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Giving and taking: Representational building blocks of active resource-transfer events in human infants

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Abstract

Active resource transfer is a pervasive and distinctive feature of human sociality. We hypothesized that humans possess an action schema of GIVING specific for representing social interactions based on material exchange, and specified the set of necessary assumptions about giving events that this action schema should be equipped with. We tested this proposal by investigating how 12-month-old infants interpret abstract resource-transfer events. Across eight looking-time studies using a violation-of-expectation paradigm we found that infants were able to distinguish between kinematically identical giving and taking actions. Despite the surface similarity between these two actions, only giving was represented as an object-mediated social interaction. While we found no evidence that infants expected the target of a giving or taking action to reciprocate, the present results suggest that infants interpret giving as an inherently social action, which they can possibly use to map social relations via observing resource-transfer episodes.

Keywords

Infancy; Action schema; Resource transfer; Giving action; Reciprocity

1. Introduction

Humans regularly transfer food and non-food items, both reactively (i.e., under solicitation) and proactively, with kin and non-kin alike (Jaeggi, Burkart, & van Schaik, 2010; Gurven, 2004). Resource-transfer practices within and between households have been documented virtually for any known society. Moreover, the archeological record contains telling evidence of sharing networks dating back to the late Upper Paleolithic, as inferred by specific site structures and butchering patterns (Enloe, 2003). This is in stark contrast with the typical resource sharing behavior of non-human primates, where the most prevalent type of resource transfer is passive food sharing, generally consisting in one individual obtaining food from another without the possessor's active help (Brosnan & de Waal, 2002). Active food sharing, consisting in one individual voluntarily handing food to another, is on the

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other hand virtually absent in non-human primates (de Waal, 1989; Feistner & McGrew, 1989; Ueno & Matsuzawa, 2004), totaling a mere 1% in almost 10,000 observations of food transfer (in capuchins: Stevens & Hauser, 2005). The few documented instances of active object transfer are mostly limited to captivity settings, either in token exchanges with human experimenters (Brosnan & de Waal, 2005; Hyatt & Hopkins, 1998) or under direct solicitation by physically impeded conspecifics (Yamamoto, Humle, & Tanaka, 2009; Celli, Masaki, Toshifumi, et al. 2006; Nissen & Crawford, 1936). An exception to this pattern is represented by Callitrichids, which proactively transfer high-quality food items in the wild. Tellingly, however, such provisioning behavior is mostly restricted to parental-care contexts (Brown, Almond, & Bergen, 2004; Jaeggi & van Schaik, 2011). Thus, despite the action of transferring a resource to another individual is part of the behavioral repertoire of a number of primate species, in none the frequency and breadth of giving-based interactions comes close to the ubiquity and variety of exchange practices documented across humans societies. This suggests that different motivational and cognitive systems, rather than mere action capabilities, should be invoked in accounting for such conspicuous divide (Delton & Sell, 2014; Tomasello, 2008).

1.1. Giving as an Action Schema

We hypothesize that humans are equipped with a specialized cognitive adaptation for understanding and participating in resource exchange. We characterize such dedicated system as an action schema: a system of domain-specific abstract knowledge whose function is to provide an internal structure for efficient event representation (Goodman, 1980; Frankenhuis & Barrett, 2013). The activation of this 'giving action schema,' like any other schema, depends on the processing of a specific set of high-validity cues (Barrett, 2005). The number of cues that the schema is sensitive to depends on the number of perceptually overlapping but functionally different action representations that could be simultaneously activated at a given time (Cosmides & Tooby, 1994). For example, the actions of transferring an object to a social partner versus disposing it may have surface similarities, but afford functionally different inferences about the agent's goals. The sensitivity of the schema to these cues is therefore revelatory of the assumptions about the target event that the schema embeds. These assumptions typically concern the number and kind of entities participating in the action, as well as changes in action parameters and in other relational properties that are relevant to the event representation (Genter, 1975; Langacker, 1987).

On an abstract level of description, GIVING[1] can be defined as an object-mediated interaction, in which an agent (the Giver) performs an action directed to the goal of transferring the possession of an object to another agent (the Givee) (cf. Gentner, 1975). A suitable representation of GIVING needs therefore to include three elements (Giver, Givee, and object) whose relations change over time due to the Giver's action, which suspends the 'possession relation' formed between Giver and object to establish a new one between object and Givee (Tomasello, 1992; Newman, 2005). 'Possession', as intended here, refers to an agent's dispositional ability to control the fate of the object in question to a greater extent than other

[1]To distinguish the concept of action schema from its instantiations, we will refer to the former in small caps (e.g., GIVING). This distinction allows us to remain agnostic as to whether and to which extent the actual representation of stimulus events that are intended to capture the essential features of an action schema instantiates its corresponding concept.

potential agents could (cf. Kummer & Cords, 1991; Stake, 2004). As such, it is conceptually different from ownership, which could be defined as a socially and normatively stipulated form of object control able to survive to temporary changes of possession (Blake & Harris, 2011; Friedman, Niery, Deifeter, et al., 2011; Kalish & Anderson, 2011).

In linguistics, the verb 'give' is considered to be an obligatorily three-place predicate requiring distinct arguments for Giver, Givee, and transferred possession (Kittilä, 2006; Newman, 2005; Tuggy, 1998). This structural feature is seemingly a linguistic universal: in none of the known languages, in fact, 'give' features among the verbs that allow the recipient to be removed from the clause core (Kittilä, 2006). An intuitive way to appreciate why 'give' entails the existence of three distinct arguments is offered by the so-called "omissibility test", proposed by Newman (2005) as a diagnostic test for necessary argumenthood. Simply put, this test requires removing one of the entities from the semantic frame and evaluating its effects on the event representation: if a given entity is an essential component of the frame, its removal should fatally compromise event representation. As it appears, a giving action would immediately cease to be an instance of GIVING once we remove either the object or the Givee from the corresponding event representation.

Recent findings from developmental psychology suggest that this and other assumptions about the verb 'give' may be derived from an early-developing conceptual representation of giving actions, which predates the understanding of the trivalent structure of 'give' clauses. Below we review some of the studies showing that preverbal infants may indeed apply these assumptions when confronted with giving actions.

1.2. Evidence from Studies with Infants

The first assumption of the definition we provided for GIVING is that the action is represented in a three-place event structure. There is ample evidence that young infants can represent the relation between two agents and encode their respective action roles for different action domains such as chasing (Rochat, Morgan, & Carpenter, 1997; Schlottman, Surian, & Ray, 2009; Southgate & Csibra, 2009) or helping (Kuhlmeier, Wynn, & Bloom, 2003; Hamlin, Wynn, & Bloom, 2007). There is also evidence that infants spontaneously include objects in the event representation when they functionally contribute to the establishment of a social interaction. In a study by Gordon (2003), 10-month-olds habituated to a puppet hugging another one or giving her a toy showed a quick recovery of looking times when the giving (but not the hugging) action was repeated without the object, thus revealing that they expected the presence of an object only in the case of giving. Note that the selectivity of these expectations could only be explained by assuming that infants were able to extract information about the goal of the object-carrying agent from the dynamics of the action causing the object to contact the other agent. These results provide empirical support for the claim that the representation of giving actions includes not only the interacting agents but also the object transferred, and that such inclusion is not merely triggered by any kind of object manipulation in a dyadic context.

Evidence for infants establishing an action schema of GIVING also comes from studies on prosocial preferences. Hamlin & Wynn (2011) reported that 3- and 5-month-olds showed a robust preference for a puppet (Giver), which was observed giving back to another puppet

the ball she dropped while playing with it, compared to a third puppet (Taker), which always took the ball away and ran off-stage. Crucially, however, such preference for the Giver disappeared when the puppet playing with the ball was replaced with a mechanical pincer, suggesting that there might be strong assumptions (in the form of selection restrictions: Markman & Stillwell, 2001) about the type of entities that could fill the Givee slot in GIVING. Recent studies on infants' sensitivity to distributive fairness point to a similar conclusion. Typically, infants in these studies are familiarized with an interaction between a distributor and two recipients, and then are exposed to equal or unequal outcomes (e.g., Sommerville, Schmidt Yun, & Burns, 2012). A converging finding of these studies is that infants look reliably longer to the unequal outcome, but crucially only when the recipients of the distribution were animate recipients (Schmidt & Sommerville, 2011; Sloane, Baillargeon, & Premack, 2012) and the distributor's actions were causally related to the production of the unequal allocation (Sloane et al., 2012). This signature limit of infants' expectations of distributive fairness highlights a further assumption about GIVING: the Giver, beyond being an agent, has to be causally responsible for the transfer of object possession to the Givee.

In fact, even this is not sufficient: the change of possession should also be interpreted as the goal of the Giver's action. In a study by Schöppner, Sodian, & Pauen (2006), twelve-month-old infants, habituated to a puppet giving a flower to another one showed a recovery of looking times during test when the roles of the two agents, but not their positions, were reversed. Importantly, however, no such difference was found between the two reversals when infants were familiarized to a transfer event broken into two separable action segments: the puppet carrying the flower dropped it before establishing hand-to-hand contact with the other puppet, who then picked up the flower and moved back to its initial position. The authors attributed the failure to integrate the dropping and picking-up actions into a single event to the violation of a critical assumption about the spatio-temporal continuity of the transfer (i.e., the uninterrupted hand-to-hand path of the object). Alternatively, however, the integration might have been precluded because the dropping action represented an inefficient means to achieve the goal of transferring possession (Gergely & Csibra, 2003). Differently from non-social goals (such as grasping or approaching: Hernik & Southgate, 2011; Southgate, Johnson, & Csibra, 2008), evaluating the efficiency of social goals that require the intervention of multiple agents may entail computing the aggregate costs of all interacting partners relatively to the production of a certain outcome. On this basis, the dropping action could not have possibly qualified as an efficient means to the goal of giving the flower, because it required the second puppet to perform an additional picking-up action in order to complete the transfer.

In sum, when interpreting actions that adults would represent as GIVING, infants seem to take into account all the crucial ingredients of this action schema: the social agents that play complementary roles in the interaction, the object whose possession is transferred, and the action that is designed to achieve this outcome. In other words, infants are likely to set up a representation of the observed event in a format akin to the action schema described above. But how abstract is this representation?

1.3. The Content of Infants' Representation of Giving Actions

The available evidence on infants' interpretation of transfer-based interactions suggests that their understanding of giving actions is not constrained by familiarity with object-transferring actions. Geraci & Surian (2011), and Meristo & Surian (2013), for example, tested infants' sensitivity to distributive fairness by using simple geometrical figures with eyes transferring fruits to each other. The giving action performed by these Givers consisted in establishing body contact with the fruit, pushing it close to the Givee, and sliding back to their initial position. The fact that infants produced social evaluations of these agents on the basis of such impoverished distributive events suggests that, in spite of their novelty, these interactions exhibited all the necessary cues for the activation of GIVING. For this reason, our definition of GIVING purposefully omitted any reference to possible effectors (e.g., human hands) or kinds of agents (e.g., humans) responsible for producing the transfer.

These studies also suggest that infants may be able to represent another crucial ingredient of giving, possession, on the basis of minimal spatial cues. Possession, like efficiency, is an abstract relational property that cannot be directly perceived but has to be inferred from available cues. And just like efficiency (i.e., cost-benefit ratio), which can be estimated on the basis of geometrical information such as pathway length, possession can also be inferred on the basis of spatial cues such as proximity. On this basis, if possession is defined as having control over the fate of an object, among several agents the one closest to the object is most likely to be ascribed with such disposition. Thus, a giving action and the possession transfer that it entails can be operationalized simply by an agent (the Giver) pushing an object located in its vicinity close to another agent (the Givee) and then moving away (to relinquish control).

1.4. The Present Studies

The present studies aimed at establishing whether infants' rudimentary understanding of giving actions employs such an abstract and flexible representational format. We presented infants with simple animations offering minimal cues to indicate the presence of the crucial elements of GIVING, such as agency, possessive relations, and goal-directed object transfer. Such animations are always compatible with multiple interpretations, and our studies were designed to test whether infants are inclined to set up a representation of GIVING when the available cues allow them to do so. Since our test required infants to track multiple animated agents and their action roles, we chose to study one-year-olds, who have be shown to be capable of such a feat (e.g., Kuhlmeier, Wynn, & Bloom, 2003; Mascaro & Csibra, 2012). However, we do not intend to make any claim about the specific age of emergence, or specific developmental course, of the ability of understanding object-mediated social interactions.

Unlike Schöppner et al. (2006), our animations of giving did not include any action by the Givee. If the operationalization of the possession concept that we provided above is correct, an agent should be represented as the recipient of the transferred object on the basis of its relative proximity to the object, even if the agent is entirely passive during the transfer. This implementation of the giving action allowed us to directly contrast it with another action: taking. TAKING is a concept that is also defined by the deliberate transfer of object possession,

but the agent who performs this action is also the one who acquires possession. This concept can be symbolically implemented in an event that is perceptually similar to the implementation of GIVING. By holding the kinematics of these two actions identical, we could test whether infants can distinguish between giving and taking events by combining three sets of cues: the agents' initial relation with the object (giving: A possesses the object, B does not; taking: B possesses the object, A does not); the direction of transfer (giving: from A to B; taking: from B to A) and the identity of the agent responsible of the transfer (A). Previous studies did not allow assessing the specificity of infants' representation of giving actions to this level of detail, since giving was always compared with actions differing in their kinematic components (cf. Gordon, 2003; Schöppner et al., 2006). Studies 1, 2, 6, and 8 tested whether infants could discriminate between giving and taking actions on the basis of these cues.

In TAKING actions, the acquisitor of the object coincides with the active agent that produces the change of possession rather than with the passive one (as in a giving action). This subtle difference has interesting implications in terms of the possible interpretive options available for the two actions. While GIVING entails an inherently social goal, a taking action can also be understood as an action directed to acquire possession of an object without reference to the previous possessor: acquiring an object is a well-formed goal without considering who (if anyone) is dispossessed by this action. In other words, the same action of gaining possession of an object can be represented as an instance of either TAKING or ACQUIRING, depending on whether the previous possessor is included in the representation. In principle, a giving action can also have a corresponding non-social counterpart, in which only the active agent's loss of possession is represented as a goal (DISPOSING). However, this action interpretation is less likely than GIVING, because it is ambiguous in which way the active agent would benefit from such an action: the loss of possession that this action produces could not be justified, unlike GIVING, as directed to making another agent the new possessor of the resource. Our experiments (Studies 2 to 4) tested whether the presence of a passive agent (a potential Givee or Takee) would equally influence the selection between social and non-social interpretation of giving and taking actions.

A related question is whether infants make further inferences from observing a social interaction involving giving. While a well-formed representation of GIVING requires inferring that the Giver's goal to modify the Givee's status (by making her possessor of the transferred object), it does not require such change to be interpreted as resulting in positive consequences for the recipient's welfare. Nevertheless, the systematic deployment of giving actions for bestowing others of valuable resources is such that defaulting on this prosocial assumption would be an efficient interpretive heuristic most of the time. To assess whether observing a giving action spontaneously elicits this interpretation about the other-benefiting nature of the Giver's goal, we tested whether it would prime reciprocity expectations. The norm of reciprocity, in fact, is not merely a behavioral rule dictating that any action that an agent was targeted with should be responded to in the same way. Rather, it applies specifically to actions that result in (positive or negative) consequences for the welfare of a social partner (Fry, 2006; Trivers, 1971). Therefore, expecting reciprocity would necessarily imply that the action to be reciprocated (giving) was interpreted as resulting in a benefit gain for the agent acquiring the resource. Studies 5 and 7 addressed this question.

2. General Methods

All the studies reported here had the same design structure and procedure, applied the same dependent measure (looking time), and were analyzed the same way. We provide here the common elements across studies, and will describe the specific aspects of the stimuli at each Study. Figure 1 depicts the structure of the stimuli used in Study 1, and Table 1 lists the variants of factors that changed across studies. A sample of the familiarization and test animations used in the different studies is available in the online Supplementary Data.

2.1. Procedure

Infants were tested in a dimly lighted, soundproof room. They sat on the parent's lap, 100 cm away from the presentation screen. A hidden camera mounted under the screen recorded infants' looking behavior at 25 frames per second temporal resolution. Parents were instructed to close their eyes during the whole procedure. The structure of all the studies was identical: infants were presented with four familiarization trials followed by two test trials. Except for Studies 3, 4 and 8, half of the infants were shown during test two giving actions and the other half two taking actions. The only difference between the two test events consisted in the identity of the agent performing the action. Tests in which the same agent performed an action similar to what had been observed during familiarization (e.g., a Giver giving) were labeled Consistent. Tests in which the agent performed a different action from the familiarization (e.g., a Taker giving) were labeled Inconsistent. The order of test events was fully counterbalanced across infants in all studies.

2.2. Stimuli

The stimuli were animations designed in Flash Professional CS5 and presented using Keynote software (version 5.0) on a wide-screen 102 cm LCD monitor in 1280*960 pixel resolution. A short (1.5 s) attention-getting animation was presented before each familiarization and test trial.

2.2.1. Familiarization events—Each familiarization animation (21 s total running time) started by showing two characters different in shape and color (approximately 12 cm wide and 12 cm high) placed 32 cm away from each other on a white platform imposed on a black background. The two characters had eyes (with rotating pupils) and nose. Close to each character, a different number of apples (each approximately 6 cm wide and 5 cm high) were shown.

During the Giving event (Figure 1, top row), infants observed two characters (the Giver and the Givee), standing on opposite sides of the platform. There were one or two apples close to the Giver, and one or none close to the Givee. The two agents stayed motionless for 3.2 s. Afterwards, the Givee moved towards the center of the platform and then back to its initial position. The whole movement of the Givee lasted 4.3 s. This movement was intended to convey additional cues of agency about the Givee, who was otherwise motionless throughout the object-transfer event. After a 2.4 s delay, the Giver slowly shifted its gaze towards the center of the screen and back, then approached its apple(s) and moved towards the Givee in a slightly curved path while pushing along an apple. The movement lasted 4 s,

at the end of which the Giver pushed the apple close to the Givee and a short sound was played. Finally, the Giver moved back to its original location in a straight path, facing away from the Givee (4.2 s).

The Taking event was equated with Giving for length, speed, and extent of motion of the agents (Figure 1, second row). The kinematic parameters were exactly the same in the two kinds of object-transfer events. The only differences in Taking events were the following: (1) the active agent (the Taker) was the character who initially had fewer apples (one or none) than the other character, the Takee (two or one); (2) the Taker approached the Takee without any apple in a curved line and transported back one of the Takee's apple in a straight line. When the Taker contacted the apple, the same short sound was played as when the Giver released its apple in the Giving event. The identity of Giver and Taker, the order of giving and taking events, and the position of Giver and Taker in the first pair of trials were fully counterbalanced across infants in all studies.

2.2.2. Test events—The test events (11 s total running time each) started by showing two grey screens (19.5 cm wide and 15 cm high) on the two sides of the platform (Figure 1, bottom). After 3.5 s delay, one of the agents from the previous familiarization events emerged from behind the screen on one side, pushing an apple towards the other side of the platform in a straight path. Once it reached the center of the platform, the agent stopped for 2 s, and then started moving again until disappearing behind the opposite screen. After 0.25 s delay, a short sound was played and simultaneously the two screens slid away from the platform, revealing the location of the same agent who had just disappeared and another character. Whether the pushing action represented Giving or Taking could have been established only once the position of the other agent (Givee/Takee) was revealed. When the other agent appeared behind the screen from which the apple-pusher emerged, and thus the two agents stood at two opposite sides of the platform, this became a Taking event. When the other agent appeared behind the screen where the apple-pusher disappeared, and thus the two agents stood at the same side of the platform, this became a Giving event. For both actions, the end of the test animations showed two agents frontally oriented, either close to each other or on the opposite sides of the platform, with one of agents (the Givee or the Taker) in direct contact of the apple.

2.3. Coding and Data Analysis

We performed an off-line frame-by-frame analysis of looking behavior. Blinks were considered as look-away if they lasted for more than 0.25 s. To be included in the final data analysis, infants had to satisfy the following criteria: (1) look at each familiarization trial for at least 50% of its overall duration, from the beginning of the movie to the moment when the Giver/Taker moves back to its initial position (10.5 s: Studies 1-5; 12 s: Studies 6-7; 6.5 s: Study 8); (2) look at each test trial for at least 50% of its duration, from the beginning to the moment when the barrier start sliding away (5 s). Looking time during test trials was measured from when the opaque screens started sliding up to the moment when the infant looked away for more than 2 s or looked cumulatively more than 60 s.

Studies 1 and 2 were ran and coded by the second author. Studies 3 to 8 were ran and coded by the first author. Fifty percent of the sample (8 infants) for each study was randomly selected and re-coded by two coders blind to the hypotheses (coder A: Studies 1 and 2; coder B: Studies 3 to 7; coder 3: Study 8). The inter-coder agreement was excellent, as indicated by the consistency measures of the intra-class correlational coefficient (Study 1: r = .991; Study 2: r = .996; Study 3: r = .997; Study 4: r = .995; Study 5: r = .995; Study 6: r = .992; Study 7: r = .993; Study 8: r = . 997).

All statistical tests used were two-tailed. Parametric statistics were performed on log-transformed looking time data to better approximate a normal distribution. For ease of reading, the looking time means are reported before log-transformation. For the effects of main interest, non-parametric statistics are also reported.

To investigate possible influence of how long infants attended to the various familiarization events, we analyzed the total amount of time spent looking at each familiarization trial using two different time windows (until the 2-seconds look away and until the end of the familiarization). We found no difference in looking time to the two types of familiarization events (Giving and Taking) in any of the studies reported, regardless of the time window used. Moreover, there was no order effect of familiarization events (Giving First, Giving Second) or of test trials (Consistent, Inconsistent) on infants' looking behavior during the test for any of the eight studies reported.

3. Study 1: Action Roles

The first study addressed the question whether infants discriminate between giving and taking actions and whether they link these events to the actor who performs them. We familiarized infants to a Giver who gave an apple to another agent and to a Taker who took an apple from the same agent. Having seen these events twice, infants were exposed to the Giver and the Taker giving or taking an apple to/from the same agent. We hypothesized that if infants are able to discriminate between these actions and link them to the agent who perform them, they would find the novel action (Giver taking or Taker giving) incompatible with the representations they formed about these events, which would be reflected in longer looking time than what they would display to the familiarized actions.

3.1. Methods

3.1.1. Participants—Sixteen infants participated in the experiment (10 females; mean age = 354 days; range = 347-383 days). An additional five infants were excluded from analyses for crying during the test (n = 1), inattentiveness (n = 3), and experimenter's error (n = 1). All the participants recruited in the studies presented here (1-8) were full-term infants with normal visual acuity and no declared clinical conditions. They all resided in Budapest, and were brought in the lab by their caregivers who volunteered in the study. The ethnic composition of the sample was entirely Hungarian.

3.1.2. Stimuli—During familiarization, infants were presented with two events in which agent A gave an apple to agent B, and two events in which agent C took an apple from agent B. Thus, while the Giver (A) and the Taker (C) were played by different characters, the

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Givee and the Takee was the same agent (B). At the start of the giving actions, A had two apples and B had one, while the taking actions started with B having two apples and C having one. The passive agent B (Givee and Takee) was a green circle, while Giver and Taker were played by a blue square and a red triangle. The second pair of familiarization trials repeated the first two trials with the left/right position of agents swapped.

During the test trials, half of the infants were presented with events with Giving outcome, and the other half with Taking outcome. All infants observed an event with the previous Giver and another event with the previous Taker. For the group who saw two Giving outcomes, the one showing the Giver as the actor was the Consistent test event and the one showing the Taker as the actor was the Inconsistent test event, whereas for the Taking group it was the other way around. The other agent on the scene was the same one (the green circle) who played the role of the passive participant (Givee or Takee) during familiarization.

3.2. Results and Discussion

Looking times during the test trials are depicted on Figure 2. An ANOVA with test trial (Consistent vs. Inconsistent) as within-subjects factor and test group (Giving vs. Taking) as between-subjects factor revealed only a significant main effect of test trial, $F(1,14) = 6.113$, $p = .027$, $\eta_p^2 = .304$; $p = .026$ by Wilcoxon signed rank test. Infants looked reliably longer at the inconsistent test trial (M = 23.37 s, SD = 14.26 s) than the consistent test trial (M = 14.69 s, SD = 9.14 s). This pattern was also evident at the individual level, as 13/16 infants looked in the predicted direction.

The looking time data confirm that infants detected the action change in the Inconsistent test event for both types of action. This suggests that 12-month-olds may have been able to form two distinct representations of giving and taking actions and link them to the respective agents. Remarkably, they did so after having been exposed only to two instances of each object-transferring action, strengthening the claim that, around the first year of age, infants are able to quickly establish three-place representations involving object transfers (Schöppner et al., 2006).

However, the present results are compatible with two different hypotheses about the type of action representation established during familiarization: infants may have encoded the specific identity of both the agents related by the object-transferring action (‘A gives to B’), or alternatively only of the active one (Giver/Taker). In the latter case, the resulting representation would still be composed of three elements, but the slot occupied by agent B would include no featural information about the agent assigned to it (‘A gives to X’). If the familiarization primed infants with a representation of the latter type, 12-month-olds would not be able to detect any change of the Givee/Takee’s identity from familiarization to test, but only a change of the action of Giver/Taker they were familiarized with.

4. Study 2: Action Generalization across Targets

In Study 2 we directly sought to test whether infants represented giving and taking in a format that allows those actions to be generalized to new recipients. We did so by exposing

infants to the same animations of Study 1, while changing the identity of the second agent from familiarization to test. If the representations of the Giving and Taking events that infants formed in the previous study did not include any information about identity of the second agent shown during familiarization, the same results of Study 1 should obtain here. That is, infants in both groups should only show sensitivity to the action change (inconsistent test event), regardless of whether the Giver and Taker are now interacting with completely new patients.

4.1. Methods

4.1.2. Participants—Sixteen infants participated in the experiment (6 females; mean age = 346 days; range = 338-374 days). An additional six infants were excluded from analyses for crying during the test (n = 1), inattentiveness (n = 2), and experimenter error (n = 3).

4.1.3. Stimuli—Infants were tested with the same animations used in Study 1 with the only difference that the passive agent (Givee and Takee) during familiarization (a yellow diamond) differed from the one used in the test (which was the same green circle used in Study 1).

4.2. Results

A repeated-measure ANOVA performed in the same way as in Study 1 revealed a significant interaction between test trial and group, $F(1,14) = 4.860$, $p = .045$, $\eta_p^2 = .258$ (Figure 3). Exploring the interaction by group, we found a significant difference in the Giving group: infants looked reliably longer at the consistent test trial (M = 20.53 s, SD = 12.28 s) than at the inconsistent test trial (M = 14.87 s, SD = 8.89 s), $t(7) = 2.81$, $p = .026$, $r^2 = .51$; $p = .028$ by Wilcoxon signed rank test. The same pattern of results was found at the individual level: only one infant in the Giving group looked longer at the inconsistent test trial. The reversed looking-time pattern was found in the Taking group, with infants looking longer to the inconsistent test trial (M = 24.43 s, SD = 16.19 s) than the consistent test trial (M = 14.98 s, SD = 8.15 s), however the difference failed to reach significance: $t(7) = 1.29$, $p = .238$; $p = .093$ by Wilcoxon signed rank test. Despite the small group size, the trend was visible at the individual level: 7/8 infants looked longer at the inconsistent test event. A Fisher's exact test confirmed the interaction between group and test trial, $p = .010$.

While the Taking group produced the same looking time pattern as in Study 1, the Giving group produced the opposite one. To explore the relation of infants' looking behavior between Study 1 and 2, we performed an ANOVA for each test group (Giving vs. Taking) separately, with test trial as within-subjects factor and Study (1 vs. 2) as between-subjects factor. The analysis revealed a significant interaction between the two factors for the Giving group, $F(1,14) = 7.157$, $p = .018$, $\eta_p^2 = .338$, and a significant main effect of test trials for the Taking group, $F(1,14) = 8.547$, $p = .011$, $\eta_p^2 = .379$. This pattern further suggests that the manipulation of the passive agent's identity in Study 2 influenced the distribution of looking times to the two test events in a way specific to the action observed during the test. Infants in Study 2 reacted to taking actions directed to a new Takee similarly to Study 1, whereas they reversed their looking behavior to giving actions directed to a new Givee.

4.3. Discussion

The statistical interaction found in Study 2 suggests that infants represented the two object-transferring actions differently. During the test trials, we exposed infants to initially ambiguous actions of two agents whose actions they had been familiarized to. In response to observing these agents, they could have set up specific expectations about the action type (i.e., the location of the other agent) and the identity of the passive agent. Note that if they had only developed an expectation about the identity of the passive agent but not about the action, their response to the outcomes would not have differed between the actors, because the identity of the passive agent always changed from familiarization to test. Had they only expected the agents to behave consistently to their respective action roles, they should have responded the same way as in Study 1. However, the looking times of the Giving group indicate that infants detected the identity change of the Givee, thus supporting the hypothesis that they encoded the identity of both agents involved in the giving action. These results suggest that infants interpret giving actions as indicative of a dyad-specific social relation (between Giver and Givee).

On the contrary, the looking-time pattern of the Taking group was similar to that of Study 1, revealing that infants may have reacted to the change of action performed by the active agent, but not to the change of the passive agent's identity. These results can be interpreted as suggesting that 12-month-olds did not encode the identity of the Takee or, alternatively, that they did so but expected nonetheless the Taker to behave consistently to its action role with new recipients – two encoding strategies that would be both equally functional to consolidating generalizable information about an agent's behavior in a trait-like format (Sabbagh & Shafman, 2009; Boseovski & Lee, 2006; Kalish, 2002; Rosati, Knowles, Kalish, et al., 2001).

Alternatively to these accounts, which posit that giving and taking were treated as structurally similar interactions, a third possibility is that infants' representations of these two object-transferring actions differed in the number of elements included. As explained in the Introduction, in TAKING the agent causing the transfer and the one acquiring the object coincide. As a consequence of such overlap, the Taker's goal of acquiring the object can be represented without any reference to the previous possessor of the object (the Takee). Therefore, this element can be removed from the event structure by representing the Taker's action not as TAKING but as ACQUIRING. The "omissibility" of the passive agent, on the other hand, could not apply to GIVING without compromising the intelligibility of the actor's goal. In light of this, the difference between the representations of the two object-transferring actions found in Study 2 could be recast in structural terms: infants represented the giving action as directed to a specific recipient, whereas they may have preferred an interpretation of the taking action as primarily directed to the acquisition of the object, and therefore encoded it in a two-place representation.

5. Study 3: Giving versus Disposing

We implemented experimentally the "omissibility test" explicated above for giving actions. We familiarized infants with an agent (Giver) performing the same giving actions used in Study 1, and another agent (Disposer) performing the same object-displacing action, but

without a Givee. We predicted that, if giving actions are obligatorily grounded in a three-place event representation, infants would react to the change in the Disposer's behavior when the agent is later observed giving during the test.

5.1. Methods

5.1.1. Participants—Sixteen infants participated in the experiment (9 females; mean age = 366 days; range = 350-379 days). An additional seven infants were excluded from analyses for fussiness (n = 4), and inattentiveness (n = 3).

5.1.2. Stimuli—During familiarization, two types of events were presented. One of them was identical to the giving event used in the previous studies. The second one ('disposing') differed from the giving event only in a single respect: the passive agent occupied the upper part of the platform, whereas only an apple occupied the side of platform above which the Givee in the previous studies event was located. The behavior of the active agent (Disposer) in this second type of familiarization event was identical to that of giving: the Disposer pushed one of its apples close to the other apple on the opposite side of the platform and then moved back. Thus, the only difference between the two familiarization events was whether the location where the actor pushed the apple included a Givee or not. The Giver and the Disposer were different characters (a blue square and a red triangle, as in Study 1), whereas the passive agent was the same (a green circle) in both types of event.

During the test trials, all infants were presented with giving outcomes with either the Giver or the Disposer as the active agent.

5.2. Results and Discussion

Infants in Study 3 looked longer when the character involved in the giving outcome was the Disposer (M = 21.28, SD = 14.16 s) rather than the Giver (M = 11.72, SD = 6.53 s), $t(15) = 2.584$, $p = .021$, $r^2 = .30$; $p = .041$ by Wilcoxon signed rank test. This pattern was evident also at the individual level: 13/16 infants looked longer at the Disposer giving test event (Figure 4).

As predicted, infants looked longer to the Disposer giving than to the Giver giving to a recipient. This is evidence that infants produced two different goal representations on the basis of whether the change of location of the displaced object relatively to the other agent made the object-pushing action result in transfer of possession or not.

6. Study 4: Taking versus Acquiring

Here we conducted the "omissibility test" on taking actions. We familiarized infants with an agent (Taker) performing a taking action, and another agent (Acquirer) performing the same object-displacing action, but without a Takee. We predicted that, if infants represent the taking action as ACQUIRING, which does not include any reference to second parties previously possessing the object taken, they would not perceive any difference between taking and acquiring, and therefore would not differentiate between the fetching action of Taker and Acquirer during the test. In contrast, did they form a three-place representation of taking, we should obtain the same result as with giving actions in Study 3.

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6.1. Methods

6.1.1. Participants—Sixteen infants participated in the experiment (9 females; mean age = 364 days; range = 353-381 days). An additional four infants were excluded from analyses for inattentiveness (n = 2), and experimental error (n = 2).

6.1.3. Stimuli—During familiarization, two types of events were presented. One of them was identical to the taking event used in Study 1. The second one ('acquiring') differed from the taking event only in a single respect: just like in Study 3, the passive agent occupied the upper part of the platform, whereas two apples occupied the side of platform above which the Takee in the taking event was located. The action of the active agent (Acquirer) in this second type of familiarization event was identical to that of taking: it approached the two apples, and pushed back one of them close to the one at its initial location. Thus, the only difference between the two familiarization events was whether the location from where the actor pushed the apple back to its place included a Takee or not. The Taker and the Acquirer were different characters (a blue square and a red triangle), and passive agent was the same (a green circle) in both types of event.

During the test trials, all infants were presented with taking outcomes with either the Taker or the Acquirer as the active agent.

6.2 Results and Discussion

Infants looked similarly long to the two test events (Taker taking: M = 12.02, SD = 9.74 s; Acquirer taking: M = 12.54, SD = 9.28 s), $t(15) = 0.167$, $p = .870$. This suggests that, unlike in Study 3, where they discriminated between giving and disposing, infants did not discriminate between taking and acquiring. An ANOVA comparing the two studies revealed an interaction between Study and test trial trending towards statistical significance: $F(1,30) = 2.937$, $p = .097$, $\eta_p^2 = .089$.

There was no difference in how long infants attended to the familiarization events between Studies 3 and 4. Infants in Study 3 looked on average for 94.38% of the familiarization duration (M = 19.82 s, SD = 1.58 s). Similarly, infants in Study 4 looked on average for 96.75% of the familiarization total time (M = 20.31 s, SD = 1.17 s), $F(1,30) = .166$, $p = .687$. Thus, the different results in the two studies cannot be accounted by differential attention to familiarization events.

Given the null result in Study 4, we cannot reject the explanation that, rather than having interpreted both the Acquirer's and Taker's action as directed to the acquisition of the object (without including the passive agent in the event structure), infants may have simply failed to establish any goal representation of the two actions during familiarization (we return to this interpretation in the General Discussion). Nonetheless, the results from Study 3 unambiguously supported our hypothesis about giving: manipulating the position of the second agent so that the displacement would not result in a transfer of object possession crucially compromised the representation of the giving action.

Taken together, the results of Studies 2, 3 and 4 provide compelling evidence for the different role that the 'patient' element played in the representation of giving and taking

actions: a necessary constituent in the former, a facultative and context-dependent addition in the latter. The difference between these two seemingly complementary actions, we suggested, is consequential to how the roles of initiator (of the transfer) and acquisitor (of the object) are distributed: in the case of giving, each of the two agents involved in the interaction occupies a distinct role, whereas in the case of taking, both these roles are assigned to the Taker. Importantly, this difference survives also when the two actions are analyzed in cost-benefits terms: in the case of GIVING, benefactor and beneficiary correspond to two different agents (Giver and Givee), whereas in the case of TAKING, they both map on the same agent (the Taker). If the difference between the interpretation of giving and taking is thus couched in terms of the benefits provided for the participating agents, giving, but not taking, may elicit a representation of the interaction as governed by reciprocity considerations, which would in turn make infants expect the beneficiary of the giving action (Givee) to return the favor.

7. Study 5: Expectations of Reciprocity

Recent findings in the developmental literature seem to suggest that infants and young toddlers are guided by reciprocity considerations. In a study by Olson & Spelke (2008) 3-year-olds were found to recommend that a doll should allocate more resources to another doll that had previously shared with her than to another who did not. Similarly, from a first-person perspective, 21-month-olds prefer to help an experimenter who displayed the intention to give them a toy (whether or not she is able to fulfill this intention) compared to an unwilling experimenter (Dunfield & Kuhlmeier, 2010). Finally, He, Kyong-Sun, Baillargeon, and Premack (2013) recently reported that 15-month-old infants expect the target of a prosocial or antisocial action to reciprocate in kind with an action of different form but similar valence, thus suggesting that infants around the first year of life may already expect reciprocity on the basis of a general valence-matching rule, encompassing return of favors as well as retaliation.

Since we found no evidence that infants represented our implementation of the taking action as a social interaction, it is unlikely that infants would expect reciprocal taking. However, the evidence provided about infants' interpretation of giving favors the possibility that infants may expect return of material benefits. We tested this hypothesis by familiarizing a group of infants with the animations of Study 1 and then showing them the passive agent interacting with Giver and Taker by reciprocating in kind or not. Importantly, given the design of our studies (in which giving is always compared to a taking action), even if infants had formed only one type of reciprocity expectation, and therefore represented the passive agent only as recipient of a giving action, we would still observe a different reaction to the two test events in both experimental groups. The expectation that favors would be returned in fact necessarily presupposes the encoding of information concerning the identity of the reciprocated agent (Giver) and the action to be performed (giving). This information alone should make infants react to the Inconsistent test events in the giving and taking group, as both tests exhibit a change along one of the two event dimensions encoded (identity of the reciprocated agent and action).

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7.1. Methods

7.1.1. Participants—Sixteen infants participated in the experiment (10 females; mean age = 347 days; range = 328-368 days). An additional eight infants were excluded from analyses for crying during the test (n = 3), and inattentiveness (n = 5).

7.1.2. Stimuli—We used the familiarization trials as in Study 1, whereas the test trials were modified. During the test, the action roles between Giver and Givee, and between Taker and Takee were reversed. Thus, in the Giving group, infants were presented with the same agent (acting as Givee and Takee during the familiarization) pushing an apple with towards the Giver or the Taker, the former being consistent with an expectation of reciprocal giving. In the Taking group, infants observed the same agent pushing an apple away from the Giver or the Taker, the latter being consistent with an expectation of reciprocal taking.

7.2. Results and Discussion

A two-way ANOVA performed in the same way as in Study 1 revealed no main effect of test trial factor, $F(1,14) = 0.971$, $p = .341$, and no interaction between test trial and group, $F(1,14) = 0.028$, $p = .869$. Differently from Study 1, infants did not look longer to the Inconsistent test trial (M = 15.00, SD = 13.12 s) than to the Consistent test trial (M = 20.94, SD = 17.58 s).

The null results of Study 5 revealed no evidence that 12-month-olds would expect the passive agent to reciprocate in kind towards the Giver or the Taker. Prima facie, this may indicate that infants failed to represent the transfer as a procurement of benefit to the Givee. However, existing evidence on infants' sociomoral evaluation in resource allocation contexts give us strong reasons to doubt this interpretation. Using animations of transfer events crucially similar to ours, Meristo & Surian (2013) and Geraci & Surian (2011), for instance, reported that 10- and 16-month-olds expected a third party to reward or approach a fair distributor over an unfair one – a selective affiliative behavior that could not be expected if the giving actions of the two distributors were not interpreted as positively affecting the recipients' welfare. Thus, absent any information about the value of the resource transferred, infants seem to interpret by default a giving action as bestowment of material benefits. It is thus likely that infants deployed this benefit-based representation of giving also in our study, but without expecting favors to be returned.

This is consistent with the observation that reciprocity is but one of the different types of long-term exchange patterns that could be established between the interacting parties. The expectation that favors should be returned, in fact, is typically considered a normative signature of quid-pro-quo transactions between equal peers, but not of other interactions similarly established through the proactive delivery of material resources (e.g., mother-infant one-way provisioning: Fiske, 1991; Mills & Clark, 1982). Under this reading, the null result of Study 5 would be thus compatible with the possibility that giving primed a relational frame not characterized by equality-matching exchanges (Fiske, 2004).

Alternatively, other-benefiting actions (such as giving) may indeed prime reciprocity, but limitedly to certain context. Despite three-year-olds struggle to modify their allocation

decisions contingently on their partner's behavior in simple bargaining games (House, Henrich, & Sarnecka, 2013), younger children easily succeed in forced-choice paradigms when confronted with agents differing in their cooperative attitudes (Dunfield, Kuhlmeier, & Murphy, 2013; Dunfield & Kuhlmeier, 2011). Warneken and Tomasello (2013) recently took this striking divergence in children's performance as evidence that they may first use reciprocity as a means of partner selection and only later learn how to modulate their prosocial tendencies when interacting with a single partner. Applying such logic to our study, it is therefore hypothesizable that, infants may have lacked the contrastive information about the two agents' social disposition necessary to guide their reciprocity expectations. Given the evidence of Studies 2 and 4, which suggest that infants did not integrate the Takee in the taking events, infants could not have in fact established any identity relation between Givee and Takee on the basis of their similar action role. Without such relation, it would not have been possible to represent the common 'patient' as standing in two partner-specific interactions with Taker and Giver[2].

It should be noted, however, that in spite of failing to confirm reciprocity expectation, Study 5 provided positive, albeit indirect, evidence that infants not only encoded the type of action (giving or taking) relating the two agents participating in the interaction, but also the complementary roles they played (e.g., Giver and Givee: cf. Schöppner et al., 2006). Had infants set up a representation of the dyadic interaction that contained information about the specific type of object-transferring action but, crucially, not about the agents' roles (e.g., 'A and B are in a giving-based interaction' – without further specifying who gave to whom), they would have produced the same looking behavior as in Study 1, detecting the change of action occurring within the giving and taking dyads, but without noticing the role reversal.

8. Replications and Extensions

Below we briefly report three additional studies explicitly designed to: replicate the results of Study 1 with a modified familiarization (Study 6); use this new familiarization to test whether it succeeds in eliciting reciprocity expectations (Study 7); and finally test whether infants used cues extraneous to our definition of GIVING to set up a representation of the social interaction between Giver and Givee (Study 8). For ease of reading, only the hypotheses motivating these additional studies and the discussion of the results are reported in the main text. For details concerning the Methods and Results, the reader may consult the Supplementary Data.

8.1. Study 6: Action Role with Object Consumption

The explanations we put forth to account for the null results of Study 5 implied that, lacking any socially relevant dimension on the basis of which the actions of Giver and Taker could be compared, infants would not be able to generate expectations about the patient's selective reciprocation. Yet, in the study by He et al. (2013) discussed above, 15-month-olds expected valence-matched reciprocation despite being exposed to only one interacting dyad (a

[2]Alternatively, the null results in Studies 5 and 7 may be a consequence of infants' failure to ascribe multiple action roles to the same agent (first Givee, then Giver). However, we find this possibility unlikely. A number of studies found that even younger infants are capable of representing the same character in both a 'patient' and 'agent' role in the helping domain (e.g., Hamlin, Wynn, & Bloom, 2007).

prosocial or antisocial character and a patient). Crucially, however, in one of the experiments reported by He et al. the recipient provided evidence of her subjective (positive) evaluation of the resource transferred (a cookie) by consuming it. Such cue may have sufficed to generate reciprocity expectations, even if no comparison between different agents' interpersonal behavior could be drawn.

We aimed at directly testing the role of cued resource value by adding an eating action (performed by the Taker or Givee at the end of the transfer) to the familiarization used in Study 5. First, however, we intended to replicate the results of Study 1 in order to test whether this additional action would compromise infants' ability to represent giving and taking. Study 6 also differed from Study 1 by including only one apple during familiarization, which, having been consumed, disappeared from the scene by the end of the event.

The results of Study 6 closely replicated the looking-time pattern found in Study 1 (Figure 5), thus demonstrating that 12-month-olds are able to distinguish between giving and taking events regardless of the number of apples possessed by the two agents and the availability of lasting perceptual cues about the direction of object transfer. Study 6 therefore fully validates the use of this modified familiarization to test for reciprocity expectations.

8.2. Study 7: Reciprocity Expectation with Object Consumption

In this study, we repeated the logic of the test for reciprocity expectation (Study 5) but adopting the familiarization sequences from Study 6, which provided evidence of benefit of the acquired resource for the Givee and the Taker.

As in Study 5, infants did not look longer to the inconsistent test event in any of the two groups (Figure 2). Thus, regardless of whether the value of the acquired resource had to be assumed (Study 5) or was explicitly cued (Study 7), this information was not sufficient to elicit the expectation that material benefits should be returned. We believe that these results give further traction to the claim that direct reciprocity is primarily conceptualized in early infancy as motivated by partner-choice purposes, and as such requires two or more agents to be compared amongst with respect to their cooperative attitudes.

8.3. Study 8: Action Role without Shared Attention

In all of the seven studies presented so far we assumed that infants established a representation of the dyadic interaction on the basis of the observed resource transfer between Giver and Givee. However, as an anonymous reviewer suggested, the familiarization events contained subtle cues that could have potentially primed a different interpretation of the interaction. These two cues were: (1) the initial movement of the Givee towards the Giver, and (2) the sequence of alternating gazes between the two agents, which together could have been interpreted as communicative interaction between them. These cues could have primed a representation of the interaction as based on shared attention over the transferred object ('A shows the apple to B') rather than transfer ('A gives the apple to B').

Given that around the first year of age infants are already able to form partner-specific experiential records after episodes of joint object manipulation (Tomasello & Haberl, 2003; Moll & Tomasello, 2007), it is not a far-fetched possibility that infants may have used these additional cues to infer the presence of an interaction in the giving case (but not in taking case, since there was no object that was jointly attended to in the event segment corresponding to the pushing/showing action). In order to test this alternative hypothesis, we ran an additional study in which both cues of shared attention were removed. Had infants represented the interaction on the basis of such cues, their absence should crucially compromise infants' ability to produce expectations about the Giver's behavior in the test.

As the results clearly showed (Figure 5), infants formed action-consistent expectations about the Giver's behavior after being exposed to this modified familiarization. This confirms that object transfer, rather than attention sharing, was the necessary cue for the representation of the interaction between the two agents.

9. General Discussion

The pervasiveness of active resource transfer in the fabric of human sociality, as manifested in the act of giving, is unparalleled among phylogenetically related species (de Waal, 1989). However, representing GIVING poses a non-negligibleinterpretive challenge. Deciding which elements count as candidate constituents of the observed event is ultimately dependent on the particular goal conjecture that the observer forms. Given the nature of transfer-based interactions, such as giving, which makes them amenable to be decomposed in purely object-directed (e.g., disposing) or partner-directed actions (e.g., approaching, establishing contact), the observer is continuously faced with a number of structurally compatible goal hypotheses to choose amongst (Gordon, 2003). We believe that our natural proficiency in solving this interpretive problem reveals the operations of a cognitive schema specific for interactions based on resource transfer (i.e., GIVING). To substantiate this claim, we contrasted GIVING with TAKING, a seemingly specular action schema, and tested whether actions that could be instantiations of either of these schemata were indeed interpreted by appealing to the corresponding concepts.

The results of eight looking-time studies revealed that 12-month-old infants were indeed able to represent these resource-transferring actions on the direction of the object transfer alone, given that the two actions did not differ in their kinematic components (Studies 1, 6, and 8). Remarkably, infants did so after being familiarized with only two instances of each type of transfer event, regardless of the overall number of objects present (Studies 1 and 6), the inclusion of potential cues of shared attention interaction (Study 8), or the presence of lasting perceptual cues of transfer direction (i.e., final distribution of apples: Study 6).

With regard to the difference between giving and taking, the results from Studies 2 to 4 showed that 12-month-olds represented them in distinct templates incorporating differing number of elements. In the case of giving, infants encoded the specific identity of both agents (Giver and Givee), suggesting that they interpreted giving actions as object-mediated relations specific to a particular dyad, whereas in the case of taking infants reacted only to the action change (Study 2). We then provided evidence that such divergence, rather than

reflecting the fact that giving and taking differ in how infants generalize them to new agents, revealed a fundamental distinction between social and non-social goals (Studies 3 and 4). However, we do not intend to claim that taking actions are always interpreted as ACQUIRING rather than as TAKING, i.e., as an object-directed non-social action. Very young infants in fact seem to easily interpret taking as a social action when the interaction provides information about the costs of losing possession that the Taker inflicts upon the Takee (Hamlin & Wynn, 2011). Nonetheless, in our studies infants systematically interpreted giving as an inherently social goal, hence requiring the presence of an animate recipient to be represented (Study 2 and 3), whereas they interpret taking as primarily directed to the acquisition of the object. This difference suggests that infants might solve the task of establishing how many participants to include in an object-transfer event by selecting the minimally sufficient number of entities to justify the costs incurred by the active agent (Giver: loss of a resource; Taker: physical exertion) as functional to the achievement of a goal of benefit procurement (for the Givee and the Taker, respectively).

One might argue, however, that our implementation of the taking interaction was missing fundamental cues, such as the attempted resistance on the part of the Takee, which could have informed infants of the costs incurred by the 'patient' and therefore motivate its inclusion in the representation. This objection does not weaken the theoretical import of the asymmetry we documented, for two reasons. First, it hinges on the assumption that taking is interpreted as an inherently antisocial action, which would represent an odd interpretive default, given the existence of socially tolerant interactions based on dispossession of material resources existing in human and non-human primates (van Noordwijk & van Schaik, 2009; de Waal & Brosnan, 2004; Clark & Grote, 2003). Second, this objection fails to acknowledge that the giving animations we used were no less 'unnatural' than the taking ones, since no responsive or affiliative behavior on the part of the recipient followed the giving action. This is was even more the case in Study 8, where the interaction was devoid of any cue of shared attention (Study 8), further strengthening our proposal that the infants' mind is prepared to recognize transfer events even in underdetermined social interactions.

There is however a different interpretation of the asymmetry between the two object-transferring actions that is compatible with the results obtained. According to this reading, the results from Studies 2 to 4 may reflect a more general failure to attribute any social or non-social goal to the taking actions. In all our studies, in fact, giving and taking actions were partly overlapping, as they were directed to the same agent (Givee/Takee). Thus, even if infants failed to represent the taking event (both in terms of goal and agents involved), the expectations they formed about giving action would be sufficient to detect any (action or identity) change during test in both experimental groups. This account could accommodate all the results obtained. However, far from invalidating the core findings of the present research, it would further deepen the asymmetry between the interpretation of giving and taking actions observed in Studies 2 to 4: according to this reading, while a brief exposure to the giving events was sufficient to invoke the concept of GIVING, the same amount of exposure to the taking events may not have been sufficient even for being interpreted as ACQUIRING, let alone TAKING.

It should be emphasized that the events infants were exposed to in these studies consisted in impoverished animations, featuring limbless agents that could cause the transfer of the object only via unfamiliar effectors (i.e., whole body), and acquire "possession" of an object only by having it in their proximity. The fact that 12-month-olds were able to for representations of these actions suggests that, in spite of their abstractness, these animations satisfied the input conditions required to deploy the schema of GIVING. This constitutes a prime example of "perceptual social illusion" – an illusion of social interactions guided by the ascription of social goals (Jacob & Jeannerod, 2005; Berry & Springer, 1993) – and, as such, calls into question the possibility that infants' own ability to execute giving and taking actions could exhaustively account for their interpretive proficiency.

The evidence that infants' participation in give-and-take exchanges increases from the first birthday onwards (Hay & Murray, 1982; Rheingold, Hay, & West, 1976) could be in fact used to suggest that, just as in other domains, the development of infants' ability to engage in object-transferring actions may have driven corresponding developments in their understanding of the causal and teleological structure of others' actions. The empirical evidence supporting this account, however, comes from studies where the contributions of first-person engagement to third-person goal understanding are typically assessed across contexts involving similar object manipulations (e.g., pulling a cloth: see Sommerville & Woodward, 2010; Sommerville, Upshaw, & Loucks 2012). In our study, on the other hand, no sensorimotor or morphological similarity could have been exploited to solve the correspondence problem between infants' own experience with transferring objects and the events they observed. What infants saw, in fact, was merely a sequence of causally induced changes in a set of skeletal agent-object spatial configurations. In order to conceptually relate such vastly different instantiations of GIVING and TAKING, infants must have already possessed an understanding of their own actions that is abstract enough to apprehend within a common teleological structure their and the agents' actions. While this remains a genuine possibility, none of the current empirical evidence supports the claim that infants' engagement in object-directed activities could possibly enable their understanding of the goals of morphologically unfamiliar agents.

Lastly, it may be argued that the inclusion of the Givee in the event structure of giving event simply reflected a more general case of goal bias. It is established that preverbal infants, toddlers, and adults are more inclined to encode and recall the featural information of objects that serve as goals rather than as sources (Lakusta & Landau, 2012; Lakusta, Wagner, O'Hearn, et al., 2007; Papafragou, 2010), as well as to make more fine-grained spatial distinctions at event endpoints than at event beginnings (Regier & Zhang, 2007). However, the stimuli used in these studies involve animated or non-animated objects moving in a quasi-linear path from one object (the source) to another (the goal). This is in contrast with what infants observed during our familiarizations, since the active agents always approached the passive one and then moved back to their initial position. No straightforward prediction could be derived from the goal-bias literature about which of the two motion segment (from the location marked by the Giver/Taker's apples to the one marked by the Givee/Takee, or from this point to the initial location) infants would select to encode its endpoint. For the goal-bias explanation to account for our results, additional assumptions have to be made: infants should disregard the event segment where the agent

moves without the apple, and encode source and goal information selectively when agent is observed pushing the apple. Furthermore, infants would have to apply the rule that the goal location should be preferentially marked by agents rather than objects, despite the Givee's own apple was always spatially closer to the endpoint of the Giver's pushing motion than the Givee. Therefore, the goal-bias account could explain only part of our results, and would require a number of ad-hoc assumptions to do so.

11. Conclusions

We propose that the ubiquity of active resource transfer across human societies, especially if compared to its exceptional rarity in other phylogenetically close primate species, reflects the major role that the delivery of material benefits played in our evolutionary history by providing a new avenue for the establishment and sustainment of fitness-revelant social relations (Baumard, André, & Sperber, 2013; McCullough, Kimeldorf, & Cohen, 2008). This evolutionary conjecture grounded the hypothesis that humans may possess a specialized knowledge system for understanding and participating in interactions based on resource transfer. Consistently with this hypothesis, here we showed that 12-month-old human infants are able to distinguish between functionally different object-transferring actions (giving and taking) by setting up two structurally distinct representations: giving as a transfer-based social interaction, taking as an object-directed action. This asymmetry, we contend, reflects the different effect and function that the two actions have in human interactional terms (Newman, 1995). Infants' selective proclivity to interpret giving in interactive terms is, in other words, testament to the unique coalitionary function that active benefit delivery had and has in our social arena. The claim that humans possess an early developing conceptual knowledge of social goals (e.g., helping: Kuhlmeier, 2013; Wynn, 2008) should be therefore extended to include basic social interactions based on GIVING, the identification of which may constitute yet another route through which infants could map and track third-party social relations even when they are not participating in them (cf. Mascaro & Csibra, 2012).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- A set of cues necessary for the representation of giving actions is defined
- Infants distinguished between abstract giving and taking events exhibiting these cues
- 12-month-olds represented giving, but not taking, as a transfer-based social interaction
- Infants did not expect reciprocation of giving or taking actions

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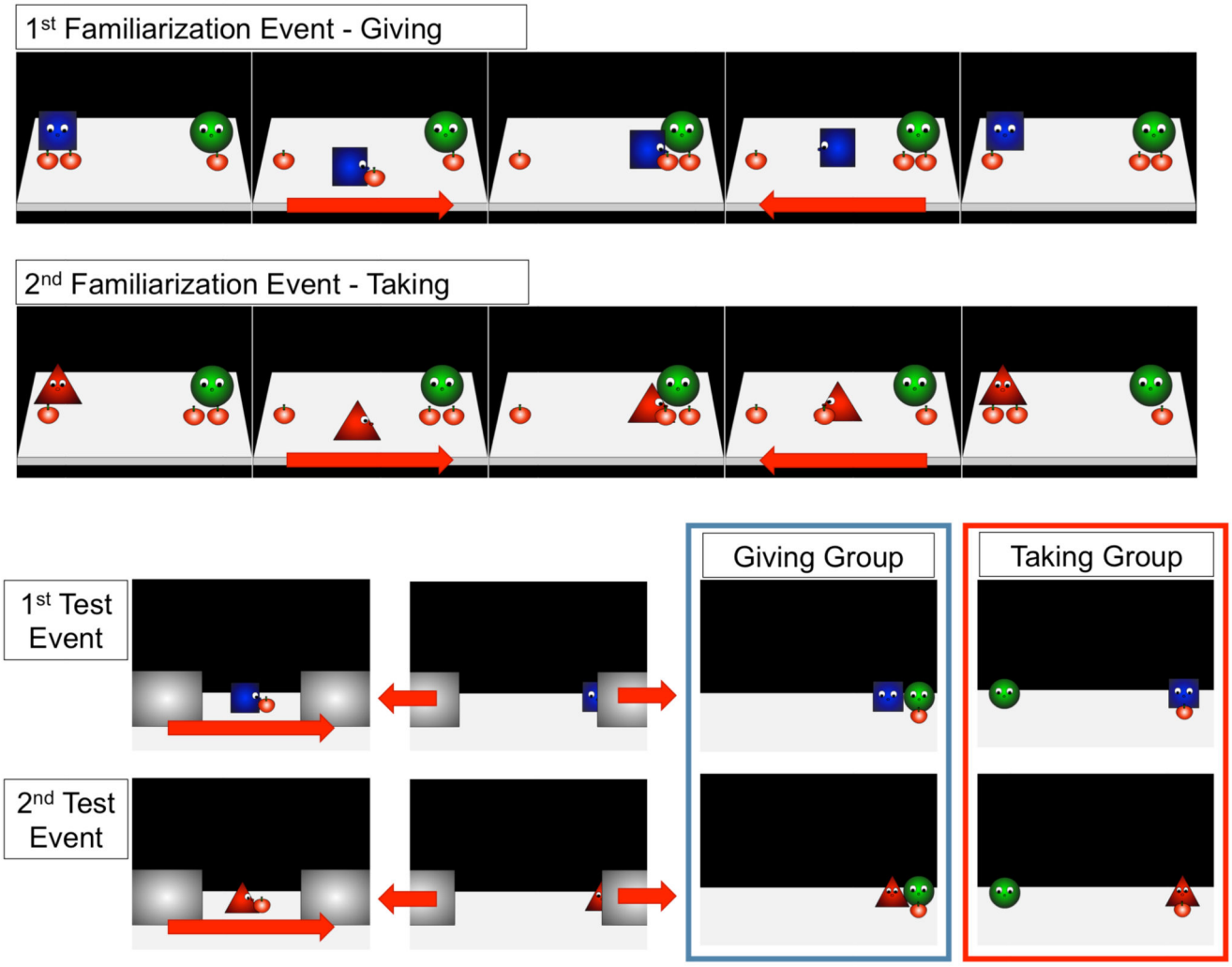

Figure 1.
Schematic visualization of the object-transfer events shown in Study 1. The arrows indicate direction of movement of the agents/objects present on the scene.

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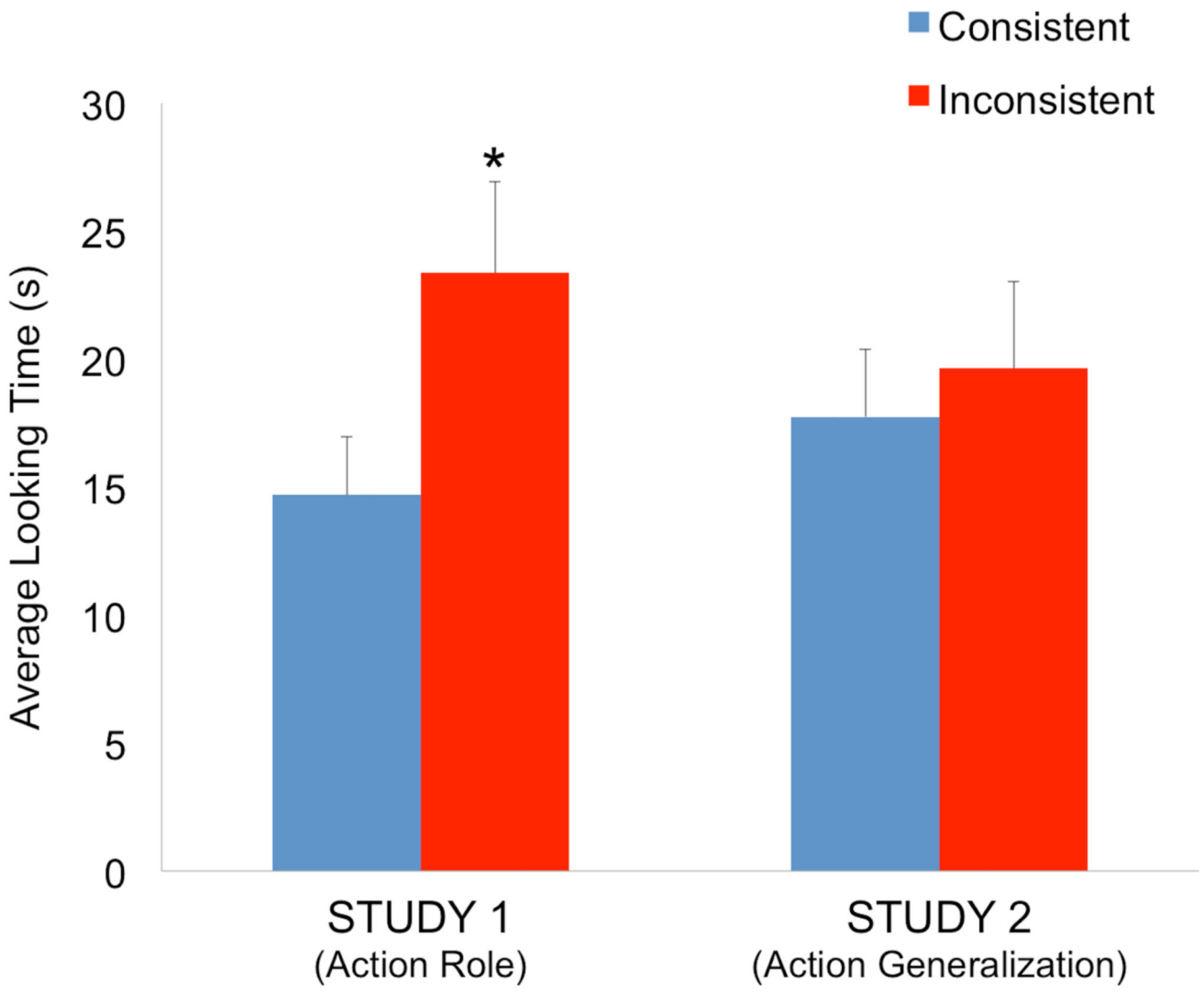

Figure 2.
Average looking times during the test trials in Studies 1 and 2. Error bars indicate standard error. Asterisks represent statistically significant differences ($p < .05$) between the two test trials.

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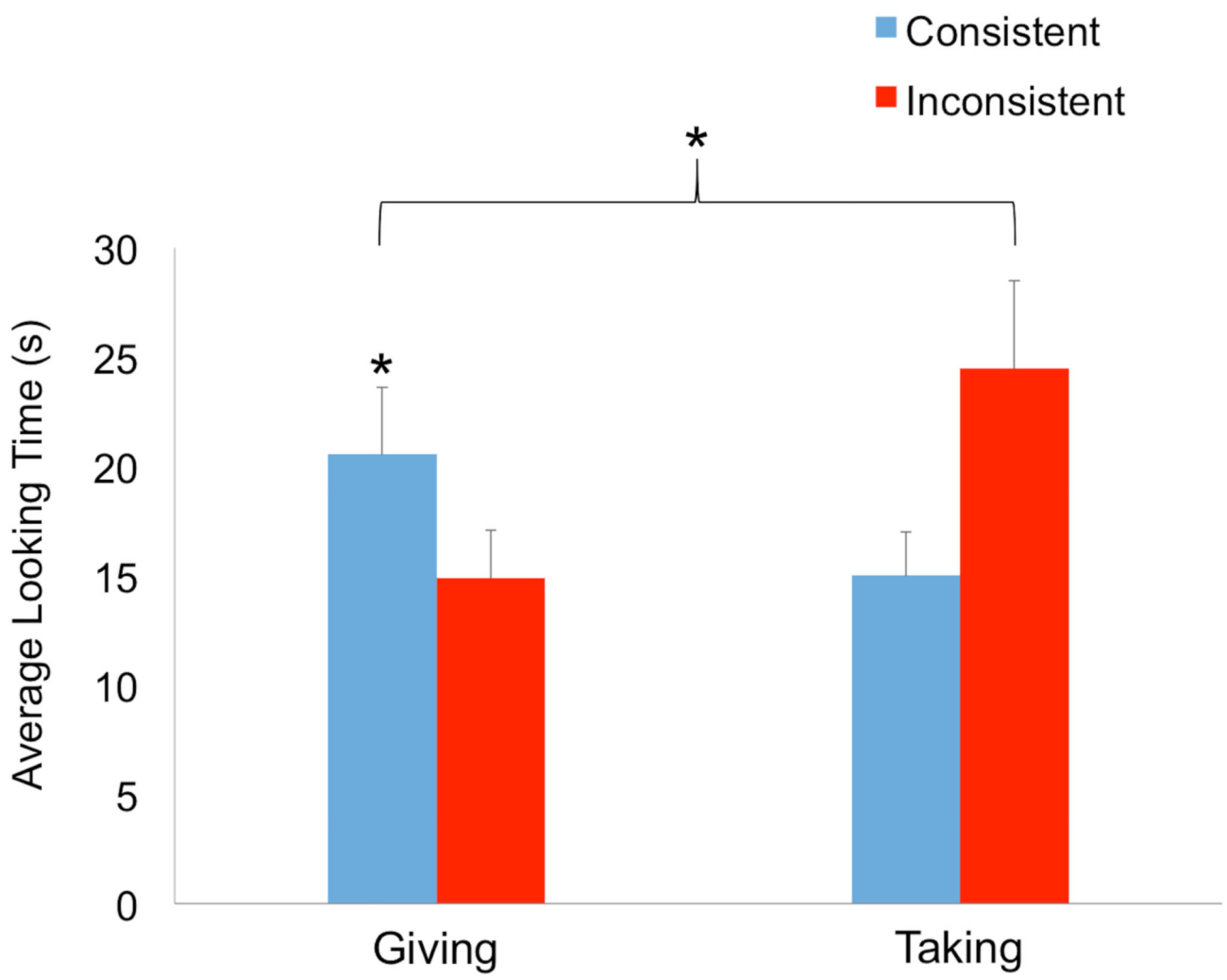

Figure 3.

Average looking times during the test trials as a function of experimental groups in Study 2. Error bars indicate standard error. Asterisks represent statistically significant differences and interactions ($p < .05$).

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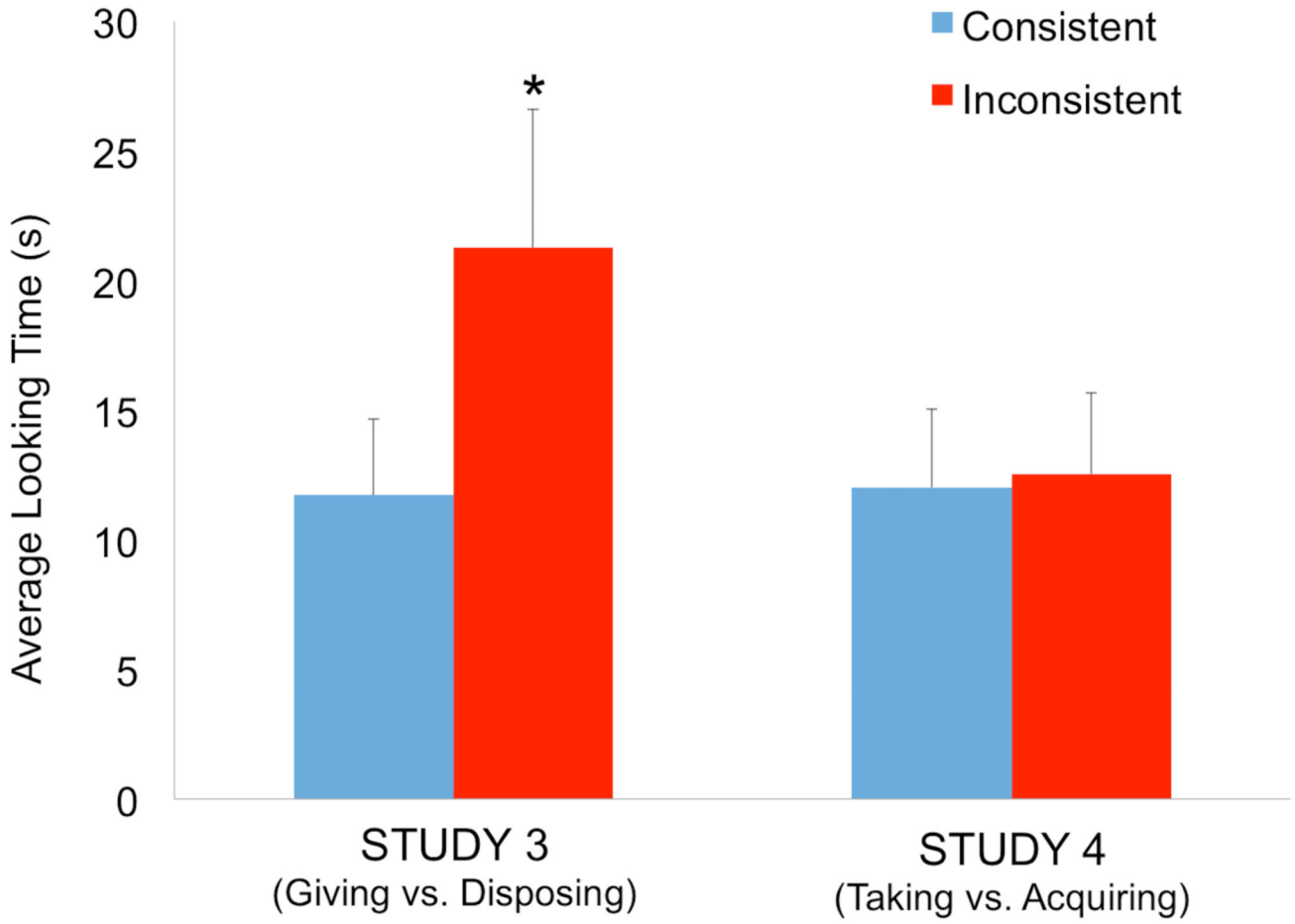

Figure 4.

Average looking times during the test trials in Studies 3 and 4. Error bars indicate standard error. Asterisks represent statistically significant differences ($p < .05$) between the two test trials.

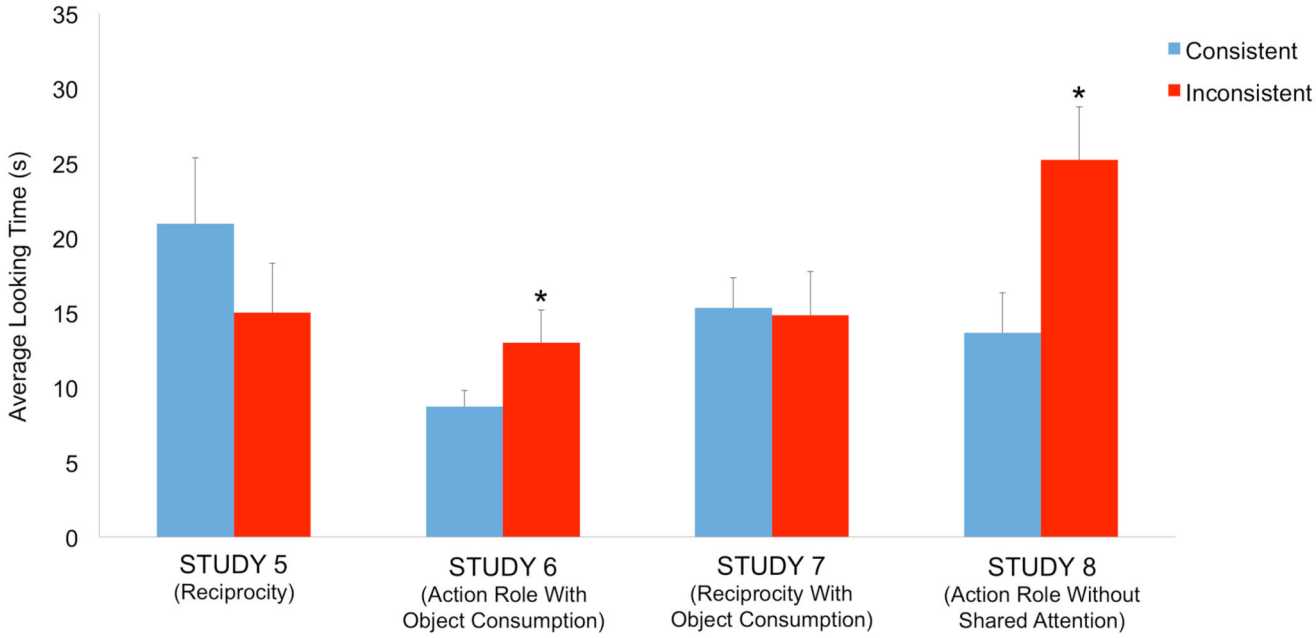

Figure 5.

Average looking times during the test trials in Studies 5-8. Error bars indicate standard error. Asterisks represent statistically significant differences ($p < .05$) between the two test trials.

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Table 1

The table provides all the relevant information about differences and commonalities between the studies.

	1st Familiarization	2nd Familiarization	1st Test Event	2nd Test Event	Initial/Final Number of Apples
STUDY 1 (Action Role)	A Gives To B	C Takes From B	A Gives To/Takes From B	C Gives To/Takes From B	3/3
STUDY 2 (Action Generalization)	A Gives To B	C Takes From B	A Gives To/Takes From D	C Gives To/Takes From D	3/3
STUDY 3 (Giving vs. Disposing)	A Gives To B	C Disposes Of An Apple	A Gives To B	C Gives To B	3/3
STUDY 4 (Taking vs. Acquiring)	A Takes From B	C Acquires An Apple	A Takes From B	C Takes From B	3/3
STUDY 5 (Reciprocity)	A Gives To B	C Takes From B	B Gives To/Takes From A	B Gives To/Takes From C	3/3
STUDY 6 (Action Role With Object Consumption)	A Gives To B	C Takes From B	A Gives To/Takes From B	C Gives To/Takes From B	1/0
STUDY 7 (Reciprocity With Object Consumption)	A Gives To B	C Takes From B	B Gives To/Takes From A	B Gives To/Takes From C	1/0
STUDY 8 (Action Role Without Shared Attention)	A Gives To B	C Takes From B	A Takes From B	C Takes From B	3/3