Infants infer different types of social relations from giving and taking actions

Denis Tatone (TatoneD@ceu.edu)
Department of Cognitive Science, Central European University
7 Október 6. utca, 1051 Budapest, Hungary

Gergely Csibra (csibrag@ceu.edu)
Department of Cognitive Science, Central European University
7 Október 6. utca, 1051 Budapest, Hungary
Department of Psychological Sciences, Birkbeck, University of London
Malet Street, London WC1E 7HX, United Kingdom

Abstract

Anthropological observations suggest that specific sharing behaviors may predictably covary with specific relational contexts, and thus can be used as relationally informative cues. Given their limited social experiences, cultural novices, such as infants, should be particularly likely to rely on these cues to discover the relational makeup of their social surroundings on the basis of sparse observations. The present study examines a particular hypothesis derived from this proposal, namely that infants interpret giving as indicative of social relations based on the principle of even balance. By systematically contrasting infants' representation of giving to that of superficially similar taking events, we showed that 12-month-olds, despite being equally likely to infer dyadic relations from the observation of either transferring action (Exps. 1-4), infants encoded the direction of resource transfer only in the representation of giving (Exp. 5-6), and, conversely, transitively inferred novel relations only for social structures composed of taking relations (Exp. 7-8). We believe that the distinct inferences elicited by the observation of the two transferring actions reflects fundamental differences in the models regulating the relations respectively inferred: one (for giving) based on a principle of even balance, which motivates the monitoring of changes in resource flow in the ongoing relation; the other (for taking), based on a principle of social equivalence, which gives rise to transitive social structure.

Keywords: infant social cognition; giving and taking; relational models; looking times

Introduction

To navigate efficiently the social world, children must know how to identify and distinguish the social relations that this is composed of. Recent developmental evidence suggests that this operation may be supported by an early-developing grammar of social relations, which constrains learning and inference in the social domain (Thomsen & Carey, 2013). These relational primitives, or models (RMs), represent structured coordination systems that humans have been shown to universally use to regulate interactions in relationally distinctive ways (Fiske, 1992; 2004).

Each RM is by its own coordination rule, which specifies the relevant features of the relation to attend to, and is associated to a set of diagnostic cues that help identifying instances of these relations in the outside world. The RMs are: communal sharing (CS), authority ranking (AR), and equality matching (EM). CS is based on the principle of social equivalence; it prototypically regulates interactions among kin individuals, and is marked by behaviors highlighting the common essence of its participants (e.g., breastfeeding). AR is based on power or prestige asymmetries; it applies to relations between dominants and subordinates, and is communicated through the hierarchical positioning of individuals in time and space (e.g., standing above vs. below). Lastly, EM is based on the principle of even balance; it typically regulates mutualistic relations among nonkin individuals, and is made manifest through operations of even balancing (e.g., matching shares).

In the domain of sharing, the most prominent type of cooperative activity in the ethnographic record, each RM tends to be characterized by a specific way in which goods are exchanged over time (Favre & Sornette, 2015): generalized reciprocity (sharing without favor accounting) in CS; tributary donations and redistributive acts (upward and downward sharing, respectively) in AR; and contingent reciprocity (return-sensitive sharing) in EM (Fiske, 1992).

While relational inferences about the specific RM at work in any given relation may be drawn by attending to the distinctive properties of each exchange pattern (e.g., whether sharing is reciprocated or not), two reasons make these *diachronic* properties poor candidates as relational cues, especially for young learners. Firstly, they require multiple observations, hence considerable time and computational resources. Secondly, and more critically, they fail to provide a solution to the learnability problem, as they presuppose that children have already figured out which relationally informative properties to attend to.

A solution to this problem lies in the use of evolved priors: i.e., probability distributions of values set on the basis of evolutionarily recurrent covariations in the human social environment (cf. Moya, 2013). Reliance on such priors helps explaining how cultural novices, such as infants, can productively infer the type of social relations governing single interaction episodes.

A burgeoning developmental literature suggests that infants may be able to infer the nature of ongoing relations by attending to specific interaction cues. In the domain of AR, for instance, infants interpret dyadic interactions based on forceful expropriation, priority of access, and monopolization of rival goods as evidence of dominance relations (Mascaro & Csibra, 2012; Gazes, Hampton, & Lourenco, 2015).

Building on this literature, we argue that sharing behaviors may similarly exhibit relationally informative cues that infants could capitalize on. In particular, we suggest that infants may be prepared to interpret giving as indicative of EM relations. Such a proposal obviates to the lerneability problem highlighted above by conferring infants the ability to draw relational inferences on the basis of *local* (i.e., immediately perceivable) features of a sharing episode, such as the way in which the transfer of possession is carried out.

The conjectured diagnostic dependency between giving and EM rests on a trove of anthropological observations. Since Mauss (2002), acts of voluntary resource donation among nonkin have been traditionally linked to, and taken to convey, expectations of reciprocity. Critically, the obligation to return favors is absent from sharing practices that coexist alongside giving (e.g., redistribution via taking: Peterson, 1993). Such normative expectation is so deeply entrenched in the act of giving that becoming the recipient of an actively bestowed good is sometimes deliberately averted through the strategic use of intermediaries, such as children (Widlok, 2016). The psychological relevance of giving-based relations is also apparent in the languages of many foraging groups, which differentiate goods surrendered upon request from goods proactively delivered, the latter typically marked with particles denoting mutuality (Bird-David, 2015).

Consistent with this picture, it has been proposed that the evolution of giving among nonkin, a human-unique feature of primate sharing (Jaeggi & van Schaik, 2011), enabled the colonization of risky foraging niches by supporting mechanisms of social insurance against high-variance yield in the form of reciprocal exchange relations (Jaeggi & Gurven, 2013). Corroborating this claim, recent experimental evidence showed that adults spontaneously use active transfer to catalyze reciprocal-exchange relations with other players in a virtual foraging game (Kaplan et al., 2018).

Taken together, disparate lines of evidence suggest that giving, at least within the domain of nonkin interaction, constitutes a psychologically compelling cue of relations governed by normative expectations conforming to the logic of EM.

These observations give plausibility to our claim that infants may use this cue to infer relations based on EM principles – which, in the context of unilateral transfer events, take the form of reciprocal exchanges.

Two main predictions follow from this hypothesis. Firstly, insofar as giving is evidence of a long-term relation, it should be represented in a format that supports the tracking of its participants through time and contexts. This minimally requires encoding the identity of the sharing partners and the action relating them. Secondly, insofar as giving is, more specifically, a cue of EM relations, it should prompt the encoding of information relevant to the coordination rule associated to this model. Given that departures from even balance represent relationally relevant features of EM relations, we expect information functional to the tracking of such departures in the representation of giving. A host of information aids to such goal: the direction of transfer (*who* gave to whom), the magnitude of transferred resources (*how much* was given), and their value or kind (*what* was given).

In the present study we focus on the encoding of the direction of transfer. While a representation equipped solely with this type of information may not support sophisticated forms of mental bookkeeping, it nevertheless allows its users to detect changes of resource flow within the relation. Such a representation may constitute a precursor of the full-fledged monitoring of changing accounts of balance that the tracking of EM relations requires.

To assess the specificity of our hypotheses, we compared infants' reactions to kinematically identical giving and taking events. We tested 12-month-old infants, because at this age they have been shown to reliably distinguish between superficially similar giving and taking actions (Tatone, Geraci, & Csibra, 2015).

To briefly preview our experimental plan, we first tested whether infants can re-identify the participants of a giving or taking interaction in a reciprocation event (Exps. 1 and 2); we then examined whether they represented the specific action relating them (Exps. 3 and 4). Subsequently, we tested whether infants registered the direction of transfer for either transferring action (Exps. 5 and 6); and lastly, we tested whether they transitively inferred novel relations between members of open triadic structures based on giving or taking actions (Exps. 7 and 8).

General Procedure

All experiments consisted of 4 familiarization trials followed by 2 test trials. The familiarization trials showed three agents in a triangle-like configuration: two at the bottom (B and C), and one on top (A). Each familiarization trial showed B and C sequentially interacting with A via GIVING or TAKING. Each test trial showed two of the three familiarized agents interacting via GIVING or TAKING.

Stimuli and design

The stimuli were 2D animations presented on a LCD screen (40-inch diagonal). The three interacting agents were a dog (A), a bird (B), and a cat (C), moving on a green platform. There were also two identical red apples, one given and one taken (Figure 1).

Familiarization. There were two types of familiarization events: in the **common-agent** events (Exps. 1-2) A gave to B and took from C; in the **common-patient** events, B gave to A and C took from A (Exps. 3-6), or alternatively, both B and C gave to (Exp. 7) or took from A (Exp. 8). GIVING and TAKING actions were equated for duration, speed, and extent of motion. The identity of Givee and Takee, the order of giving and taking actions, and the initial location of Givee and Takee were fully counterbalanced across infants.

Test events. There were two types of test events: giving and taking. In the **GIVING test event**, one of the agents pushed an apple behind a screen, which slid away to reveal either of the other two other agents (one for each trial) as the Givee.

In the **TAKING test event**, one of the agents emerged from behind the screen pushing an apple towards the opposite side of the platform, until the screen slid away to reveal either of the two other agents (as potential Takee).

The test events were equated for length, speed, and extent of agent's motion. The order of events was counterbalanced across infants.

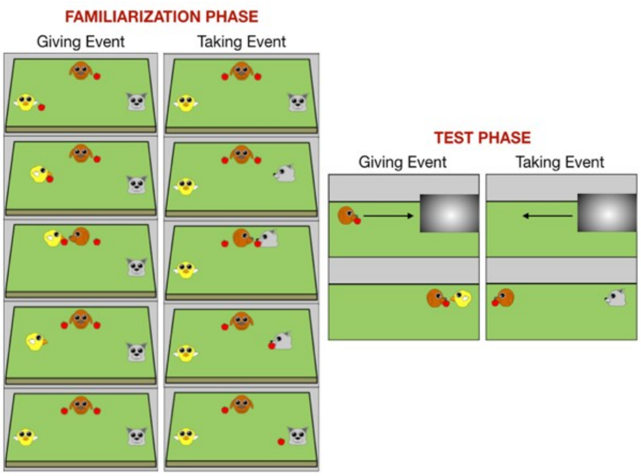

Figure 1. Schematic visualization of the animations used during familiarization and test (before and after the removal of the screen). All experiments featured the same number and type of agents and objects. Black lines indicate the motion path of the agents at test.

Coding and data analysis

The looking-time data were coded off-line. To be included in the final analysis, infants had to attend to each transferring action for at least 50% of its overall duration in all trials. Looking times during test trials were measured from when the screen started sliding away until the infant looked away for more than 2 s or looked cumulatively more than 60 s. Despite resulting in a sizable number of excluded infants per experiments (6.12 on average), such stringent inclusion criteria were required to guarantee sufficient exposure to the relevant events, given the short exposure that infants received to the relevant interactions (4 giving vs. taking events) during familiarization. For similar criteria, see Tatone et al. (2015).

Data were log-transformed before being subjected to conducted both Bayesian and frequentist statistical analyes. For the Bayesian analysis, we used the method recommended by Csibra et al. (2016).

There was no effect of test trial order on infants' looking in any of the experiments, and no difference in how long infants attended to each action during familiarization. For this reason, we do not report these analyses.

Design and hypotheses for Exps. 7 and 8 were preregistered at the OSF [https://osf.io/psxtu].

Experiment 1

Exp. 1 tested whether infants inferred the presence of a dyadic social relation from the observation of GIVING by testing whether its representation allowed them to re-identify its participants in a reciprocation event. If so, infants should find reciprocal GIVING among previous sharing partners (Reciprocation) more compatible with the inferred relation than GIVING between the Givee and a previously unrelated agent (New Interaction).

Methods

Participants Sixteen infants participated in the experiment (M= 366 days, 9 females). An additional 7 infants were excluded due to inattentiveness (n = 5), technical failure (n = 1), and experimenter error (n = 1).

Stimuli During familiarization, infants were shown agent A giving to B and taking from C. At test, infants were shown two events involving agent B giving an apple either to A (Reciprocation) or to C (New Interaction).

Results

Infants looked longer to the New Interaction (M = 15.92, SD = 4.55) than to the Reciprocation event (M = 9.23, SD = 7.83), $t(15) = -2.422$, $p = .029$, $r^2 = .214$, with 13/16 infants looking in the predicted direction. The data yielded a log-BF (Bayes Factor) of 4.562. These results suggest that infants re-identified the participants of the GIVING interaction (Figure 2).

Experiment 2

Exp. 2 tested whether infants represented TAKING in a format that supported the re-identification of the sharing partners, in the same manner as giving.

Methods

Participants Sixteen infants participated in the experiment (7 females; mean age: 359 days). An additional 7 infants were excluded due to inattentiveness (n = 4), crying (n = 1), technical failure (n = 1), and experimenter error (n = 1).

Stimuli The familiarization was the same as in Experiment 1. At test, infants were shown agent C TAKING an apple away from B (Reciprocation) or from A (New Interaction).

Results

Infants looked longer to the New Interaction (M = 25.99, SD = 18.89) than to the Reciprocation event (M = 14.33, SD = 8.81), $t(15) = -2.285$, $p = .037$, $r^2 = .135$. Eleven out of 16 infants displayed this looking pattern. The data yielded a log-BF of 4.668. An ANOVA with test type (Reciprocation vs. New Interaction) as within-subject factor and Experiment (1 vs. 2) as between-subject factor revealed a main effect of

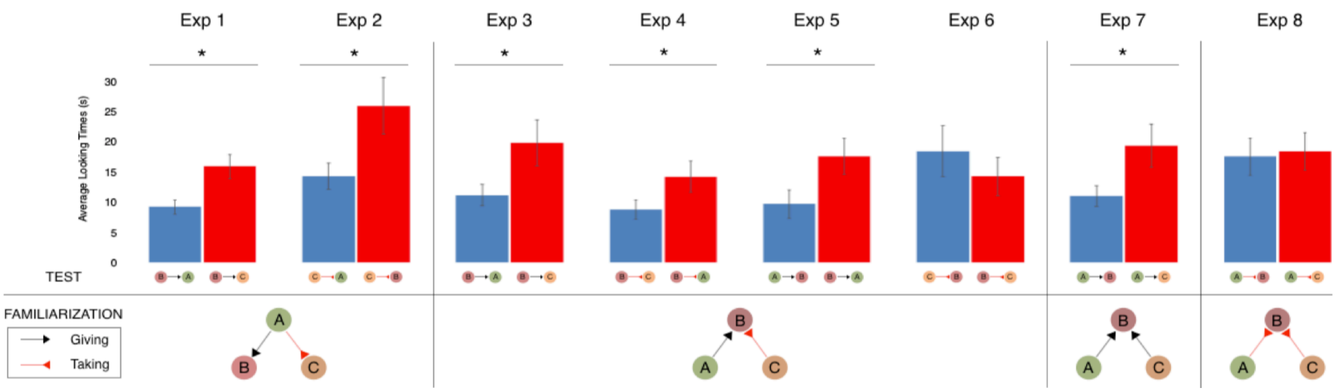

Figure 2. Average looking times during the test trials in Exps. 1-8. Error bars indicate standard errors. A schematic rendition of the familiarization and test actions is represented above. Circled letters represent agents; black and red arrows represent giving and taking actions, respectively.

condition, $F(1, 30) = 11.074$, $p = .002$, $\eta_p^2 = .270$, but no interaction. These findings suggest that, just as for GIVING, infants successfully re-identified the agents participating in the TAKING interaction.

Experiment 3

In Exps. 1 and 2 we showed that infants encoded the identity of the participants for both GIVING and TAKING. However, this evidence does not conclusively indicate that infants encoded the specific types of transferring action involved. Instead, infants may have merely represented which agents approached one another. To rule out this possibility, in Exp. 3 we presented infants with test events featuring role-reversed transferring actions between previously related agents, which were either consistent with the type of transferring action previously performed or not.

Methods

Participants Sixteen infants participated in the experiment (9 females; mean age: 361 days). An additional 6 infants were excluded due to inattentiveness ($n = 4$), crying ($n = 1$), and technical failure ($n = 1$).

Stimuli During familiarization, infants were shown agent B GIVING to A, and agent C TAKING from A. At test, infants were presented with two events involving agent A GIVING an apple either to B (Consistent Reciprocation) or to C (Inconsistent Reciprocation).

Results

Infants looked longer to the Inconsistent (M = 19.86, SD = 15.28) than to the Consistent Reciprocation event (M = 11.18, SD = 7.05), $t(15) = -2.763$, $p = .017$, $r^2 = .117$, with 11/16 infants looking longer in the predicted direction. The log-BF was 3.666. While providing a replication of Exp. 1, these results also indicate that infants encoded the type of transferring action occurring in the GIVING interaction.

Experiment 4

Exp. 4 tested whether the representation of TAKING similarly included information about the transferring action adopted.

Methods

Participants Sixteen infants participated in the experiment (9 females; mean age: 363 days). An additional 7 infants were excluded due to inattentiveness ($n = 4$), crying ($n = 1$), maternal intervention ($n = 1$), and technical failure ($n = 1$).

Stimuli The familiarization was the same as in Experiment 3. At test, infants were shown two events involving agent A TAKING an apple either from C (Consistent Reciprocation) or from B (Inconsistent Reciprocation).

Results

Infants looked reliably longer to the Inconsistent (M = 14.23, SD = 10.28) than to the Consistent Reciprocation Event (M = 8.80, SD = 6.23), $t(15) = -3.170$, $p = .006$, $r^2 = .092$. Fourteen out of 16 infants exhibited this looking-time pattern. The data yielded a log-BF of 2.917.

To assess the consistency of these results with the findings from Exp. 3, an ANOVA with test trial type (Consistent vs. Inconsistent Reciprocation) as within-subject factor and Experiment (3 vs. 4) as between-subject factor revealed a main effect of condition, $F(1, 30) = 16.407$, $p < .001$, $\eta_p^2 = .354$, but no interaction. These results show that, similar to Exp. 3, infants encoded the transferring action in the representation of TAKING.

Experiment 5

The previous experiments showed that infants' representation of GIVING and TAKING similarly supported the re-identification of their participants (Exps. 1-4), and the type of transferring action relating them (Exps. 3-4). However, it remains unclear whether infants did detect the reversal of transfer direction occurring at test. The shorter looking at the reciprocation events at test may have simply reflected the greater conceptual resemblance of these events to the familiarized interaction, relatively to the events these were contrasted with, without necessarily implying that infants recognized the test interactions as role-reversed.

Exp. 5 directly tested this possibility by assessing whether infants would be capable of discriminating between the same familiarized interaction at test vs. its role-reversed counterpart.

It is worth noting that information about the direction of transfer is not required to track and differentiate relations from each other. It is necessary, however, to track changes in resource flow within a given relation. Following our hypothesis that GIVING is a cue of EM relations, we predicted that infants would encode such information, but selectively in the representation of GIVING, not TAKING, interactions.

Methods

Participants Sixteen infants participated in the experiment (10 females; mean age: 362 days). Six additional infants were excluded due to inattentiveness (n = 4), crying (n = 1), and experimenter error (n = 1).

Stimuli The familiarization was the same as in Experiment 3. At test, infants were shown two events involving agent B GIVING an apple to A (Repetition) and agent A GIVING an apple to B (Reciprocation).

Results

Infants looked reliably longer to the Reciprocation (M = 17.63, SD = 11.89) than to the Repetition event (M = 9.73, SD = 9.43), $t(15) = -3.689$, $p = .004$, $r^2 = .119$. Fifteen out of 16 infants displayed this pattern. The data yielded a log-BF of 5.305. Infants detected the reversal of transfer direction at test, providing initial evidence that giving induced the encoding of bookkeeping-relevant information, consistent with the EM model.

Experiment 6

Exp. 6 tested whether the representation of TAKING similarly included information about the direction of transfer.

Methods

Participants Sixteen infants participated in the experiment (8 females; mean age: 363 days). Four additional infants were excluded due to inattentiveness (n = 1), crying (n = 2), and experimental error (n = 1).

Stimuli The familiarization was the same as in Experiment 3. At test, infants were shown two events involving agent C taking an apple from A (Repetition) and agent A taking an apple from B (Reciprocation).

Results

Differently from Exp. 5, infants did not look longer to the Reciprocation event (M = 14.28, SD = 12.61) than to the Repetition event (M = 18.45, SD = 16.86), $t(15) = .370$, $p = .716$, $r^2 = .019$. The data yielded a log-BF of -0.471. An ANOVA with test trial type (Repetition vs. Reciprocation) as within-subject factor and Experiment (5 vs. 6) as between-subject factor revealed only an interaction, $F(1, 30) = 5.083$, $p = .032$, $\eta_p^2 = .145$.

Unlike in Exp. 5, infants showed no reaction to the reversal of transfer. This asymmetric pattern of results shows that, in spite of the structural isomorphism of the GIVING and TAKING representations, information suited to tracking changes in resource flow within the relation was only encoded in the former. This difference in representational content is consistent with our hypothesis that GIVING actions are specifically indicative of EM relations.

Experiment 7

The previous experiments showed that infants represented TAKING as a social relation to be distinguished from co-occurring giving relations (Exps. 2 & 4), but did not encode information necessary to track changes of resource flow within the relation (Exp. 6). This type of representation, we argue, satisfies the requirements of a CS model. Being based on the principle of social equivalence, CS is characterized by promiscuous sharing and the absence of bookkeeping (Fiske, 1992). Under such model, membership (i.e., who belongs to the relation) is the only socially relevant feature of the relation, making the monitoring of its transaction history irrelevant.

To explore the hypothesis that taking may be indicative of CS relations, we tested whether infants would represent structures composed of TAKING interactions as transitive. Transitivity is a key signature of kinship structures, which are prototypical instantiations of CS (Levi Martin, 2011): e.g., if A is a sibling of B, and B is a sibling of C, it follows that A is a sibling of C.

Specifically, we exposed infants to an open triadic structure composed of two TAKING interactions (A–B and B–C), and tested whether they inferred a relation between the two non-interacting members (A–C). To assess the specificity of this prediction, we first tested whether infants would draw the same transitive inference from observing an identical social structure composed of GIVING interactions. Since EM is based on non-generalizable (anti-transitive) indebtedness obligations, we expected infants to not infer a novel relation for triadic structures based on GIVING.

Methods

Participants Sixteen infants participated in the study (10 females; mean age: 368 days). Seven additional infants were excluded from the analyses due to inattentiveness (n = 3), crying (n = 2), maternal intervention (n = 1), and reaching the maximum looking time on both test events (n = 1).

Stimuli The familiarization was the same as in Exp. 3, with the only difference that both B and C gave an apple to A. At test, infants were shown two events involving agent B giving an apple to A (Repetition) and agent C giving an apple to B (New Interaction). The identity of the Giver at test was counterbalanced across infants (B vs. C).

Results

Infants looked longer to the New Interaction (M = 19.17, SD = 14.37) than to the Repetition event (M = 10.74, SD = 6.65), $t(15) = -2.799$, $p = .014$, $r^2 = .124$, with 13/16 infants looking in the predicted direction. The data yielded a log-BF of 3.024. As in Exp. 1, infants reacted to the occurrence of a novel interaction, suggesting that they did not transitively inferred a relation between the two previously non-interacting agents.

Experiment 8

Exp. 8 assessed whether infants transitively inferred a novel relation upon observing the same triadic structure used in the previous experiment, this time composed of TAKING relations. Unlike in Exp. 7, we predicted infants here should interpret the novel interaction, in spite of its novelty, as equally compatible with the represented structure as either of the familiarized relations.

Methods

Participants Sixteen infants participated in the study (7 females; mean age: 364 days). Five additional infants were excluded due to inattentiveness ($n = 2$), crying ($n = 1$), and technical failure ($n = 2$).

Stimuli The familiarization was the same as in Exp. 3, with the only difference that both B and C took an apple from A. At test, infants were shown two events involving agent B (or C) taking an apple from A (Repetition) and agent B (or C) taking an apple from the other previous taker (New Interaction). The identity of the Taker at test (B or C) was counterbalanced across infants.

Results

As predicted, infants looked similarly to the New Interaction (M = 18.05, SD = 11.07) and to the Repetition event (M = 17.56, SD = 12.50), $t(15) = -0.15$, $p = .988$, $r^2 < .001$. The data yielded a log-BF of -0.631. An ANOVA with test trial type (Repetition vs. New Interaction) as within-subject factor and Experiment (7 vs. 8) as between-subject factor revealed a marginally significant interaction, $F(1, 30) = 4.034$, $p = .054$, $\eta_p^2 = .119$, as well as a marginally significant main effect, $F(1, 30) = 4.116$, $p = .051$, $\eta_p^2 = .121$.

The similar looking times to the novel and familiar interaction suggest that infants considered both events compatible with the represented structure. The comparison with Exp. 7 suggests that infants produced transitive inferences about the same triadic structure only when this was composed of TAKING, but not GIVING, interactions. These results are consistent with our claim that taking is a cue of CS relations, adding to an emerging literature suggesting that the representation of CS structures, such as kinship, exhibits transitive properties for both infants and adults (Spokes & Spelke, 2017; Brashears, 2013).

Crucially, the present null results are unlikely to reflect a failure to encode the identities of the agents in the familiarized TAKING interactions, since infants reliably detected changes of action or participants within these interactions in previous experiments (Exps. 2 & 4).

General Discussion

In the present study we sought to explore whether infants interpret sharing behaviors as relationally informative cues. This possibility was motivated by the proposal that humans may be endowed with a set of evolved priors, which captured evolutionarily recurrent covariation between sharing behaviors and corresponding relational contexts in the form of diagnostic dependencies. We posited a reliance on such priors to be especially pronounced in infants, given their need to discover the relational makeup of their local communities on the basis of sparse observations.

On the backdrop of anthropological data suggesting a psychologically privileged link between acts of resource donation and expectations of reciprocity, we tested whether infants are prepared to interpret the observation of GIVING as evidence of an underlying relation based on the principle of long-term balance (EM), and rigorously assessed the specificity of our hypothesis by comparing the representation of GIVING with that of superficially similar TAKING events.

Across eight looking-time experiments, we showed that 12-month-old infants adopted different encoding strategies for representing GIVING and TAKING, compatibly with the claim that these may prime distinct RMs.

Exps. 1-4 showed that the representation of GIVING and TAKING included information about the identity of the participating agents and of the transferring action relating them. In spite of such similarities, however, Exps. 5 & 6 showed that only the representation of GIVING included information about the direction of transfer. Lastly, Exps. 7 & 8 revealed further differences in the interpretation of these transfer events, as evinced by the infants' selective propensity to transitively infer novel relations in social structures composed of TAKING, but not GIVING, relations.

These commonalities and differences paint a coherent picture of the relational inferences afforded by different types of transferring behaviors in infancy. Although GIVING and TAKING were similarly interpreted as diagnostic of long-term relations, these appear to be patterned onto qualitatively different RMs: one (EM), primed by GIVING, is based on the principle of even balance, which motivates the encoding of bookkeeping-relevant information (such as the direction of transfer); the other (CS), primed by TAKING, is based on the principle of social equivalence, which gives rise to transitive social structures when more than two CS relations are combined together. Our experiments thus showed that each of these models directly determines the informational content of the representations that infants adopted (Table 1).

It is worth noting that the TAKING action, unlike acts of forceful expropriation that have been shown to induce the representation of dominance in infants (Gazes et al., 2015), was never resisted by the possessor. In this respect, our implementation of TAKING resembled the "tolerated taking" characterizing the relaxed sharing of mother-infant dyads in several primate species (Brosnan & de Waal, 2002). The evidence that infants can draw different relational inferences from superficially similar instances of resource procurement (e.g., tolerated vs. forced taking) suggest that, together with a set of relational primitives, infants possess a differentiated repertoire of action concepts pertaining to sharing and resource control.

Relational Model	Coordination Rule	Relevant Features	Diagnostic Cues	Directionality	Transitivity
Communal Sharing (CS)	Social Equivalence	Who is in the relation (membership)	Tolerated Taking	NO	YES
Authority Ranking (AR)	Authority, Dominance	Who is above whom (ordered differences)	Priority of Access, Forceful Taking	YES	YES
Equality Matching (EM)	Even balance	Who owes how much to whom (additive imbalances)	Giving	YES	NO

Table 1. Relational models, their corresponding cues in the domain of possession-related behaviors, and formal properties of their associated representations.

Having discussed our findings, we shall reserve a brief discussion about the strengths and weaknesses of our design. All experiments involved within-subject comparisons, allowing us to control for individual variance in looking duration. At the same time, infants' representations of giving and taking were always assessed independent of each other, given that perceptual differences in test displays, such as the relative proximity of the agents at the end of the transfer, may have otherwise influenced infants' looking behavior. Moreover, while the small sample size should caution about the robustness of our findings, several of our experiments (1-2, 3-4) represented conceptual replications of the same effects. Relatedly, while we did report a significant drop-out rate (with 6.12 infants excluded per experiment on average), this was chiefly a consequence of the stringent inclusion criteria adopted (after Tatone et al., 2015), required to ensure that infants received enough exposure to the relevant transfer events, given the otherwise short familiarization phase.

To conclude, complementing and expanding on previous work attesting an early-developing preparedness to infer social relations from episodic interactions revolving around resource possession (Mascaro & Csibra, 2012), the present contribution identifies new putative cues in the domain of sharing that infants may use to identify and track different social relationships (Table 1).

Acknowledgements

This research has been supported by the European Research Council (ERC) under grant agreement no. 742231 (PARTNERS).

References

Bird-David, N. (2005). The property of sharing: Western analytical notions, Nayaka contexts. In T. Widlok & W. Tadesse (Eds). *Property and equality* (pp. 201–216). New York: Berghahn.

Brashears, M. E. (2013). Humans use compression heuristics to improve the recall of social networks. *Scientific Reports, 3*, 1513.

Brosnan, S. F., & De Waal, F. B. (2002). A proximate perspective on reciprocal altruism. *Human Nature, 13*(1), 129-152.

Favre, M., & Sornette, D. (2015). A generic model of dyadic social relationships. *PloS one*, 10(3), e0120882.

Fiske, A. P. (1992). The four elementary forms of sociality: framework for a unified theory of social relations. *Psychological Review, 99*(4), 689.

Fiske, A. P. (2004). Four modes of constituting relationships: Consubstantial assimilation; space, magnitude, time, and force; concrete procedures; abstract symbolism. In N. Haslam (Ed.), *Relational models theory: A contemporary overview* (pp. 61-146). Psychology Press.

Gazes, R. P., Hampton, R. R., & Lourenco, S. F. (2015). Transitive inference of social dominance by human infants. *Developmental Science*, *20*(22), e12367.

Gurven, M. (2004). To give and to give not: the behavioral ecology of human food transfers. *Behavioral and Brain Sciences, 27*(04), 543-559.

Jaeggi, A. V., & Van Schaik, C. P. (2011). The evolution of food sharing in primates. *Behavioral Ecology and Sociobiology, 65*(11), 2125.

Kaplan, H. S., Schniter, E., Smith, V. L., & Wilson, B. J. (2012). Risk and the evolution of human exchange. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1740), 2930-2935.

Mascaro, O., & Csibra, G. (2012). Representation of stable social dominance relations by human infants. *Proceedings of the National Academy of Sciences, 109*(18), 6862-6867.

Mauss, M. (2002). *The gift: The form and reason for exchange in archaic societies*. Routledge.

Moya, C. (2013). Evolved priors for ethnolinguistic categorization: A case study from the Quechua–Aymara boundary in the Peruvian Altiplano. *Evolution and Human Behavior*, 34(4), 265-272.

Peterson, N. (1993). Demand sharing: Reciprocity and the pressure for generosity among foragers. *American Anthropologist*, *95*(4), 860–874.

Spokes, A. C., & Spelke, E. S. (2017). The cradle of social knowledge: Infants' reasoning about caregiving and affiliation. *Cognition, 159*, 102-116.

Tatone, D., Geraci, A., & Csibra, G. (2015). Giving and taking: Representational building blocks of active resource transfer events in human infants. *Cognition*, *137*, 47-62.

Thomsen, L., & Carey, S. (2013). Core cognition of relational models. In M. R. Banaji, & S. A. Gelman (Eds.), *Navigating the Social World: What infants, children, and other species teach us* (pp. 16-22). Oxford University Press, New York.

Widlok, T. (2016). *Anthropology and the Economics of Sharing*. Routledge.