: .04; LOO weight: .04). As such, this analysis indicates a significant effect of *Social Reward* [Adult] on *False Belief Understanding* beyond an effect of *Age*.

Finally, we tested for developmental variation in children's *False Belief Understanding* beyond the effect of *Social Reward* [Adult]. The $Model_{Age}$ (WAIC weight: .99; LOO weight: .99) indicated much better predictive accuracy than the $Model_{Null}$ (WAIC weight: .01; LOO weight: .01), providing strong evidence for developmental variation in Hai||om children's *False Belief Understanding*.

Closer inspection of the conditional effects of the $Model_{Adult+Age}$ indicated that children showing higher *Social Reward* (i.e., more social button presses in the adult condition) also showed greater *False Belief Understanding* (see Figure 2A). No credible evidence for such an effect of *Social Reward* was observed for the $Model_{Peer+Age}$ (see Figure 2B).

We found no evidence for systematic variation in these effects based on whether or not caregivers were present throughout the study ($Model_{Adult+Age}$: WAIC weight: .62; LOO weight: .63; $Model_{Adult+Age+Caregiver\ Presence}$: WAIC weight: .38; LOO weight: .37; $Model_{Peer+Age}$: WAIC weight: .64; LOO weight: .65; $Model_{Peer+Age+Caregiver\ Presence}$: WAIC weight: .36; LOO weight: .35).

Finally, as documented by the $Model_{Adult+Age}$, children's *False Belief Understanding* increased with *Age*, reaching above-chance levels by age 5 to 6 (see Figure 2C).

5 | DISCUSSION

Social motivation has been theorized to be an ontogenetic driver of Theory of Mind in child development (Chevallier et al., 2012) by biasing children to engage and learn from social interactions. Accordingly, to build their theories of others' minds, social interaction provides children with valuable input akin to scientific data that helps them form expectations about others' mind and behaviors. Children's tendencies to orient to social stimuli, find them socially rewarding, and to maintain social interactions, have been posited as distinct domains of a species-typical set of social

motivations (Chevallier et al., 2012). This developmental interplay of social motivation and Theory of Mind is considered an evolutionary adaption to the social niche of our species (Chevallier et al., 2012; Levinson, 2006; Tomasello et al., 2005). Yet, empirical research targeting the link between the two constructs is sparse and generalizations beyond available data remain limited due to lacking sampling diversity and representativity in developmental science (Draper et al., 2022; Nielsen et al., 2017).

The current research links one domain of Namibian Hai||om children's social motivation (i.e., their social reward responsivity; Chevallier et al., 2012; Ruta et al., 2017) and their false belief understanding (Setoh et al., 2016). These children grow up in a cultural context which markedly differs from urban middle-class families with regards to several aspects affecting early social development, including Theory of Mind. For example, peer interactions and self-dependent learning are more strongly emphasized compared to adult pedagogy and tuition. Individuals hold modest opacity of mind beliefs emphasizing the subjectivity and inaccessibility of motives and believes without prohibiting mental state thought and talk (Widlok, 2009, 2023). Prior research has shown that Hai||om children struggle with classic explicit Theory of Mind tasks (Stengelin et al., 2020b) while showing sophisticated socio-cognitive skills in non-verbal, behavior-based paradigms (Stengelin et al., 2020c).

In line with the Social Motivation Theory of Autism (Chevallier et al., 2012), our first research question asked whether interindividual variation in Hai||om children's preference for social stimuli predicted their false belief understanding. Indeed, our results support generalizations of this link beyond developmental science' standard participant pools to some rural, subsistence-based communities. Notably, these findings also align with another cross-cultural investigation (Stengelin et al., 2020b), revealing that children's positive expressed emotions during peer collaboration predicted their Theory of Mind across cultures.

Secondly, we asked whether links between social reward responsivity and Theory of Mind would vary across adult and peer stimuli. Children's preference for adult, rather than peer faces related to their false belief understanding. It is important to note that we had no directed hypothesis regarding such conditional effects. We thus highlight the need for further investigations, in particular conceptual and pre-registered replications of these findings. Our findings lend initial support to the idea that adult-specific social motivations may support children's Theory of Mind specifically as adults are sources of child-directed mental state talk and tuition in considering others' mental states (Roby & Scott, 2018; Taumoepeau, 2019; Taumoepeau & Ruffman, 2006). Hai||om emphasize psychological autonomy as a socialization goal such that children enter and navigate social interactions with peers and adults according to their own desires. Here, a motivational disposition to socially engage with adults may support children's Theory of Mind development or, more specifically, their performance in standard paradigms relying on verbal story comprehension by getting exposure to mental state conversations—directed at them or via eavesdropping. As such, one may speculate whether the distinct effects of adult, compared to peer faces, would replicate when investigating children's false belief based on non-verbal, exclusively behavioral tasks that resemble children's everyday social encounters more closely (Stengelin et al., 2020c).

Interestingly, children tested in the current study did not prefer social over non-social stimuli. At first glance, this opposes the widespread assumption that typically-developing children perceive social stimuli as intrinsically rewarding (Chevallier et al., 2012). On the other hand, the current pattern replicates the finding by Ruta and colleagues (2017) and aligns with prior research in which Hai||om children did not show a motivational bias for peer collaboration over individual activity (Stengelin et al., 2020b). In any case, it is important to note that our findings are restricted to the stimuli we employed: we used pictures of swings as competing, non-social stimuli, which might hold high reward value for children. In their original study, Ruta and colleagues (2017) employed pictures of toys as competing non-social stimuli. Since crafted and dedicated toys are rare among the Hai||om, we decided to use swings as stimuli after discussions with the local research team. Note that the social reward task was not applied to reveal community-level biases in social versus non-social motivation. Instead, it aimed to capture individual variations in the extent to which children actively seek social interaction. Therefore, it is not appropriate to make general statements about Hai||om children being more or less responsive to social rewards based on these findings. It may well be that patterns of social reward

responsivity would have been different if we had employed other social reward stimuli (e.g., videos of social agents, familiar individuals) or non-social reward stimuli (e.g., toys, animals).

Our third research question targeted whether the false belief paradigm we employed would reveal false belief understanding in Hai||om akin to developmental trajectories typical for children in urban, industrialized communities. Indeed, we found that older children showed more sophisticated false belief understanding than their younger counterparts. From around 5 years of age children mastered the false belief task above chance levels. At first glance, this finding is not surprising as it mirrors decades of research in diverse cultural communities (Callaghan et al., 2005; Wellman et al., 2001). However, prior research among the Hai||om indicated little developmental progress in explicit false belief understanding and other Theory of Mind facets when tested with standard paradigms imposing higher demands on pretense, verbal comprehension, and response production (Stengelin et al., 2020b; see also Mayer & Träuble, 2015, 2013; Dixson et al., 2017). Such tasks typically require children to listen to stories told by adults and respond to rhetorical questions, a pedagogical setting that is highly unusual for the Hai||om and many other cultural communities worldwide. To address these challenges, we adopted an explicit false belief task developed by Setoh and colleagues (2016), which effectively reduces these demands by supporting children's story comprehension with visuals and providing response training. This approach has been successfully replicated in previous studies (Grosso et al., 2019; Scott et al., 2020), and similar materials have been applied in prior cross-cultural research on early false belief understanding (Barrett et al., 2013). By reducing the demands on response inhibition and production, this paradigm facilitated children's performance and revealed a steady developmental increase in children's false belief understanding.

Reiterating previous calls (Greenfield, 1997; Jukes et al., 2024; Broesch et al., 2020; Callaghan et al., 2005), we emphasize the importance of carefully adopting and adjusting experimental paradigms from psychological research for cross-cultural use. Many of the standard paradigms in developmental science heavily rely on children's attention and responding to adult tuition, a setting for which Western child-directed pedagogy lays much groundwork. In the absence thereof, however, Hai||om and other children growing up in subsistence-based and indigenous communities face additional challenges rendering cultural comparisons methodologically unfair and scientifically inadequate without detailed contextualization. Culturally-informed method development and innovation as well as systematic efforts to contextualize samples *and* methodologies will help moving forward in the collective aim of developmental psychology of being a global, as opposed to regional, science of human development.

5.1 | Limitations and outlook

This study establishes a link between social motivation and Theory of Mind by relying on specific proxies for these phenomena: preferences for social stimuli as a marker of their social reward responsivity as one key domain of social motivation (Chevallier et al., 2012; Berridge & Robinson, 2003) and false belief understanding as a proxy of Theory of Mind (Wellman et al., 2001). This operationalization provides a narrow perspective on much more multifaceted phenomena. For example, the current approach taps into different aspects of reward responsivity as it requires children to form an association between cues and stimuli and to choose between cues based on their preferences for the associated stimuli. Such combined assessments are commonly used in early child development research on social reward responsivity (Dubey et al., 2022; Thiele et al., 2021; Vernetti et al., 2018). A related version of the current elicited-choice paradigm has been shown to correlate with children's social skills in a U.K. community, suggesting that the task captures developmentally meaningful aspects of social reward responsivity. At the same time, the processes of reward responsivity tapped in this research—learning, seeking, and liking—are not necessarily interconnected (Dubey et al., 2022; see also Berridge & Robinson, 2003; Berridge et al., 2009) and may thus contribute differently to the current findings. Thus, further research is needed to dissect the components of social reward and social motivation more generally to understand their effects on childhood socio-cognitive development.

Moving beyond social reward, future research also needs to employ alternative measures of social motivation and Theory of Mind to conceptually replicate the current investigation and assess the extent to which the links

observed apply to other domains of social motivation and cognition. This will advance our understanding of how prior research and theory applies across cultures while capturing the nuances of social motivation and Theory of Mind as determinants of childhood social development.

Finally, given the exploratory character of this investigation, pre-registered study designs are needed to confirm the current conclusions in diverse societies. The Hai||om mimic other contemporary hunter-gatherer communities in some domains relevant to childhood social development, such as their emphasis on child autonomy, modest opacity of mind beliefs, and the predominance of peer settings in daily social life. Further targeted cultural comparisons are needed to iteratively dissect the contribution of these variables on childhood social cognition and motivation.

In sum, the present study suggests that while both social motivation and Theory of Mind vary across children's diverse, culturally mediated lifeways, they may nevertheless be linked in ways that are cross-culturally robust.

AUTHOR CONTRIBUTIONS

Roman Stengelin: Conceptualization; Methodology; Formal Analyses; Investigation; Resources; Data Curation; Writing—Original Draft; Project administration; Ljubica Petrović: Writing—Review & Editing; Maleen Thiele: Writing—Review & Editing; Robert Hepach: Conceptualization; Writing—Review & Editing; Daniel B. M. Haun: Conceptualization; Writing—Review & Editing; Funding acquisition.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data and script supporting the findings of this study are published with the manuscript and available on OSF.

ORCID

Roman Stengelin https://orcid.org/0000-0003-2212-4613
Maleen Thiele https://orcid.org/0000-0002-1695-1850
Robert Hepach https://orcid.org/0000-0003-4780-6549
Daniel B. M. Haun https://orcid.org/0000-0002-3262-645X

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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