SOCIAL PSYCHOLOGY

Early concepts of intimacy: Young humans use saliva sharing to infer close relationships

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Across human societies, people form "thick" relationships characterized by strong attachments, obligations, and mutual responsiveness. People in thick relationships share food utensils, kiss, or engage in other distinctive interactions that involve sharing saliva. We found that children, toddlers, and infants infer that dyads who share saliva (as opposed to other positive social interactions) have a distinct relationship. Children expect saliva sharing to happen in nuclear families. Toddlers and infants expect that people who share saliva will respond to one another in distress. Parents confirm that saliva sharing is a valid cue of relationship thickness in their children's social environments. The ability to use distinctive interactions to infer categories of relationships thus emerges early in life, without explicit teaching; this enables young humans to rapidly identify close relationships, both within and beyond families.

To become a competent member of society, humans must learn how the people around them are related to each other (*1*–*3*). Across cultures, people distinguish a special category of relationships, which we will call "thick" (*4*–*7*). Thick relationships feature strong levels of attachments, obligations, mutual responsiveness, and a feeling of oneness that is conceived in terms of shared bodily substance (*5*–*7*); they are often, but not always, between close genetic relatives (*8*–*12*). The fact that only some relationships are thick presents young humans with a problem: How do they identify which ones? For older children, distinct relationship categories can be explicitly verbally labeled (*13*). Anthropologists have claimed that younger children and even infants must be sensitive to how relationships are embodied in distinctive interactions (*14*, *15*). For example, interactions that involve deliberate consensual transfer of saliva, such as kissing or sharing food utensils, distinctively occur in thick relationships (*16*–*18*). Here, we applied experimental techniques from developmental science to test whether young children, toddlers, and infants do indeed infer that two individuals who share saliva are likely to be in a thick relationship.

In a first experiment, when presented with interactions between cartoon people, young children (experiment 1, N = 113, 5 to 7 years old, from an American urban environment) predicted that sharing utensils, or licking the same food item, would occur within nuclear families, whereas sharing toys and partitionable food would occur equally within friendships and families (χ^2 = 72.74, P < 0.001; Fig. 1) (*18*–*20*). Thus, young children recognize that saliva-sharing interactions distinctively occur within nuclear families.

In the next experiments, we tested whether toddlers and infants would predict that when two individuals have shared saliva, those individuals will be more emotionally responsive in future interactions (*1*). This experimental design was inspired by classic studies of vervet monkeys who heard a familiar juvenile in distress and looked toward that juvenile's mother, as if expecting her to respond (*21*). We used this design to test whether young humans use a brief observation of saliva sharing to infer a thick relationship between novel individuals whose genetic relatedness is unknown.

Toddlers (experiment 2A, N = 26, 16.5 to 18.5 months old) and infants (experiment 2B, N = 20, 8.5 to 10 months old) saw a central puppet alternately eat from the same orange slice with one actress (implying saliva sharing) and play ball with another actress (Fig. 2). Then they saw the puppet seated between the two actresses, expressing distress. We measured which actress participants looked toward first, and longer, as though expecting the actress to react to the puppet's distress. Both toddlers and infants looked first, and longer, toward the actress who had shared food and saliva with the puppet [first look: 2A toddlers, 20/26, BF_{10} (Bayes factor) = 10.796; 2B infants, 16/20, BF_{10} = 10.306; proportion look: 2A toddlers, mean = 0.774, BF_{10} = 149.377; 2B

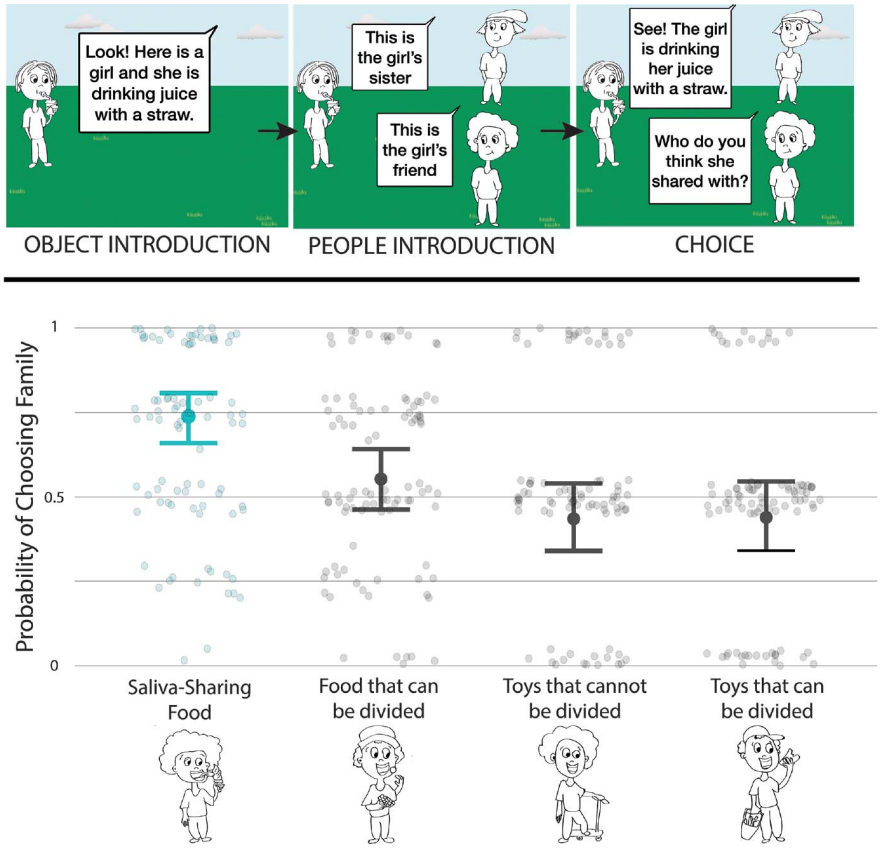

Fig. 1. Materials and results for experiment 1. Top: Sample images and text for one item of the storybook task. Bottom: Solid dots are average probability estimates of choosing family as opposed to friend in each condition. The bars are 95% credible intervals for each condition (controlling for multiple comparisons and participant age). Open dots are response rates from each individual child. Note that there were four items in each food condition and two items in each toy condition.

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infants, mean = 0.675, BF_{10} = 6.084]. These results were replicated in an independent sample of toddlers in the test condition of experiment 2C (N = 23) and an independent sample of infants in the test condition of experiment 2D (N = 24) (first look: $2C_{test}$ toddlers, 19/23, BF_{10} = 39.471; $2D_{test}$ infants, 22/24, BF_{10} = 2431; proportion look: $2C_{test}$ toddlers, mean = 0.788, BF_{10} = 3853; $2D_{test}$ infants, mean = 0.734, BF_{10} = 132).

Further experiments revealed that toddlers and infants looked toward the food- and saliva-sharing actress (i) only when the central puppet expressed distress and (ii) only when the puppet in distress was the actress' own thick relation. When the central puppet was removed, leaving only the two actresses, toddlers and infants looked at both actresses equally (Fig. 2) (*18*). When the central puppet was replaced by a new puppet, who then expressed distress, neither infants nor toddlers looked first or longer at the food sharer (first look: $2C_{control}$ toddlers, 11/26, BF_{01} = 3.108; $2D_{control}$ infants, 12/25, BF_{01} = 4.03; proportion look: toddlers, mean = 0.496, BF_{01} = 4.903; infants, mean = 0.470, BF_{01} = 4.46). These results suggest that toddlers' and infants' expectations concern the relationship, not the individuals' traits.

For experiment 2E, we recruited a larger, more economically, geographically, and racially diverse sample of toddlers (N = 118; age 14.5 to 19 months) (*18*). The familiarization events were the same. Then, the central puppet either expressed distress as before ($2E_{test}$) or asked for the ball ($2E_{control}$). When the central puppet expressed distress, toddlers looked first, and longer, toward the food sharer rather than the ball passer ($2E_{test}$, first look: 35/48, BF_{10} = 59.5; proportion look: mean = 0.65, BF_{10} = 1002). By contrast, when the puppet requested the ball, toddlers looked first and longer at the ball passer ($2E_{control}$, first look: 13/52, BF_{10} = 267; proportion look: mean = 0.37, BF_{10} = 54). These conditions differed decisively (first look: BF_{10} > 1000; proportion of time: BF_{10} > 1000). Thus, toddlers from a diverse range of households expect that two people who share food and saliva will respond to each other's distress, but not that they will be socially more responsive to one another in general.

In experiment 3, we isolated sharing saliva, without food, as the visible evidence of a thick relationship. Interacting with one puppet, a central actress put her finger in her own mouth, rotated it, put her finger in the puppet's mouth, rotated it, and finally returned her finger to her own mouth. When interacting with a second puppet, the actress performed the same rotating finger actions touching her own and the puppet's forehead. We then measured which puppet infants and toddlers looked toward, when the central actress expressed distress.

Toddlers (age 16.5 to 18.5 months) looked first, and longer, toward the puppet from the mouth-to-mouth interaction when the actress expressed distress (experiment 3A, N = 26, first look: 20/26, BF_{10} = 10.796; proportion look: mean = 0.746, BF_{10} = 477.6) (Fig. 3). These

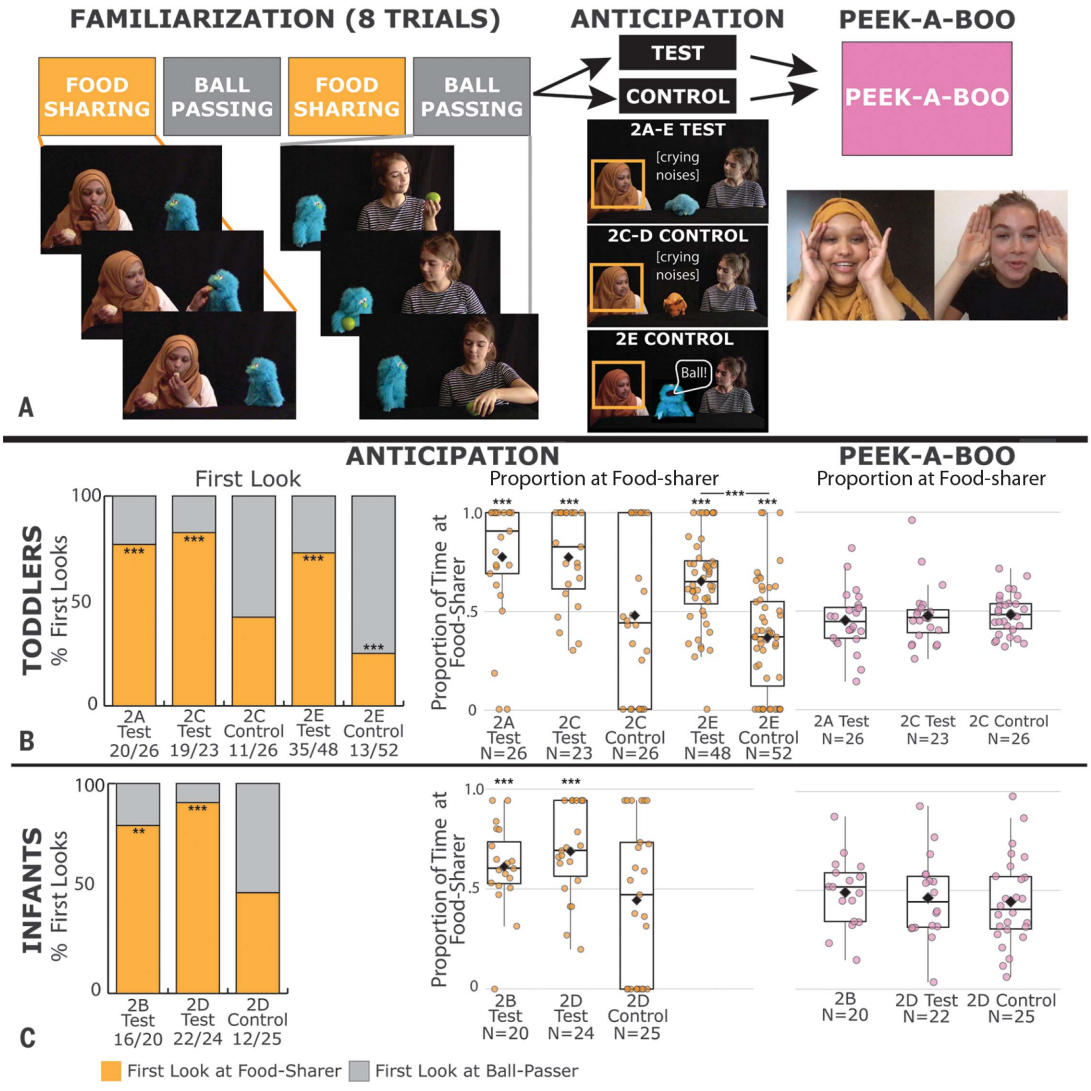

Fig. 2. Displays and results for experiment 2. (**A**) Experimental design flowchart and stills from videos used in experiment 2. The order of the familiarization trials (i.e., food sharing or ball passing first) and the identity of the food sharer were counterbalanced across participants. Participants were randomly assigned to the test or control condition. (**B** and **C**) Left: Percentage of participants who looked first toward the food sharer (orange) or ball passer (gray). Center: Proportion of time spent looking at the food sharer during the pause. Black diamonds are means; bars are medians. Right: Proportion of time that participants spent looking at the food sharer during the peek-a-boo trial. ***Bayes factor of >10. **Bayes factor of >8.

results were replicated in an independent sample of toddlers ($3C_{test}$, N = 31, first look: 25/31, BF_{10} = 91.15; proportion look: mean = 0.748, BF_{10} = 14,856). Infants' (age 8.5 to 10 months) first looks were distributed equally between both puppets (3B, N = 21, first look: 11/21, BF_{01} = 3.700; replication $3D_{test}$ N = 26, 14/26, BF_{01} = 3.886). Yet infants did look longer toward the puppet from the mouth-to-mouth interaction while the actress expressed distress (3B, mean = 0.631, BF_{10} = 1.55; replication $3D_{test}$, mean = 0.716, BF_{10} = 26.812).

Further experiments revealed that toddlers and infants looked toward the mouth-to-mouth puppet (i) only when the actress in distress was the person in the initial interactions, and (ii) only when the central actress expressed distress. In the control conditions of experiments 3C (N = 23) and 3D (N = 22), the actress was replaced by a new actor who expressed distress. Here infants and toddlers seemed to expect that the other puppet, who had the forehead-to-forehead interaction with the first actress, was more likely to react (toddlers $3C_{control}$, first look: 6/23, BF_{10} = 3.462; proportion look: mean = 0.364, BF_{10} = 1.023; infants $3D_{control}$, first look: 8/23, BF_{01} = 1.403; proportion look: mean = 0.252, BF_{10} = 88.72). An independent group of toddlers (experiment 3E) (*18*) looked toward the mouth-to-mouth puppet when the central actress expressed distress ($3E_{test}$, first look: 40/52, BF_{10} = 823; proportion look: mean = 0.690, BF_{10} = 71,669), but not when the actress uttered a nonsense word ($3E_{control}$, first look:18/45, BF_{01} = 2.43; proportion look: mean = 0.426, BF_{01} = 0.84). These two conditions differed decisively (first look: BF_{10} = 418; proportion look: BF_{10} > 1000). Thus, toddlers from a wide range of households expect saliva sharing to selectively predict responses to distress.

The results of experiments 2 and 3 suggest that when toddlers and infants observe two unfamiliar individuals sharing saliva, they infer that those people are in a thick relationship. A separate survey of parents (N = 129, experiment 4) (*18*) of infants and toddlers (age 8 to 19 months) from the same population suggested that this inference would be valid. The parents expressed comfort with their child having positive social interactions (e.g., playing, reading, hugging) with people in many different relationships, but they expressed comfort with saliva-sharing interactions (i.e., sharing a utensil, drinking from the same cup, kissing on the face) only in relationships the participants assessed as thick (BF_{10} > 1000; Fig. 4). In summary, saliva-sharing interactions provide externally observable cues of thick relationships, and young humans can use these cues to make predictions about subsequent social interactions.

Substantial prior research has shown that infants have an "intuitive psychology," supporting inferences about individuals' traits (e.g., cooperative, fair) (*22*–*24*), mental states (e.g., goals, perceptions) (*25*–*27*), and group membership (e.g., ethnicity, language) (*28*–*32*). By contrast, representations of social relationships

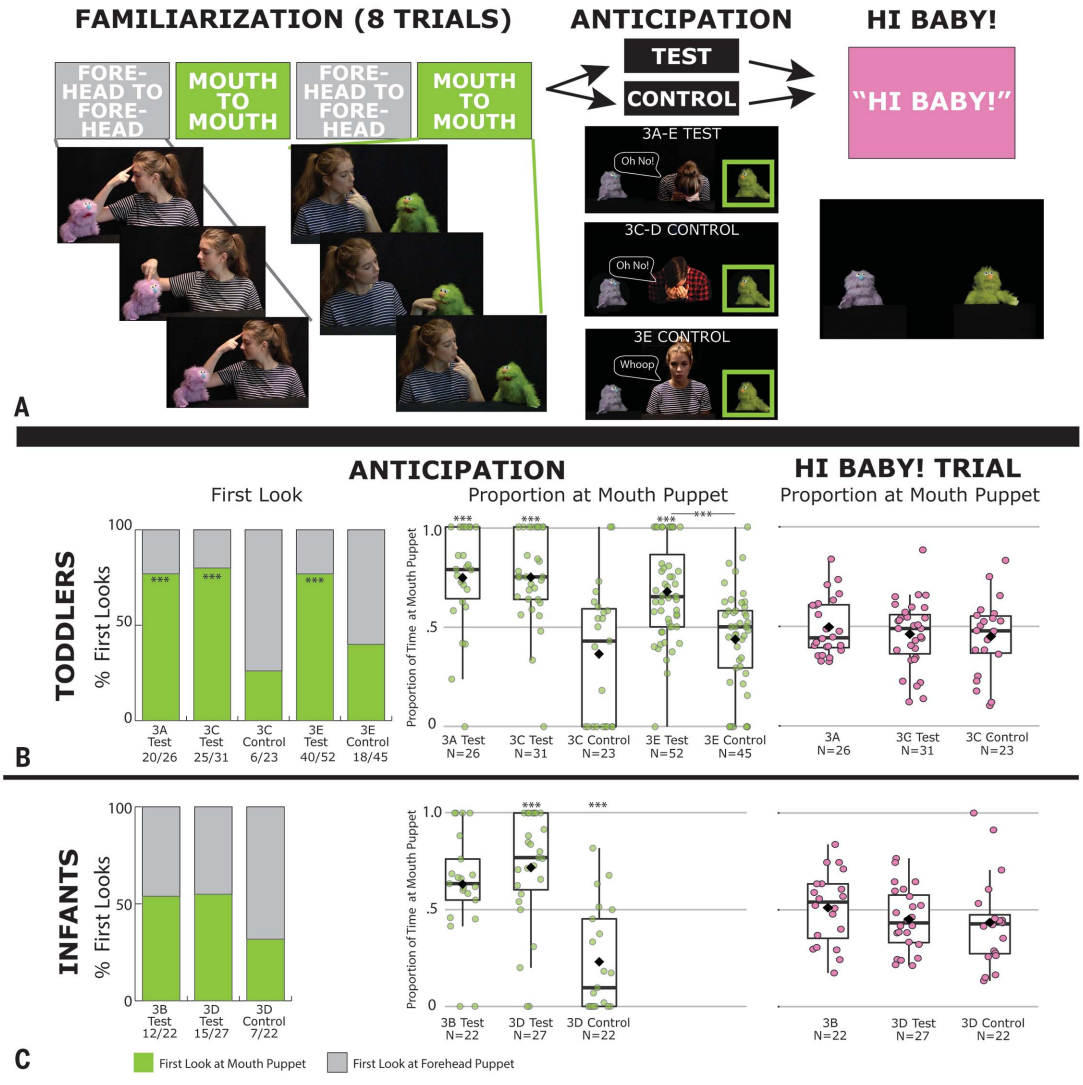

Fig. 3. Displays and results for experiment 3. (**A**) Experimental design flowchart and stills from videos used in experiment 3. (**B** and **C**) Left: Percentage of participants who looked first toward the puppet and who had engaged in the mouth-to-mouth interaction (green) or forehead-to-forehead interaction (gray). Center: Proportion of time spent looking at the mouth-to-mouth puppet during the pause. Black diamonds are means; bars are medians. Right: Proportion of time that participants spent looking at the mouth-to-mouth puppet during the "hi baby, hi" trial. ***Bayes factor of >10.

and social structures, which are a central concern of sociology and anthropology, have been relatively understudied using experimental techniques in infants (*33*–*35*). The key distinction revealed here, between thick and thin relationships, may be one foundation of infants' "intuitive sociology" (*1*, *2*).

School-aged children's judgments about saliva sharing are likely reinforced by explicit prohibitions (particularly during a pandemic), but similar intuitions appear to originate earlier and to generalize beyond the content of verbal rules motivated by hygiene (*18*). We hypothesize that an early intuitive distinction between thick and thin relationships allows infants to rapidly learn the distinctive behaviors that occur in these relationships in their social environment (*14*, *15*). These rapidly bootstrapped representations would be useful for parsing the small set of thick, intimate relationships from the larger set of thin, cooperative relationships in typical human social networks (*14*, *15*).

Our experiments have limitations. We have not established whether thick and thin relationships are conceived as qualitatively distinct categories [e.g., (*5*, *7*, *36*)] or as ends of a continuum, with close friends or confidants having a mixture of features (*37*, *38*). Saliva sharing is likely only one example of the set of interactions that children and infants can use to distinguish thick relationships from other cooperative relationships. Interactions distinctively occurring in thick relationships include confiding and emotional comforting, consensual exchange of blood, and touching of genitals (*15*). Infants may also have expectations about the social categories of the people in thick relations [for example, older women may be more likely than older men to be in thick relationships with infants (*39*)]. Conversely, some interactions involving transfer of saliva are aggressive and demeaning, such as spitting on a person (*18*). We have not established whether toddlers and infants can distinguish between saliva-sharing interactions that are consensual versus coercive.

Our evidence that young children, toddlers, and infants make distinctive inferences about thick relationships has broad theoretical implications. Anthropologists have stressed that thick relationships, characterized by strong attachment, obligation and mutual responsiveness, have highly variable mappings onto genetic relatedness (*10*, *40*). We have identified a proximal psychological mechanism that might allow infants to parse this variability (*1*, *3*). A consistent inferential mechanism, operating in diverse social and ecological settings, could enable young humans to rapidly acculturate to their local and culturally specific relationship and kinship structures. In sum, children, toddlers, and infants recognize saliva-sharing interactions as distinctive evidence of a thick relationship. The pattern of who does, and who does not, share saliva may help infants to distinguish those who are kin (e.g., parents, siblings, grandparents) versus non-kin (e.g., daycare teachers, nannies) among their many caregivers (*41*, *42*). Young humans may use observations of saliva sharing to inform their earliest understanding of the conceptual structure of family.

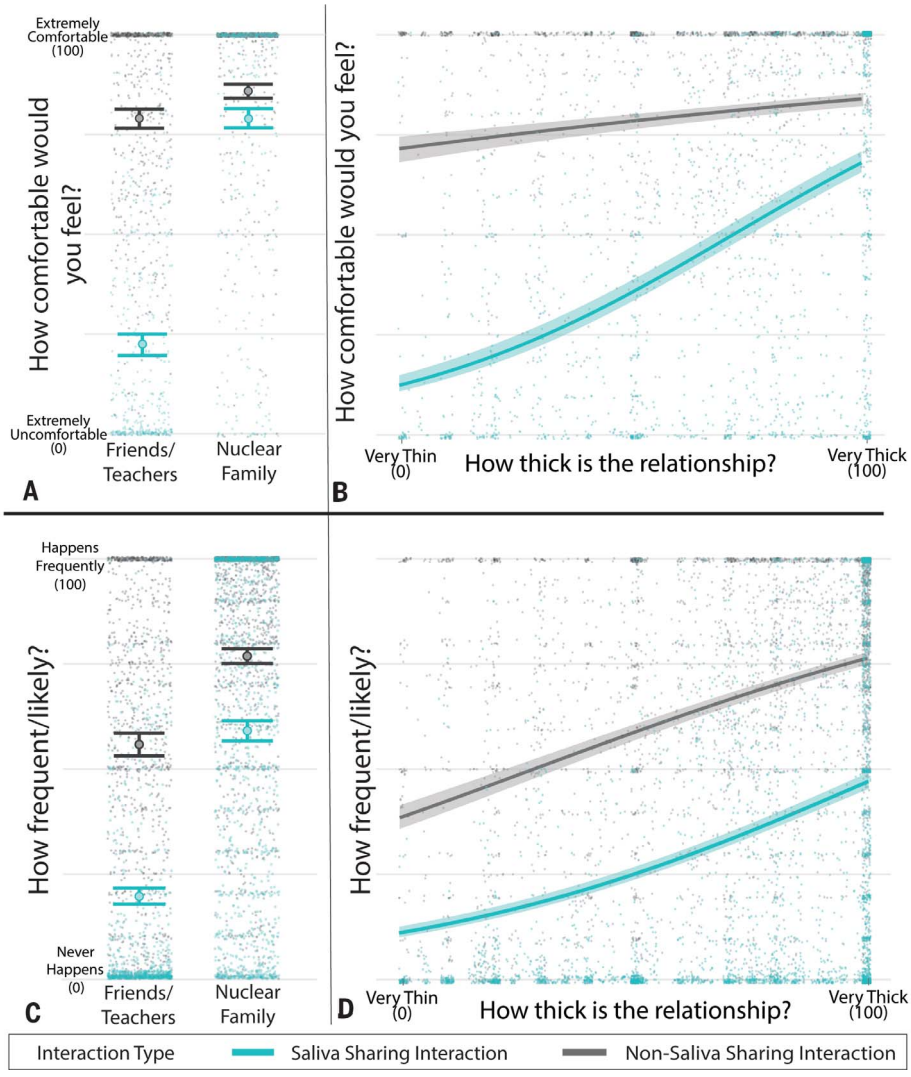

Fig. 4. Results for experiment 4. (**A** to **D**) Parent-reported comfort [(A and B)] and frequency [(C and D)] of saliva-sharing interactions, versus other caregiving and prosocial interactions, in their child's social environment as a function of relationship thickness. We operationalize relationship thickness as nuclear family [versus friends and teachers; (A) and (C)] or by directly asking parents to report the thickness of many of the child's relationships [e.g., including aunt, grandparent, etc.; (B) and (D)].

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SUPPLEMENTARY MATERIALS

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Materials and Methods
Supplementary Text
Fig. S1
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Science

Early concepts of intimacy: Young humans use saliva sharing to infer close relationships

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A kiss tells the tale

Young humans are remarkably helpless, relying entirely on the adult humans around them for survival. However, not all adults are as invested in the care of a particular child, and there is benefit in being able to determine from a very young age which relationships are close. Thomas *et al*. tested young children and infants to determine whether they were able to identify close, or "thick, " relationships based on whether individuals participated in activities that involve sharing saliva, such as eating, kissing, or sharing utensils (see the Perspective by Fawcett). The children expected relationships like these to be closer than other relationships, indicating that they can distinguish closeness very early in life. —SNV

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