The naïve sociology of resource transfer

An empirical investigation of the inferential links between sharing behaviors and relational models in human infants

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Declaration of Authorship

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or which have been accepted for the award of any other degree or diploma at Central European University or any other educational institution, except where due acknowledgment is made in the form of bibliographical reference.

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Abstract

The ubiquitous occurrence of active transfer (giving) in the domain of nonkin interactions represents one of the most distinguishing features of the human sharing complex, and a striking departure from the sharing behavior of non-human primates, where giving occurs rarely and only in the presence of dependent offspring. The re-deployment of giving outside of parental-care contexts, we surmise, reflects human-unique selective pressures for the formation of cooperative partnerships to smooth the risks of high-variance foraging via reciprocal sharing.

The co-variation between giving and reciprocally patterned relationships, we hypothesize, represented an evolutionarily recurrent feature of our ancestral social ecology, which has been captured in the human cognitive system in the form of an adaptive prior: an inbuilt propensity to infer from the occurrence of a giving-based interactions the existence of an underlying relationship regulated on reciprocal exchange. Borrowing from Fiske's (1992) Relational Models Theory, we characterize such relationship as conforming to the equality-matching (EM) model (i.e., a model governed by a directive standard of even balance).

Building on these premises, the present work seeks to experimentally investigate such sensitivity to giving as cue of EM relationships in human infants. The dissertation is composed of five sets of studies (excluding the Appendix), which addressed this hypothesis at different levels: first, by assessing whether infants are capable of representing giving actions, and which are the minimal input conditions for inducing such representation (Chapters III and IV); second, by testing whether infants encode information functional for the bookkeeping of welfare imbalances (a socially relevant aspect of EM relationships) selectively for giving-based interactions (Chapters V and VI); and, third, by exploring whether infants expect equal resource division specifically for allocation procedures involving active distribution (Chapter VII).

The findings produced by these studies convergently supported the hypothesis that the observation of giving primes the representation of EM relationships, additionally suggesting that superficially similar transferring actions (i.e., unresisted taking) may elicit fundamentally different inferences about the coordination rules adopted by the sharing partners. These results have two major implications for the research on early social cognition. Firstly, they demonstrate that infants are equipped with a rich conceptual repertoire of possession-related actions, which they exploit to infer different rules for regulating benefit exchange over time. Secondly, they suggest that, beyond the attribution of morally relevant dispositions and the representation of cooperative/competitive coalitions, infants' naïve sociology also encompasses the understanding and classification of social relationships on the basis of different rules of long-term exchange and benefit distribution.

To Melanie,
who met me in the darkest of times
and yet stood her ground.

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List of abbreviations

KS	Kin Selection
RA	Reciprocal Altruism
TS	Tolerated Scrounging
CoSi	Costly Signaling
CBH	Cooperative Breeding Hypothesis
RMT	Relational Models Theory
RM	Relational Model
CS	Communal Sharing
AR	Authority Ranking
EM	Equality Matching
MP	Market Pricing
LT	Looking Time
MCP	Manual Choice Paradigm
FAE	Fundamental Attribution Error

Chapter I. General Introduction

1.1 Sharing, a human universal

Sharing pervades the fabric of human sociality. Social relationships based on resource transfer have been documented virtually in any subsistence society (Gurven & Jaeggi, 2015), between a variety of social actors (differing in age, gender, relatedness, and social status: Kaplan & Gurven, 2005), and for a wide array of exchange commodities (food items primarily, but also tools and objects of ritual value: Foa & Foa, 1981). The archeological record is replete with evidence of sharing networks dating back to the Upper Paleolithic (Enloe, 2003), which suggests that collaborative food production and redistribution represented core features of our ancestral social ecology (Isaac, 1978).

Consistently with this picture, it has been argued that a long evolutionary history of sharing shaped key dimensions of our social psychology (e.g., ownership and fairness norms for coordinating resource extraction and distribution: Boyer, 2015; Boehm, 2004) and organization (e.g., division of labor and economies of scale: Kaplan, Hooper, & Gurven, 2009). Similarly, behavioral ecologists proposed that the human extensive reliance on sharing favored the selection of strategies of intertemporal budgeting which led to the evolution of unique features of human life-history, niche exploitation, and sociality. Intergenerational sharing, for instance, is thought to have enabled the evolution of extended juvenile dependence, making thus possible the acquisition of skill-intensive foraging techniques (Robson & Kaplan, 2003; Kaplan, Schniter, Smith, & Wilson, 2015). Risk-buffering sharing, on the other hand, may have facilitated the entry in a foraging niche characterized by high variance and asynchronous acquisition (Gurven, Allen-Arave, Hill, & Hurtado, 2000). Lastly, meritocratic sharing has been described as a crucial retributive strategy for stabilizing the composition of cooperative ventures (e.g., hunting parties) against the risk of free-riding (Gurven, 2004a). The ubiquity of sharing across societies, its rich archeological evidence, and its major role in the evolutionary history of our species make this type of cooperative behavior, by and large the most prevalent in the ethnographic record, a prominent candidate in the catalogue of human universals (Chapais et al., 2014; Gurven, Stieglitz, Hooper, et al., 2012; Brown 1991).

1.1.1 Cutting at the joints of sharing

Anthropologists have long emphasized the functionally manifold nature of human sharing. From household provisioning (Marlowe, 2003) and courtship sharing (Barclay, 2003) to reciprocal aid between collaborators (Gurven, 2004b; Lee, 1993), through elaborate forms of competitive feasting (Hayden, 2014; Flannery & Marcus, 2012), the kaleidoscope of transfer-based interactions documented across the foraging spectrum provides a dramatic demonstration of the functional diversification that sharing underwent during hominization. Moreover, rather than representing isolated episodes of transfer, such interactions are often part of long-lasting exchanges regulated on the basis of mutually negotiated principles of social investment (e.g., Fiske, 1992; Clark & Mills, 1979). Unlike in non-human primates, where sharing tends to occur in an incidental fashion (as it seems to represent the inevitable by-product of individual foraging strategies, rather than a desired outcome: Gurven & Jaeggi, 2015), and is mostly limited to parental-care contexts, sharing in humans occurs across a number of adaptive domains (kin support, mate acquisition, alliance formation, status seeking: Kenrick et al., 2009) and constitutes a prime means of relationship formation (Schiefenhövel, 2014).

These two dimensions need to be understood jointly. Sharing is essentially diachronic, because it evolved to promote the initiation and maintenance of fitness-relevant relationships, and functionally heterogeneous, because of the different adaptive significance that these relationships have in the human social arena. An immediate implication of such view is that sharing cannot be treated as a unitary phenomenon, but needs to be functionally partitioned according to the type of fitness benefits that it produces with different social actors. Cutting at the adaptive joints of sharing thus requires firstly identifying which fitness opportunities could have been exploited via resource transfer in the human social ecology over evolutionary times and secondly inferring which types of sharing behaviors specifically evolved to harness such opportunities.

Four evolutionary models have been proposed to explain the fixation of altruistic behaviors, such as sharing, in a population: kin selection (KS), tolerated scrounging (TS), reciprocal altruism (RA), and costly signaling (CoSi[1]). Each model specifies a way in which the donor could benefit from the decision to share: by increasing the fitness of genetically related individuals (KS); by reducing the costs inflicted by requesting have-nots (TS); by soliciting reciprocation from beneficiaries (RA); and by advertising underlying genetic qualities (CoSi). Given the social complexity of our species and the unparalleled pervasiveness of resource transfer, it is likely that all these models need to be recruited to account for the full functional scope of sharing in humans. While there is no disagreement over such conclusion, there is substantial debate on how to adjudicate which model a particular sharing practice may be best explained by. In an effort to obviate to the problem of 'overdetermination', which arises when multiple evolutionary processes can equally account for the stabilization of a given trait (Gurven & Jaeggi, 2015), behavioral

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[1] We resorted to this abbreviation to distinguish "Costly Signalling" from "Communal Sharing", a concept which will be introduced later, as the two respective acronyms would have been otherwise identical.

ecologists have recently begun to focus on sharing attributes for which diverging model-specific predictions can be produced. These typically concern:

(a) the identity of the sharing partners (e.g., whether they are kin or not);
(b) the shape of the relationship (i.e., the long-term patterning of several episodes of sharing; e.g., whether the exchange is reciprocal or one-sided: Hinde, 1976a);
(c) the mode of transfer (i.e., how the change of possession occurs within a sharing episode; e.g., by giving one's possession or letting the recipient take it).

Simply put, these dimensions specify who are the participants of a sharing event, what type of exchange pattern the transfer is embedded in, and how it is carried out. We can understand how the analysis of these attributes can help adjudicating among competing models by means of a brief example. Let us consider for instance a sharing interaction that regularly takes place between family members in the form of facilitated taking (where the provider makes manifest to the intended recipients that food is available and encourages them to freely take shares), which shows little to no contingency between given and received food over time. Such interaction can be unambiguously interpreted in terms of KS: the targeted recipients are genetically related to the donor; the sharing relationship persists in spite of the lack of direct (immediate or delayed) benefits for the donor; and the way the transfer is initiated suggests an interest on the donor's part to let recipients benefit from her possessions according to their own needs. While this may represent a uniquely straightforward case, it is important to note that no such conclusions could have been reached, had these dimensions not been jointly considered. The mere occurrence of sharing among kin, for instance, is not sufficient to rule out reciprocity-based explanations, since kin individuals often provide a pool of familiar and reliable partners with whom to establish return-sensitive exchange relations (e.g., Allen-Arave, Gurven, & Hill, 2008).

1.1.2 The adaptive link between local and diachronic sharing

Notwithstanding these issues, this analytic approach is useful to introduce an assumption fundamental to the model of sharing we intend to develop: namely, that transfer modes and exchange patterns are functionally interrelated as components of the same adaptive package which evolved to support domain-specific relationships (*sensu* Kenrick et al., 2009). Under this reading, correlations between local and diachronic dimensions of sharing (i.e., how the transfer is carried out, and which logic of exchange it conforms to in the long run) represent evidence of design features of a common relationship-specific "sharing psychology": i.e., a set of evolved decision rules pertaining to resource distribution for navigating fitness-relevant partnerships with specific group members (e.g., kin, dominant individuals, collaborators (Jaeggi & Gurven, 2013). At the core of our model of sharing lies therefore a three-tiered relation between modes of transfer, long-term exchange patterns, and the corresponding relational benefits that these dimensions co-evolved to exploit. To provide an example of such relation, we shall succinctly preview our evolutionary conjecture about the evolution of giving, which represents the starting point of our empirical inquiry into infants' representation of transfer-based interactions. As we shall later argue (see Section 1.4), giving among nonkin (a specific mode of transfer involving specific social actors) evolved to support the formation of mutualistic relationships based on asynchronous benefit delivery (a specific adaptive domain), which can be stabilized only by maintaining the exchange reciprocal over time (a specific relationship shape). While our conjecture focuses mostly on giving (among nonkin), the underlying assumption that non-fortuitous correlations between local and diachronic dimensions of sharing may reflect the existence of functionally discrete sharing psychologies evolved to sustain specific types of social relationships can be potentially generalized to other sharing practices.

Our interest in developing such a model lies ultimately in providing sound evolutionary grounding to the set of hypotheses about infants' understanding of resource transfer which will be articulated and tested in the following chapters. If, as we argued, specific modes of transfer (e.g., giving) evolved to sustain specific relationships (e.g., reciprocal exchange), we can expect humans to have evolved a preparedness to exploit these evolutionarily recurrent correlations to draw probabilistic guesses about the existence and nature of specific relationships on the basis of sparse social interactions (for a similar argument: Balliet, Tybur, & van Lange, 2016). This would have provided the human cognitive system with a type of inferential productivity about the social world which is of undoubted adaptive significance for a socially gregarious species such as ours, as the fecund research on third-party representations of social relations in group-living primates convincingly showed (Cheney & Seyfarth, 2008; Bergman et al. 2003).

1.2 Food sharing in the primate family

As emphasized before, human sharing has an unparalleled adaptive breadth (*sensu* Barrett, 2014): i.e., the number of life-history domains into which resource transfer has been pressed into service in humans vastly outnumber that of other species. Identifying these domains is therefore the first step we must undertake if we wish to cut the human sharing complex along its adaptive joints. A useful starting point towards this goal is to map the taxonomic distribution of food-sharing phenomena within the primate family. This comparative approach may allow us to eventually reconstruct the evolutionary history of specific sharing patterns by revealing cross-species correlations between particular transferring behaviors and the specific socio-environmental niches in which these selectively occur (Jaeggi, Boose, White, & Gurven, 2016). Recent efforts have been undertaken to detect such correlations by means of phylogenetic analyses on large samples of primate species (Jaeggi & van Schaik, 2011; Jaeggi & Gurven, 2013).

Before discussing the conclusions of these studies, we need to specify what type of behavior(s) we identify as sharing. Following Feistner & McGrew (1989), we define sharing as the unresisted transfer (of food) from one food-motivated individual (the possessor) to another (the recipient). Note that this definition does not include less conspicuous forms of food-related tolerance, such as feeding in the same patch (co-feeding), which may be predominant among social carnivores and some non-human primates (Rapaport & Brown, 2008), focusing instead on cases of genuine food transfer: i.e., cases in which the possessor (i.e., the individual in physical contact with the food) relinquishes her possessions voluntarily to the benefit of the recipient. By specifically targeting episodes of costly and non-coerced resource relinquishment, the definition limits its focus on *prima facie* altruistic forms of transfer – i.e., behaviors unambiguously costly for its producer. At the same time, however, such definition leaves intentionally unspecified how the change of possession is expected to occur (i.e., whether by giving or tolerated taking), thereby admitting variation in how the transfer is carried out.

Focusing on this definition of sharing, Jaeggi & van Schaik (2011) recently published a comprehensive review (the largest to date) of the distribution of sharing behaviors in 68 primate species, from prosimians to humans. The outcome of this unprecedented work can be briefly summarized in three main findings:

1. Sharing was reported for only about half of the species considered. Predictably, solitary species, such as prosimians, and species having regular access to widely scattered food, such as many Old-World monkeys, showed little to no sharing. When sharing occurred, it invariably did so in the context of mother-offspring interactions. Importantly, sharing with dependent young, despite varying enormously in readiness and intensity between species (Brown, Almond, & Bergen, 2004), was significantly predicted by the degree of extractive foraging, which indicates the relative processing difficulty of food items and therefore the relative benefits gained by the offspring via transfer (Silk, 1978; Jaeggi, van Noordwijk, & van Schaik, 2008);
2. Sharing with nonkin only evolved in a subset of species where sharing with offspring had already been established. This strongly suggests that sharing in parental-care contexts is a pre-requisite for the later evolution of sharing among nonkin individuals. This type of sharing can thus be conceived of as a derived behavior (*sensu* Tinbergen, 1952);

3. Sharing among nonkin adults co-evolved with opportunities for partner choice. Between-sexes transfer was reported in species where females could bias mating to other males, i.e., whenever there is an opportunity for female mate choice, whereas within-sexes transfer was prevalently found in species where adults formed same-sex coalitions[2] (most notably, chimpanzees: Nishida et al., 1992; Watts, 2002).

As these findings show, food sharing in the primate family first emerged in the context of offspring provisioning, and progressively expanded its scope to incorporate nonkin interactions wherever a species' social environment posed selective pressures favoring the association with specific group members. It should be no surprise thus that species living in groups characterized by mixed kinship, high fission-fusion dynamics, and shifting coalitions (Harcourt & de Waal, 1992) – a social environment that puts strong pressure on the ability to navigate multiple relationships simultaneously (Aureli et al., 2008; de Waal & Tyack, 2009) – have been reported to use food as a fungible currency for different commodities (e.g., agonistic support, reproductive access) with privileged exchange partners (Gomes & Boesch, 2011; Silk, Brosnan, Henrich, Lambeth, & Shapiro, 2013). These characteristics are eloquently typified in the chimpanzee social environment, known to require forms of sophisticated social strategizing (e.g., de Waal, 2007). For this reason, this high-breadth sharing complex has been dubbed the "chimpanzee model" (McGrew & Feistner, 1992).

1.2.1 The TS, RA, and CoSi models of sharing

If the evidence that chimpanzees (and other eight species of primates, including bonobos and capuchins: Jaeggi & van Schaik, 2011) do engage in nonkin sharing is undisputed, an intense debate surrounds the putative selective pressures that led to nonkin sharing (reviewed in: Carter, 2014). As previewed earlier, three evolutionary models have been proposed to explain the emergence of altruistic acts among nonkin: TS, RA, and CoSi. Adjudicating which model best accounts for chimpanzee nonkin sharing solely on the basis of the sharing partner's identity (the first of the sharing attributes listed in 1.1.1) would be obviously insufficient, since all these models specifically target genetically unrelated individuals. To distinguish among these models, we thus need to additionally detail which predictions these yield about the types of relationship (if any) and

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[2] The only, telling, exception is represented by olive baboons, which do not engage in nonkin food transfer despite extensively engaging in male-male associations. As Jaeggi & van Schaik (2011) convincingly argued, this is likely due to the fact that coalitions in olive baboons are mostly formed by post-prime males, who rarely get the chance to become food possessors, and hence cannot trade food for support (Strum, 1981).

modes of transfer expected to occur under each model. Before exploring these predictions, however, we shall flesh out in more details what these models presuppose.

According to the TS model[3], as we said, possessors share to avoid the costs of having to continuously defend the food against hungry beggars (Stevens & Stephens, 2002; Blurton Jones, 1987). Sharing, thus, rather than being guided by the goal of benefiting a social partner, represents a self-interested strategy to minimize the costs of protracted harassment in light of the differential marginal value of food to have-nots compared to possessors (Stevens & Gilby, 2004). This makes TS a case of manipulative mutualism, in which beggars influence the possessor's cost-benefit ratio such that sharing becomes the most beneficial option for the donor.

According to the RA model, on the other hand, sharing can increase the donor's fitness if the costs of resource relinquishment are outweighed by the benefits of future reciprocation (Trivers, 1971). For RA to work, a number of conditions need to be satisfied. Firstly, there should be a high-enough probability for individuals to meet again, and the roles of donor and recipient should regularly reverse over time. These represent ecologically enabling conditions that are typically satisfied in several group-living primates (Flack & de Waal, 2000). Secondly, a suite of cognitive adaptations must be in place (besides individual recognition, which is minimally necessary to identify past interactants) to prevent exploitation by free-riders (i.e., non-reciprocators): bookkeeping systems to register welfare imbalances in the interaction history accumulated with specific partners (Cosmides & Tooby, 2005), and motivational programs to prompt social partners to regulate the partners' respective investments on the basis of such imbalances (e.g., gratitude: McCullough, Kimeldorf, & Cohen, 2008; anger: Sell, 2011; Delton & Sell, 2014). Unlike in the TS model, sharing in RA *necessarily* presupposes the continuation of the interaction between the parties (Hinde, 1976a; 1976b). If in TS the decision to share can be readily explained by appealing to the immediate benefits accruing to the donor (in the form of relaxed competition), no such possibility exists in the RA model, where the decision to share could only be justified by appealing to the deferred benefits of reciprocation.

Finally, according to the CoSi model, sharing (especially if it involves hard-to-catch or risky items: Hawkes & Bird, 2002), may act as an honest signal of the donor's qualities, thus encouraging association with, and resulting in social or reproductive benefits for the signaler (Bird, Smith, & Bird, 2001). While the dynamics underlying CoSi has sometimes been characterized as a form of exchange (e.g., food for sex: Smith & Bird, 2000), it should be emphasized that individuals who

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[3] The TS model, as used here, is meant to encompass different variants of the same basic mechanism of harassment-induced sharing, such as demand-sharing theory (Peterson, 1993), scrounger-producer model (Vickery et al., 1991), or the sharing-under-pressure hypothesis (Wrangham, 1975). Despite differing in details, all these models share the same idea that food is relinquished when the benefits of hoarding are outweighed by the costs of monopolization.

(decide to) affiliate with the signaler do so only in light of her advertised qualities, not to reward the signaler for the benefits gained from signal production (possibly to encourage its continuation, which would make CoSi a case of pseudoreciprocity, as discussed in: Leimar & Connor, 2003)[4]. This explains why in CoSi the benefits derived for the audience from being recipient of the signal do not act as "reference point" for future transactions with the signalers/donors: the function of the signal is to sort the sender from low-quality competitors, not to set an anchoring point for expected paybacks from the recipients (Smith & Bird, 2000). Because of this, donors should not resent a lack of giving on behalf of past recipients, nor should recipients feel obliged to return benefits to a donor (Gurven, 2004a). This is a key distinction to keep in mind between the otherwise superficially similar exchange logics underlying CoSi and RA.

1.2.2 Adjudicating between competing models

Having briefly reviewed the core tenets of these models, we shall spell out diverging predictions about the types of transfer-based interactions each is associated with. We already suggested that RA-based sharing, unlike TS and CoSi, presupposes an enduring association between the parties. Sharing under RA is expected to exhibit two additional key characteristics: high selectivity, since the decision to deliver benefits to a group member is entirely conditioned on the interaction history with that specific partner, and high contingency between given and received favors, necessary to keep the relationship profitable for its participants over time. Crucially, selectivity also requires a high degree of resource control, to ensure that the resource can be safely transferred (against interlopers) to the intended recipient at the intended time (e.g., when the recipient is needy, and thus stands to gain large benefits from the transfer).

None of these characteristics are expected in the TS or CoSi model: there is no need for contingency, since the donor's decision to share is not conditioned upon the recipient's previous behavior; sensitivity to need is superfluous (in fact, sharing is often modulated by need in TS, but this is only insofar as needy have-nots make for particularly persistent beggars: Gilby, 2006); and resource control is low to none, either because the resource is proactively relinquished on behalf

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[4] These benefits in fact do not play any *essential* role in the CoSi model. The model is entirely agnostic about what type of behavior should qualify as honest signal: insofar as the production costs of the signal could guarantee its honesty, whether producing the signal results in additional benefits for the audience (besides providing reliable information about the signaler's quality) should not matter in making the signaler desirable to its audience. Nonetheless, many of the prototypical instances of CoSi described in subsistence societies consist of ostentatious acts of generosity (e.g., provision of public goods: Hawkes et al., 1993; Boone, 1998). Why is this the case? An elegant answer to this dilemma has been proposed by Smith & Bird (2005). Since providing large food packages for public consumption is likely to attract large audiences interested in getting a share, this has the effect of enhancing the broadcast efficiency of the signal (i.e., the number of observers attracted per unit of signaling effort), and hence its effectiveness.

of large audiences to maximize the signal's broadcasting efficiency (as in CoSi: Kaplan & Gurven, 2009), or reactively relinquished in front of harassing beggars when staking possession claims becomes prohibitively costly (as in TS). Because of this, CoSi and TS are typically associated with *passive* transfer: in CoSi, because the signaler is primarily interested in being publicly recognized as high-quality provider, rather than in biasing the distribution towards specific individuals; in TS, because sharing does not represent a payoff-dominant option for the possessor unless the costs of staking ownership claims outweigh additional consumptive benefits.

1.2.3 TS and partner selectivity in the "chimpanzee model"

With these distinctions in mind, we can now attempt to understand which model best accounts for the sharing behavior typified by the chimpanzee model. We begin by excluding CoSi from the list of candidate explanations, because in none of the species reported to engage in nonkin sharing does the males' decision to pursue high-cost foraging options seem to depend on signaling opportunities, such as the presence of estrous females or dominant individuals (Mitani & Watts, 2001; Gilby, Thompson, Ruane, & Wrangham, 2010). Of the two models remaining, TS is deemed by many (e.g., Gilby, 2006; Clutton-Brock, 2009) the most plausible account of primate sharing, on the grounds that:

1. It is cognitively undemanding, because it does not need to evoke delayed benefits in order to explain the decision to share (unlike RA[5]);
2. It predicts that sharing should prevalently take place with large packages that are hard to monopolize, which is undoubtedly the case in great apes (Watts & Mitani, 2002; Hockings et al., 2007);
3. It predicts that food should be mostly shared in a passive and reluctant way, since it is motivated by the intention to be left alone by potentially aggressive beggars – a mode of transfer characterizing the vast majority of transfer episodes in primates (>95%,

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[5] The idea that non-human primates may cultivate social relationships for *future* benefits has been heavily criticized by Henzi & Barrett (Barrett, Henzi, & Dunbar, 2003; Barrett, Henzi, & Rendall, 2007), since it introduces a prospective element that proximally conditions the primates' decision to interact with other group members. Against the concept of "social relationship" championed by Hinde (1976a; 1976b) and Kummer (1978), which is also the one employed here, their alternative purports to explain primate sociality as based on short-term contingent responses to current needs. However, as noted by Aureli et al. (2012), the concept of RA-based altruism need not to imply that animals are motivated by/conscious of the long-term outcomes of their actions. Instead, it simply implies that they are influenced by the past history of interactions with other individuals. Moreover, observations indicating that social interactions may be influenced by the current supply and demand of alternative trading partners are not inconsistent with the idea that primate sociality may be concurrently influenced by long-term patterns of affiliation. As noted by Cheney (2011), grooming among baboons typically occurs in the absence of an immediate reward, and it is seldom evenly balanced between partners within single bouts.

reviewed in: Jaeggi et al., 2010). Under this account, sharing is thus the direct by-product of the pursuit of individual foraging options, which are in the individual's best interest to pursue in spite of the scrounging, because her ultimate share is nonetheless greater than in alternative foraging yields.

However, several evidences accumulated in recent years suggest a more nuanced picture of primate sharing, where TS-like sharing attributes may nonetheless coexist with a logic of social exchange based on direct and mutual (but asynchronously produced) benefits for the sharing partners. In one famous example, sharing among olive baboons was found to never occur with other males, but with females, which are much smaller and therefore easier to rebuff. Rather than the harassment costs inflicted on males, what seems to be the decisive factor here for sharing are the social costs of potentially losing a consort by being greedy (Strum, 1981). These costs have been shown also in orangutans, where males are socially tolerant towards females attempting to take their food because displaying an otherwise stingy disposition may jeopardize the males' future reproductive opportunities (van Noordwijk & van Schaik, 2009). This "relationship testing" function of sharing (Goldstone, Sommer, Nurmi, Stephens, & Fruth, 2016), where taking is selectively tolerated from recipients who have leverage over possessors, because of the social or sexual opportunities that the former may otherwise forgo, has been found also for plentiful browse, furthering suggesting that the taking is initiated to test for the social tolerance of a designated partner rather than because of mere nutritional gains (Yamamoto, 2015).

Additionally, the low resource control associated with TS does not necessarily preclude the establishment of specific possessor-recipient associations over time (Gilby, 2012; Jaeggi & Gurven, 2013). In fact, insofar as the possessor has some (albeit partial) control over the resource, sharing can be selective, and hence preferentially directed towards valuable social partners. Supporting this idea, successful chimpanzee hunters in Mahale have been shown to allow only long-term allies inside the begging cluster during carcass sharing (Kawanaka, 1982; Nishida, Hasegawa, Hayaki, Takahata, & Uehara, 1992). More tellingly, selective food access to particular scroungers tends to correlate with repeated service exchange among chimpanzee (Watts, 2002; Gomes & Boesch, 2009), suggesting that, even in conditions of pressured sharing, partner-specific tolerance could lead to preferential associations developing over time into loosely reciprocal friendships (e.g., Mitani, 2006; Silk, 2003; 2003; Schino & Aureli, 2009). Thus, despite sharing in primates has been persuasively described as a case of manipulative mutualism, even under conditions of minimal resource control there may be nevertheless room for the formation of enduring and selective associations[6].

1.3 The absence of active sharing in non-human primates

Prima facie, human sharing seems to share many features with the "chimpanzee model", as it also occurs within a social environment characterized by high fission-fusion dynamics, leveling coalitions, and intense partner choice (Nesse, 2009). Unlike in chimpanzees (and other primates), where sharing is decoupled from foraging decisions, food sharing in humans in intimately linked to production, since the latter represents a collaborative endeavor which can be incentivized only under the prospect of rewarded effort (Gurven, 2004a; Gurven, Hill, & Jakugi, 2009). There is however one more difference that makes human sharing stand out – a difference which does not concern either the breadth or frequency of sharing, but the mode of transfer adopted: in our species, goods frequently circulate via giving. In glaring contrast, passive sharing, where individual obtains food from another without the possessor's active help (Brosnan & de Waal, 2002) accounts for the overwhelming majority of transfer episodes in non-human primates. Active sharing, where one individual voluntarily handles food to another, is conspicuously absent (de Waal, 1989), totaling a mere 1% in 10.000 episodes of food transfer in capuchins (Stevens & Hauser, 2005), and 0.9% in 228 episodes of transfer in chimpanzees (Jaeggi, Stevens, & Schaik, 2010).

Such divergence cannot be explained in terms of different action capabilities. In captivity, under conditions of solicited or reinforced transfer, primates are in fact capable of engaging in active transfer, as it has been convincingly shown in the bartering and targeted-helping paradigm. In the former, the animal is given access to a number of tokens to be transferred to the experimenter or a conspecific in exchange for food. Using this paradigm, a number of primate species has been found able to engage in significant exchange behavior (gorillas: Chalmeau & Peignot, 1998; capuchins: Westergard, Liv, Rocca, Cleveland, & Suomi, 2004; chimpanzees: Brosnan & de Waal, 2005), but, crucially, only after extensive training and under the experiment's supervision. Tellingly, despite having successfully exchanged tokens between themselves for several rounds, chimpanzees would cease to sustain the exchange when the experimenter stopped enforcing the transfer (Brosnan & Beran, 2009)[7]. In the targeted-helping paradigm, on the other

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[6] It is worth noting here that some influential hypotheses about the evolution of human sharing were based on similar premises. Blurton Jones (1984), for example, envisioned a transition from tolerated scrounging to reciprocal gift-giving through the development of assortative social dynamics. In similar fashion, but from a group-based perspective, Winterhalder (1996) argued that tolerated theft in archaic communities may have led to the emergence of reciprocal relationships.

[7] A similar failure was also reported in a similar paradigm in which chimpanzee dyads, successfully trained to take turns in inserting tokens in a vending machine for food, ceased to take operate the device in an alternate fashion when

hand, the animal's task is to retrieve a food item from an apparatus by using a tool out of her reach, placed inside an adjacent cage occupied by a conspecific. In these conditions, chimpanzees were found able to transfer the required tool to their social partners, although transfers only occurred in mother-juvenile dyads and upon intense solicitation (Yamamoto, Humle, & Tanaka, 2011; Yamamoto & Tanaka, 2009a). These findings strongly suggest that, though the action of actively transferring an object to another individual is part of the primate behavioral repertoire, heavy scaffolding is required for this type of interaction to emerge and stabilize, revealing how marginal is the role that giving plays in the social life of most non-human primates[8] (Paquette, 1992; Celli, Tomonaga, Toshifumi, Udono, Teramoto, & Nagano, 2006).

1.3.1 The Callitrichids exception

A glaring exception to this pattern is represented by Callitrichids, a family of cooperatively breeding New World monkeys (including marmosets and tamarins), known to regularly engage in proactive food transfer with their immature offspring in the wild (Feistner & Chamove, 1986). The transfer typically occurs in the absence of any prior begging, involves high-value food items (i.e., insect preys or tree exudates), and is signaled by specialized offering calls (Rapaport & Ruiz-Miranda, 2002), revealing a high sharing motivation and a remarkable ability on the part of the adult provider to suppress her own feeding motivation for the benefit of the recipient (Ferrari, 1987). Importantly, adults outside of the breeding pair (i.e., alloparents) often join forces in the task of offspring rearing.

Given the reproductive profile of Callitrichids (characterized by short interbirth interval, postpartum conception, and high rate of twinning: Leutenegger, 1980), extensive allomaternal care appears to be an evolved response to the demands of maintaining high fertility rates, which cannot be met by the breeding pair alone (Jaeggi & Gurven, 2013; Brown et al., 2004). Consistently with this idea, Callitrichids live in kin-based groups characterized by high genetic relatedness and reproductive suppression (i.e., the group only contains one pair of breeders at the time), features that jointly make alloparenting a fitness-maximizing strategy for non-breeding individuals (Lukas & Clutton-Brock, 2012).

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they could manipulate it simultaneously (despite the payoff structure of the game remained unchanged: Yamamoto & Tanaka, 2009; see also: Melis, Grocke, Kalbitz, & Tomasello, 2016).

[8] Even in naturalistic experiments of high ecological validity, where animals are provisioned with food items amenable to be monopolized but also large enough to make transfer feasible (group provisioning studies: Jensen, 2016), active transfer is extremely rare in contrast to co-feeding, harassment-induced sharing, and scrounging (Crick, de Waal, Suchak, Eppley, & Campbell, 2013).

When compared to the sharing of other primates in parental-care contexts, which is often reluctant, invariably passive, involving unpalatable or low-quality food items (Ueno & Matsuzawa, 2004), and restricted to mother-offspring interactions, the collaborative and active sharing of Callitrichids stands out as an eloquent example of how specific evolutionary challenges (in this case, to minimize infant neglect in the face of high reproductive rates) can lead to dramatic chances in a species' sharing psychology.

It is important to emphasize, however, that active sharing does not extend outside parental-care contexts. Adults rarely transfer food among themselves, and they cease to produce invitational signals for the young by the end of the weaning period, and start instead to resist their food requests through physical displacement or aggressive displays (Stevenson & Poole, 1976). The occurrence of active provisioning only in the presence of immature young thus suggests that giving evolved in Callitrichids specifically to secure the survival and growth of highly dependent offspring, otherwise unable to reach adulthood by relying on solitary foraging or scrounging (Jaeggi & van Schaik, 2011).

1.3.2 The cooperative-breeding hypothesis of human sharing

The proposal that active transfer may have evolved in the context of cooperative childcare, as exemplified in the Callitrichids case, has been recently advanced also to account for the uniquely prosocial nature of human sharing. Humans, in several respects, can in fact be considered an extreme example of cooperative breeders[9]: children require provisioning into their late teenage years (Hawkes, O'Connell, & Blurton-Jones, 1997), and caregivers are often required to attend to multiple dependents at the same time (Gurven & Walker, 2006). Building on these similarities, proponents of the "cooperative breeding hypothesis" (henceforth, CBH) proposed that proactive sharing in humans and Callitrichids represents a convergent solution to the demands of cooperative breeding (Burkart & van Schaik, 2010; Burkart, Hrdy, & van Schaik, 2009).

If taken to indicate which selective pressures *first* (phylogenetically) led to the evolution of active transfer in our evolutionary lineage, the hypothesis stands on robust empirical grounds, as Jaeggi & Gurven (2013) showed. If taken on the other hand to suggest that Callitrichids and human giving serve similar adaptive goals (despite the former is circumscribed to offspring provisioning, whereas the latter happens across a variety of relational contexts), the hypothesis runs into the

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[9] It should be however emphasized that in other respects humans cannot be considered cooperative breeders. As Silk & House noted (2015), in other mammals the shift from social monogamy to cooperative breeding is associated with polytocy, whereas humans typically produce a single young. Moreover, levels of within-group relatedness are typically high, whereas in humans only a small fraction of a foraging band is biological kin to the other members. Thirdly, as we argued before, human infants are by no means the only beneficiaries of active provisioning.

paradoxical implication that the panoply of giving-based relationships observed across human societies is the evolutionary outcome of a re-deployment of the very same relational template that supports parental care[10] – a conclusion which flies in the face of the functional heterogeneity of human sharing previously discussed (see also: Chapais, 2009).

Furthermore, the hypothesis leaves critically unexplained why the scope of giving-based interactions has been expanded in the first place. We already showed that Callitrichids rarely engage in active transfer outside mother-offspring interactions. This is consistent with the species' social organization, which consists of family groups with low internal complexity, where the only relevant social distinctions are between older breeders and younger nonbreeding helpers (Solomon & French, 1997), and where there is little to no scope to negotiate access to resources of reproductive opportunities (cf. Kutsukake & Clutton-Brock, 2000; Lazaro-Perea, 2001). These characteristics suggest relaxed (or absent) selection for the evolution of individualized relationships outside the family unit and may explain why giving has never been pressed into service in contexts other than parental care (McAuliffe & Thornton, 2015). If Callitrichids do not show any decisive evidence of non-discriminating band-wide exchange, in spite of the high levels of within-group relatedness, there is even less reason to expect that humans, which evolved in groups with multiple breeding pairs, low reproductive skew, and mixed kinship, would.

Thus, if the "Callitrichids model" well illustrates the idea that active sharing is expected to evolve whenever ensuring the delivery of benefits to a specific class of recipients has sizable fitness consequences for the donor (as it is the case for the Callitrichids' breeding unit), the idea that it may concurrently explain the extension of the scope of giving to encompass nonkin interactions stands on shaky grounds, both theoretically and empirically (Thornton, McAuliffe, Dall, Fernandez-Duque, Garber, & Young, 2016).

1.3.3 Giving among nonkin, a human-unique trait

The primatological comparisons discussed here allow us to zoom in on the peculiarities of the human sharing complex. Consistent with the proposal that high levels of partner choice and coalitionary dynamics (which require the ability to initiate and sustain multiple individualized

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[10] Here lies a confusion between phylogenetic and functional level of analysis. Nonkin sharing is indeed derived from offspring sharing, but this need not to imply functional homology between the two traits. Besides humans, another instructive example of the functional diversification of a pre-existing behavioral pattern is courtship feeding in corvids, which is clearly derived from offspring provisioning (Legg, Ostojić, & Clayton, 2015). Interestingly, this type of sharing is also used by juvenile birds to strengthen social bonds (von Bayern, Kort, Clayton, & Emery, 2007). However, there is a functional difference between possessor-initiated sharing, which is used prevalently as costly signal, and recipient-initiated sharing, which is on the other hand a passive response to a request by an important social partner, and may lead to equitable and reciprocal interactions over time (de Kort, Emery, & Clayton, 2003; 2006).

relationships: de Waal & Tyack, 2003) are associated with functionally differentiated sharing, we argued that humans employ resource transfer in a way that loosely resembles the sharing of species similarly characterized by intense social strategizing (chimpanzees: Silk et al., 2013; Gomes & Boesch, 2011). Crucially, however, we also showed that, in stark contrast to the prevalent mode of transfer documented in those species (i.e., passive and reluctant: Jaeggi et al., 2010), human sharing is largely based on acts of voluntary and active transfer. Thus, if the chimpanzee model can help identifying the selective pressures leading to the exaptation of sharing outside parental-care contexts (namely, the presence of fitness premiums for the formation of stable and enduring associations with nonkin), it leaves crucially unexplained why, concomitantly to the broadening of the adaptive scope of sharing in humans, a change in mode of transfer occurred[11].

Complementarily, if the callitrichids model may help us understanding the type of selective pressures that first led to the emergence of active transfer in our species (i.e., the need of securing the survival and growth of highly dependent young), it fails to account for its extension beyond offspring provisioning.

Neither of the two models, singly considered, can thus satisfactorily explain how giving, a mode of transfer that in the primate family evolved only once under KS pressures (i.e., through indirect benefits) has been eventually recruited in the domain on nonkin interactions (which can only be stabilized via direct benefits).

1.4 Reverse-engineering giving

Having individuated a key feature of the human sharing complex (i.e., the occurrence of transfer-based interactions among nonkin adults based on active resource delivery) that neither of the two most influential models of primate sharing (cf. McGrew & Feistner, 1992) can account for, we shall now attempt to identify the selective pressure that may have plausibly led to its emergence. To this end, we will employ a reverse-engineering method (Cosmides, Tooby, & Barkow, 1992) to evaluate which of the evolutionary models previously considered may best account for the *design features* of our target adaptation (i.e., giving).

Resource-transferring actions can be broadly analyzed according to two parameters: resource control (already introduced in 1.2.2), and signalling. By *control* we refer to an individual's

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[11] The evolution of active transfer among nonkin represents a genuine puzzle, since tolerated taking, as we showed, might nonetheless allow for selective associations to emerge, and, more importantly, represents an even more efficient redistributive option compared to giving (because it reduces the transaction costs for the producer and eliminates the need of staking ownership claims) when returns are diminishing and interdependence is substantial (conditions that are met in several foraging bands: Gurven, 2004a; for a formal model: Nettle, Panchanathan, Rai, & Fiske, 2011).

ability to freely maintain and relinquish possession of a resource in a sharing context. By *signalling* we refer to the ability to advertise certain qualities via resource transfer (Smith & Bird, 2005).

1.4.1 The control parameter

As we discussed earlier, control over the distribution is a requirement for selective sharing, which is in turn necessary to use food sharing as a means of partner choice. While passive sharing does not necessarily preclude the formation of specific associations (see 1.2.3), even in its most proactive and partner-specific form (i.e., facilitated taking, where the possessor places herself in front of the designated recipient, making behaviorally manifest that food can be taken without repercussions: Brosnan & de Waal, 2002), it is vulnerable to two types of interventions that may hinder the formation of dyadic exchanges. First, unless the share which the possessor intends to relinquish is spatially segregated from her resource pool, the transfer is constitutively vulnerable to the possibility that the recipient may take more than intended by the donor (see: van Noordwijk & van Schaik, 2009). Second, since food production typically attracts audiences of food-motivated individuals, the possessor would have to physically exclude other individuals from the sharing site to grant selective access to a specific recipient. Despite coerced expropriation of acquired possessions is in fact infrequent in primates (Brosnan, 2002), designated recipients may be nonetheless wrestled out of the begging cluster by physically formidable individuals who would intercept the transfer. Consistently with this proposal, size of begging clusters and presence of dominant individuals are negatively correlated with the probability of obtaining meat for the possessor's allies in chimpanzees (Gilby, 2006). In the case of giving, on the contrary, the possessor remains in full control of the resource until the transfer is complete, leaving little room for coordination impasses during the change of possession, thereby reducing the possibility that the resource would be left unattended or intercepted.

1.4.2 The signaling parameter

Differences between passive and active sharing can also be found concerning our second parameter: signaling. Passive sharing presents a number of interpretive ambiguities about the possessor's sharing intention (or lack thereof), which are greatly reduced in its active counterpart. Unless the possessor makes the sharing intention overtly manifest (for instance, through invitational signals), her lack of reaction towards an incipient taking would represent poor evidence that the transfer was consented to since it is also compatible with an attention lapse (i.e., failure to detect the approaching scrounger; for a similar argument: Stevens & Hauser, 2005). No such ambiguity exists in active sharing, where the action is ostensibly directed at making another individual possessor of the transferred food: the disposition to share here needs not to be inferred on the basis of the possessor's inaction, but can be straightforwardly read off from her resource-directed behavior.

Furthermore, even assuming that the possessor's passivity can be taken as good evidence that the transfer is consented to, her behavior is compatible with radically different motivations: disinterest towards the food (e.g., due to satiation), submissiveness in the presence of physically intimidating individuals, or genuine prosocial intent. Despite, limited to a single sharing episode, any of these are equally conducive to a beneficial outcome for the recipient, it is only the possessor's motivation to invest in the recipient's welfare that may encourage the recipient to seek repeated interactions with her (Vigil, 2007; Gurven et al., 2000). The availability of competing interpretations for the possessor's passivity (some of which do not imply the ascription of prosocial intent) reduces the signalling value of passive tolerance in sharing contexts, making it a poor signal of prosocial intent. Giving, on the contrary, entails by its own design that the possessor voluntarily submits herself to paying high costs (resource loss and transportation effort) to benefit another individual. These costs alone, we argue, suffice to equip giving with a stronger signalling value. Additionally, once we consider that sharing among hunter-gatherers never occurs under the prospect of immediate returns (i.e., bilateral trade) or enforced exchange (Kranton, 1996), we can appreciate how the structural possibility of non-reciprocation that the donor voluntarily exposes herself to amplifies the generous disposition conveyed by the immediate costliness of the giving action (Molm, Schaefer, & Collett, 2007).

1.4.3 Which model does account for the design features of giving?

To briefly summarize our arguments, we suggested that giving, compared to unresisted taking, is associated with higher control over distributive outcomes (how much and whom to share with: Kopp & Liebal, 2016), and stronger signaling of generous intent. With these conclusions in mind, we can now evaluate which of the evolutionary models earlier considered best accounts for the design features of giving.

The first possibility is that giving may have evolved to meet the demands of nepotistic sharing (KS). Under this scenario, active transfer emerged to ensure within-family distribution in a context of spatially overlapping family units with low between-family relatedness. This conjecture may indeed account for the evolution of a mode of transfer characterized by higher control, since possessors are pressed to exclude nonkin from participating in the sharing. Consistently with this proposal, when family-biased distribution does not automatically result from the spatial arrangement of the households, the goods are actively distributed by the family provider instead of being left near the household for individual apportioning (Gurven et al., 2001; 2002). This scenario however makes signalling a largely redundant component of giving. Given that, in the context of kin-directed sharing, the cost of altruistic acts are offset by indirect fitness benefits (Hamilton, 1964), these benefits alone can explain the occurrence of sharing, even in the absence of mutualistic gains, thereby providing no justification as to why benefit-delivery mechanisms should have been engineered for signaling generous dispositions. Moreover, since kin-directed sharing does not require reciprocal gains to be stabilized, there would be no particular selective pressure towards tracking welfare imbalances between two exchange partners over time. The nepotistic-sharing hypothesis thus would leave critically unexplained the emergence of an arsenal of bookkeeping adaptations, which, as we will argue in 1.5.1, is crucial to understand the system of return-sensitive sharing that allowed the entry of our species in a risky foraging niche (Cosmides & Tooby, 2005). Most importantly, this hypothesis would leave unaccounted what we previously identified as a unique feature of human sharing: the occurrence of giving among nonkin individuals.

In this respect, the TS model seems even less suitable to account for the design features of giving, since it predicts that sharing should occur passively, in conditions of low resource control, and mainly to relieve the possessor of the costs inflicted by harassing beggars. While, as the literature on food sharing among wild chimpanzees showed (e.g., Mitani, 2006), tolerated scrounging may be compatible with assortative partner choice among nonkin, this model would nonetheless pose no additional selective pressure to explain the emergence of active sharing.

A similar argument holds against CoSi-based sharing. The CoSi model certainly involves a signaling component, but crucially different from the one associated with a selective act of benefit delivery (Gurven, 2004a). In CoSi the efficiency of the signal is the product of its costliness and of the size of the audience it attracts (cf. Guilford & Dawkins, 1993). Because of this, we should expect that sharing evolved under CoSi should be geared towards maximizing its broadcasting value. Giving, as it appears, works in the opposite fashion – it may act as a signal, due to its inherent costliness, but only for its intended beneficiary. The CoSi model therefore poses no pressure for the evolution of a selective mode of transfer, like giving. Similarly, there would be no reason for maximizing resource control in distributive contexts. Indeed, in the most typical instances of CoSi-sharing among foragers resource distribution is typically accomplished by someone other than the acquirer (Bird et al., 2001). Hunters publicly renounce to the perks of ownership by dropping the carcass at the edge of the camp, leaving entirely to the audience the task of determining the shares that each individual should receive. This type of "pecuniary distancing" (Bird & Power, 2015) communicates a lack of interest in extracting contingent repayments from the recipients (Cronk, 1994), while allowing the provider to broadcast her generosity without laying bare discrepancies in the treatment of different group members (since the onus of equal allocations is entirely placed on the audience: cf. Peterson, 1993). As this example illustrates, high control and selectivity are therefore not only unnecessary in a CoSi framework, but also counter-productive.

Such is not the case in the RA model. As we discussed, the assumption underlying RA is that sharing may evolve in a population as long as its costs can be recouped via later reciprocation by the recipient. Given that social partners may vary in their ability and willingness to match the donor's investment, the donor is expected to pay the costs of sharing selectively with those members able and motivated to later incur comparable costs for the donor (McCullough & Petersen, 2013). Hence, selection should favor modes of transfer characterized by high control to maximize the likelihood of successfully directing investments towards collaborative social partners. Moreover, since the goal of sharing is to persuade the recipient into entering a mutualistic exchange relationship with the donor, selective benefit conferral also bears an obvious signaling component. As Gurven (2004a) suggested, when payoffs to cooperative partnerships are high, restricted sharing may act as reliable signal of prosocial intent in virtue of its selectivity, i.e., by making manifest that the donor places greater value in the recipient's welfare compared to other potential partners. In the RA model therefore selectivity and signalling are intimately linked.

Summing up, the RA model accounts for all the design features of giving, jointly considered: control, selectivity, and signaling. Additionally, in this model, the signal's function is not merely to promote affiliation with the donor but to communicate to the recipient the level of relative investment that she is expected to mirror to ensure the profitability of the relationship from the donor's perspective (Delton & Robertson, 2016; 2012). The donor's action acts as anchoring point relatively to which adequate reciprocation can be assessed.

1.5 The co-evolution of nonkin giving and bookkeeping

Given its investment-matching logic, the RA model presupposes an additional feature of our sharing psychology which none of the previous models can readily account for: namely, the ability to bookkeep imbalances between exchange partners against the possibility of exploitation (under-investment). The evolution of a mechanism for the detailed mental accounting of a partner's favors, we argue, cannot be understood isolatedly from the emergence of selective transfer among nonkin. In our scenario, the extension of giving outside the parental-care domain and the emergence of human-unique bookkeeping systems are therefore two components of the same "adaptive package" evolved in response to the evolutionary challenge of establishing relationships based on asynchronous favor exchange among unrelated individuals.

1.5.1 Differences between human and non-human bookkeeping systems

Before trying to identify what type of evolutionary recurrent ecological pressures in the ancestral human foraging niche may have favored the establishment of exchange relationships, it is worth clarifying in which sense we consider human bookkeeping "unique". The claim may seem contentious, especially in light of the evidence reviewed (section 1.2.3). Selective associations among nonkin have in fact been reported in a number of group-living primates (Seyfarth & Cheney, 2012; Silk, 2007; 2002). Remarkably, these relationships are characterized by degrees of contingency between given and received services comparable to those registered among hunter-gatherers (Jaeggi & Gurven, 2013). This strongly suggests that primates are capable of forming assessments of a partner's value on the basis of her specific interaction history, providing a strong argument for the idea that bookkeeping systems predate the recruitment of giving in nonkin associations. Supporting a "continuist" view of the evolution of bookkeeping systems, these findings speak also against the "constraint hypothesis" (Stevens & Hauser, 2005), according to which primates are incapable of forming reciprocal relationships because they lack specific computational abilities required to support delayed reciprocation (e.g., numerical discrimination and temporal discounting). The "constraint hypothesis", and the cognitively demanding view of reciprocal altruism that it presupposes, have also been recently challenged by Schino & Aureli (2010; 2009)'s idea of "emotional bookkeeping". Under their proposal, partner-dependent emotional states act as affective read-outs of the statistical summary of an individual's social value, produced by integrating and updating disparate information about individual-specific interaction histories (e.g., frequency, duration, and quality of the interactions: Silk, Cheney, & Seyfarth, 2013) without retaining detailed representations of each exchange episode.

While we share the skepticism towards the cognitive-constrain argument, which merely pinpoints the cognitive challenges that a successful application of a repeated Tit-for-Tat strategy is required to overcome (without providing a cogent reason as to why non-human primates could not have possibly evolved the cognitive machinery necessary to overcome such challenges), we are nonetheless unconvinced that the concept of "emotional bookkeeping" may successfully bridge the gap between the investment-matching logic implemented in human and nonhuman primates[12]

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[12] The concept of "emotional bookkeeping" seems to ride on an outdated dichotomy between emotion- vs. reason-based assessment, reminiscent of the (equally simplistic) notion of "hot" and "cold" reasoning still popular in the social sciences. The criticism here goes both ways: the claim that the evaluation is "emotion-mediated" does not entail by necessity that the computations producing the aggregate value of a social relation, stored as individual-specific affective tags, are themselves imprecise (as emotions are frequently portrayed; for an excellent rebuttal of this thesis: Tooby, Cosmides, Sell, Lieberman, & Sznycer, 2008); and, conversely, the claim that reciprocity is "calculated" does not presuppose the deliberate experiencing of conversion ratios or favor-tallying.

(as other authors seem to believe: Evers, de Vries, Spruijt, & Sterck, 2015; Berra, 2014; Jaeggi & Gurven, 2013).

As Silk (2005) noted, evoking emotions as proximate mechanisms does not help solving the problem of "fuzzy score-keeping". Regardless of how computations about partners' values are implemented in the brain, coarse-grained bookkeeping mechanisms are inherently vulnerable to exploitation, as they can be parasitized by strategies systematically under-investing in reciprocation without being detected (Gilby, 2012). If primates do rely on such forms of score-keeping, we then need to explain why these have not been selected against. Two explanations have been put forth to solve this apparent puzzle: (a) material commodities occupy a marginal role in the primate's social exchange; (b) the types of other-benefiting investments that primates engage in have negligible costs.

Consistently with (a), the majority of favors exchanged among primates consist in *services*: commodities such as grooming and access to feeding sites, which can neither be stolen or stored, let alone easily quantified (de Waal, 1997; Silk & House, 2016). On these premises, it has been argued that primates' service-based exchange does not require the sophisticated forms of bookkeeping that underpin "commodity exchange" to be stabilized (Brosnan, Grady, Lambeth, Schapiro, & Beran, 2008; Yamamoto & Tanaka, 2009b). Consistently with (b), primates seem unable to condition their behavior on recent cooperative acts (i.e., short-term reciprocity), privileging instead long-term partners in a variety of experimental tasks concerning help allocation (food sharing: Jaeggi et al., 2012; joint pulling: Melis, Hare & Tomasello, 2006). Such insensitivity to recent acts of altruism has been taken as evidence that individual episodes of failed reciprocation have negligible costs in primates (and that therefore it is more relevant to choose partners on the basis of their overall willingness to return benefits than to avoid being cheated: Aureli, 2012; Schino & Aureli, 2009). Regardless of which explanation may best account for the emergence of the primate bookkeeping system, both highlight fundamental differences between human and non-human primates' reliance on commodity exchange which support our contention that species-unique selective pressures should be evoked to account for the computational feats of the humans score-keeping system.

1.5.2 Are humans genuine score-keepers?

As several authors noted (Schiefenhövel, 2014; Aktipis, de Aguiar, Flaherty, Iyer, Sonkoi, & Cronk, 2016), humans often also eschew "calculated reciprocity" in favor of imbalance-tolerant relationships (for evidence in the ethnographic record: Widlok, 2016; Hruscka, 2010). This evidence has been used to suggest that differences between human and primate bookkeeping systems have been unduly overemphasized (e.g., Jaeggi & Gurven, 2013). Without taking sides on this issue, we nonetheless would like to note an often-overlooked detail: the accumulation of welfare imbalances in humans is not a structural consequence of approximate investment-tracking mechanisms, but of strategically adopted or socially normed exchange rules that can be flexibly modified depending on the relational goal at hand (Fiske, 1992; Clark & Mills, 1979). Such tolerance, for instance, may reflect differences in timescale over which accounting is performed (Shackleford & Buss, 1996): in coalitions and other fleeting partnerships, short-term reciprocity is required to prevent cheating (thus making a detailed bookkeeping of imbalances necessary), whereas in temporally extended relationships short-term imbalances may be more easily tolerated, especially given the trust-signaling function that this tolerant disposition conveys (by covertly communicating the donor's confidence in the recipient's prospective reciprocation: Barclay, 2013; Cheshire, Gerbasi, & Cook, 2010). Alternatively, tolerance for imbalances may reflect lack of social alternatives: if the costs of being the victim of a temporary defection is less than the costs of terminating a relationship which cannot be readily replaced, individuals should be tolerant of such defections (Hruschka & Henrich, 2006). As these examples demonstrate, welfare imbalances may accumulate in a mutualistic relationship not because undetected, but rather because bookkept and nevertheless tolerated (for strategic reasons[13][14]). In spite of the fact that humans oftentimes avoid behaving in a strict Tit-for-Tat fashion, and form relationships ostensibly devoid of any favor-tallying component (Silk, 2003), the anthropological literature on gift-giving shows that forms of calculated reciprocity based on precise accounting of material favors can be successfully sustained,

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[13] Interestingly, chimpanzees' expectations of reciprocity and tolerance for inequity seem to be similarly modulated by social closeness. Chimpanzees playing a rope-pulling version of the trust game were more willing to 'trust' friends (i.e., individuals with high composite index of sociality: see Silk, Seyfarth, & Cheney, 2013) than non-friend, preferring to pull a rope that allowed them access to their preferred food, which the beneficiary could eventually send part back, rather than a rope resulting in immediate access for the subject to less preferred food (Engelmann & Hermann, 2016). Similarly, chimpanzees participating in a food-for-effort exchange task were more prone to tolerate inequalities when working alongside conspecifics who they had strong social bonds with (Brosnan, Schiff, & de Waal, 2005). Specularly, the contingent effect of grooming on food sharing has been repeatedly reported to be more pronounced in socially distant partners (de Waal, 1997; Jaeggi et al., 2013), which is compatible with the idea that recent cooperative acts weigh more heavily in dyads who did not yet form a relationship (as predicted by the partner-choice model: Schino & Aureli, 2010).

[14] As Xue & Silk (2012) argued, friendship seems to be based on two fundamentally incompatible rules. On one side, it seems inappropriate to keep careful and accurate track of the benefits given to and received from friends, or to help them under the explicit expectation of future repayment. On the other, friendships are based on the idea that costs and benefits need to be balanced in the long run. This "paradox of friendship" can be easily dispelled by considering the trust-signaling function of imbalance tolerance. Corroborating this claim, people perceive negatively one's attempt to immediately repay her social debts, because it reveals a desire to sever the relationship with the beneficent (Hruscka, 2010). Furthermore, as Carter (2014) suggested, concealing expectations of exchange may also function similarly to indirect speech (Lee & Pinker, 2010), allowing people to negotiate topics of implicit social conflict while at the same time maintaining plausible deniability about their own expectations (see also: Bohl, 2015).

which *per se* constitutes evidence of fine-grained bookkeeping of commodity exchange at work (e.g., debt-relationships among Masaai and Turkana people: Bollig, 2010; but see: Aktipis et al., 2016).

For the present purposes, these arguments suffice to clarify in which sense we suggest that the human bookkeeping mechanisms are *unique* (Cosmides & Tooby, 2005). It should be manifest that the version of human exceptionalism that we are defending here is lean and decidedly gradualist[15]. Just as in the case of the transition from quasi-selective associations formed on the basis of tolerated scrounging to the more efficient mechanisms of social assortment made possible by the evolution of giving among nonkin, we can similarly trace a phylogenetic progression from the primate bookkeeping system, which can only safeguard against the accumulation of long-term imbalances (and only support weakly contingent service exchange), to sophisticated accounting mechanisms able to stabilize strongly contingent commodity exchange also in the short term.

1.6 The ancestral social ecology of RA-based relationships

We previously suggested that active sharing among nonkin and fine-tuned mechanisms for investment-tracking evolved in humans in response to the adaptive challenge of attracting partners for long-term associations based on reciprocal exchange. However, our hypothesis is still lacking a contentful characterization of the socio-ecological context which may have posed a selective pressure for the evolution of such associations. We shall briefly attempt to remedy this omission in the present section. Following Jaeggi & Gurven (2013) we propose that the context in which reciprocal and selective sharing emerged was defined by two main factors: one ecological, the other social. The first consisted of a risky foraging niche defined by frequent shortfalls, asynchronous production, and large resource packages; the latter in a pool of potential social partners differing in harvesting ability, effort, and hoarding motivation (Kaplan et al. 2012; 2009). A coherent narrative concerning the evolution of selective and reciprocal sharing can be built upon the interplay of these two factors: the high variance in resource availability provided the selective pressure for the evolution of collaborative strategies to smooth consumption over time (Winterhalder & Smith, 2000); the resource size and distribution produced conditions conducive to reciprocity, since possessors could often provide large benefits to have-nots at small marginal costs, and the roles are frequently reversed (Winterhalder, 1996; Kaplan & Hill, 1995); and finally, the individual variation in foraging skills and efforts, as well as the possibility of exploitation,

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[15] Our reconstruction is reminiscent of Chapais' (2009) proposal that the emergence of enduring dyadic relationships in primates (sustained through service exchange: Mitani, 2009) paved the way for humanlike contingent reciprocity of material resources.

provided the selective pressure to make sharing selectively return-sensitive and directed towards the best collaborators. Consistently with this scenario, Gurven (2004a) found across eight subsistence societies that the need of ensuring a regular resource flow between producers in the face of shortages was a stronger predictor of the occurrence of sharing than the possibility of trade (i.e., simultaneous exchange of goods), even for groups with high division of labor (correlated with a wide produce variety and consequently a higher scope for trading), and that, crucially, only this risk-buffering sharing targeting previously collaborative producers ("restricted sharing") tended to be patterned in a reciprocal fashion[16].

1.7 Giving as a cue of reciprocal exchange relationships

It should be clear by now that the evolutionary conjecture we developed in the previous sections ties the emergence of a mode of transfer (giving) to a relationship among specific social actors (nonkin individuals) characterized by a certain long-term patterning of the resource flow (reciprocal exchange)[17]. In 1.4.3 we used a form-to-function argument to explain why such linkage is not coincidental: RA is the only model that exhaustively accounts for the design features of giving, thereby suggesting that its exaptation in the domain of nonkin interactions has been due to RA-like selective pressures. Accordingly, in 1.6 we sketched a candidate evolutionarily recurrent

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[16] Gurven (2004) also noted that high-control (and merit-sensitive) transfer may have evolved also to stabilize forms of collaborative food production requiring the *simultaneous* participation of several individuals, such as collective hunting. Consistently with his proposal, sharing at the killing site follows clear prescriptions according to who contributed to the hunting gear and the hunting effort and it is typically carried out by a designated distributor, whereas subsequent sharing at the base camp is more indiscriminate and leaves considerable room for scrounging. The sequence of sharing thus can be connected with different levels of more or less widespread and prescribed sharing (Bahuchet, 1990), which reflect the different importance of benefiting particular social actors (e.g., the participating hunters).

[17] The anthropological literature on sharing is rife with observations supporting the proposal that acts of giving may be associated to expectations of reciprocation. This is indirectly corroborated by the evidence that, among foragers, people often take pains to avoid giving-marked interactions, precisely because of such expectations: acts of giving are "downgraded" to acts of "leaving goods for others to take" by either sending intermediaries (typically children) with demands for a share, or by allowing others to simply take without any offer being made (Widlok, 2016). Importantly, tolerated taking and giving often occur side by side, without requiring the transaction to be marked as either a gift or a recipient-initiated share to specify its expected social implications: the action itself is sufficient to communicate the type of expectation at work (Wiessner, 1982). In a similar fashion, Testart (1987) described the co-occurrence of two types of sharing: system A (producer-initiated) and system B (recipient-initiated) in several hunter-gatherer societies, suggesting that these two systems define distinct kinds of relational obligations. A distinction between different types of sharing and their corresponding obligations is also put forth by Damas (1972), who describes voluntary giving as tied to recognized social bonds and previous exchanges, whereas sharing via taking as a redistributive act unburdened by any social requirement. Given this evidence, it is no surprise that many foraging groups, spanning from Inuit to !Kung, use different linguistic markers to differentiate items surrendered because asked for vs. items given with the intention of benefiting someone (Kishigami, 2004).

challenge (i.e., risk smoothing among producers) that may have provided such selective pressures in the ancestral foraging niche.

Crucially, the co-evolution of giving and reciprocally patterned exchange implies that the co-occurrence of these attributes of sharing represented an enduring statistical regularity in the human social environment, amenable to constitute itself a target for further adaptations to be fashioned onto. The adaptive linkage (between giving and reciprocal relations) above hypothesized therefore regularly produced correlative evidence which, if exploited, would have allowed individuals to predict from a limited sample of transfer-based interactions the shape of the relationship that these instantiated. Differently put, the co-occurrence of active sharing and asynchronously mutualistic (i.e., reciprocal) associations could have been captured in the form of a *diagnostic* dependency between the two terms on the basis of the fitness-enhancing effects that exploiting such correlative evidence would have had (by allowing a fast and efficient mapping of an individual's social surroundings). Given the adaptive benefits that charting out the relational fabric of a resident group (in terms of kinship, dominance structures, and temporary coalitions) has for a number of obligatorily gregarious primates (Seyfarth & Cheney, 2015; Silk, 2015; Silk et al., 2013b; Cheney & Seyfarth, 2008), we expect natural-selection processes to have harnessed such diagnostic relation in the human cognitive architecture as an *evolved prior* (cf. McKay & Efferson, 2010). By this concept, we broadly refer to the propensity to assign a greater likelihood to a certain hypothesis over competing others on the basis of available cues[18]. In our scenario, this prior can be conceived of as a preparedness to treat the occurrence of a giving-based interaction as diagnostic of the existence of a long-term relationship (between Giver and Givee) sustained via reciprocal exchange.

1.8 Core tenets of the Relational Models Theory

The idea that natural selection endowed humans with a sensitivity to perceptually available indicators that identify instances of long-term relations in the social arena was first championed by Fiske in his Relational Model Theory (henceforth, RMT: Fiske, 1992). The RMT postulates that humans across cultures structure their social interactions according to four fundamental "relational models" (henceforth, RM). Fiske (2004) defined these models as *fundamental* in the sense that they influence social cognition at multiple levels: how social experiences are encoded, processed, and recalled; how socially relevant actions are planned and carried out; and how actions are evaluated.

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[18] It is worth emphasizing that a cognitive prior only describes a probability distribution of values before observations are taken into account (Moya, 2013). As such, it does not imply that the regularity that this is based upon needs to be appraised by the perceiver in a theory-rich sense.

As such, RMs can be conceived of as structured coordination systems that provide social actors with: a cognitive schema to generate and interpret meaningful social interactions; a set of emotions that motivate actions consistent with the inferred model; and a sense of commitment to act accordingly to the negotiated model, along with the right to impose sanctions for behaviors violating the model's directive standard.

These models represent universal and cognitively modular relational proclivities, which Fiske calls *mods*. Three characteristics of mods should be discussed here. Firstly, mods represent highly structured learning mechanism resulting in social competencies (i.e., the ability to recognize and differentiate social relations) that would be otherwise impossible to learn without a set of innate expectations. Paralleling the learnability question first raised by Chomsky (1976) in the domain of language acquisition, Fiske (1992; 2014) argues that a set of conceptual primitives are necessary to constrain the potentially infinite inductions about the meaning of a social action that can be generated in interpersonal contexts. Mods thus solve the bootstrapping problem by providing an abstract "grammar of social relations": i.e., an in-built skeletal knowledge functional to constrain learning, inference, and experience in the social domain (Thomsen & Carey, 2013).

Secondly, as posited by Fiske's "conformation theory" (2009), each mod is constituted and communicated in a distinct medium, which humans are prepared to recognize as indicative of a given RM. It therefore follows that humans are not only endowed with a conceptual vocabulary of RMs, but also with a complementary sensitivity to their prototypical instantiations.

Thirdly, mods represent evolved cognitive templates for organizing social interactions, which cannot function without "cultural complementation" (Fiske, 2000). If mods specify the kinds of socially meaningful operations in each RM, they do not delineate when, how, or with whom to implement them (Fiske, Thomsen, & Thein, 2009). People therefore need socially transmitted prototypes, precedents, and principles (referred to as *preos*) to complete the mods. For instance, Communal Sharing, which (as we shall soon discuss) is a relational structure that organizes people in equivalence classes, requires local cultural inputs to specify what determines membership in the corresponding relation. Similarly, Equality Matching, which structures interactions with reference to a principle of even balance, requires socially transmitted knowledge about, e.g., what counts as a favor, what are the conventions regarding the proper interval before reciprocating, and so on (Fiske, 2000).

1.8.1 The four relational models

With these three characteristics in mind, we can now introduce the four RMs identified by Fiske (1992; 2004): communal sharing (CS), authority ranking (AR), equality matching (EM), and market pricing (MP). For each model, we will briefly discuss its normative principle, the type of information that the individuals participating in these relations should be motivated to attend to, the formal properties of the relationship that the model instantiates, and the adaptive domain which it is associated with.

In CS people perceive each other as socially equivalent or undifferentiated with respect to the matter at hand. CS relations are prototypically manifested in close-family bonds, as well as in larger collectives (e.g., teams, armies). The only meaningful social distinction that people in a CS relation attend to concerns who is part of the CS relation and who is not. CS relations are thus equivalence relations and can be exhaustively represented using a nominal scale. These are based on actions that substantively connect individuals' bodies: e.g., nursing, breastfeeding, cuddling, moving together in a synchronized fashion, marking a common identity with physical tags. These practices and behaviors, which Fiske collectively refers to as consubstantial assimilation, *indexically* represent the equivalence of the actors involved. Despite CS relations can be arbitrarily extended to include nonkin individuals, the phylogenetically earliest and prototypical manifestation of CS concerns mother-infant interactions. For this reason, CS relations pertain to the parental-care domain (Haslam, 1997).

In AR, on the other hand, people are asymmetrical ranked along a linear hierarchy of power. Typical examples of AR relations include military hierarchies, caste systems, and other instances of power differentials based on gender or age. These relations differentiate individuals in subordinates, expected to defer to high-rankers, and dominants, expected to protect and lead low-rankers. In AR relations people need to consider not only whether two individuals belong to the same rank, but also the direction of such difference (i.e., who is higher in rank to whom). AR relations can be thus modeled using an ordinal scale based on the assumptions of relational identity (i.e., two people cannot outrank each other), and complete connectedness (i.e., for any two individuals in an AR relation, their rank is exhaustively defined, which assumes that there are no loops in a single AR relation: cf. Fiske, 1992). AR relations are *iconically* constructed by positioning individuals along dimensions of physical space, magnitude, time, and force (e.g., above/below; preceding/following; bigger/smaller). Despite Fiske (1992; 2004; Fiske & Haslam, 2005) systematically portrays AR relations as prestige-based hierarchies (based on a freely deferred status granted to certain individuals because of key political competencies or leadership in decision-making: Henrich & Gil-White, 2001), the phylogenetic antecedent of these relations consists of dominance-based hierarchies, in which priority of access to resources is determined through physical formidability, threat, and intimidation (Cummins, 2005). AR relations fall squarely within the adaptive domain of status seeking (Kendrick et al., 2009).

In EM, relations are based on a criterion of even balance or one-to-one correspondence. Typical instantiations of EM relations are interactions among friends and acquaintances based on the (long- or short-term) directive standard of even balance. Unlike in AR, in EM relations, differences are not only directional (i.e., who is greater than whom), but they also have magnitudes (i.e., how much A owes to B). People have thus to consider how much they need to invest to even out welfare imbalances between participants. EM relations can be formally represented as Abelian groups (Bolender, 2010), to which the associative and commutative laws apply: i.e., the way in which the exchanged benefits are grouped together, and the order in which they are added, is irrelevant to the (additive) tallying of welfare imbalances. EM relations are manifested by means of *concrete operations* of even balancing, e.g. taking turns, matching shares in a one-to-one correspondence, or flipping a coin (Fiske, 1992). The directive standard of even balance suggests that EM relations fall within the adaptive domain of mutualistic nonkin interactions, since these can only be stabilized by generating direct benefits (in the long run) for the parties involved.

Finally, in MP, relations are based on socially meaningful proportions. Instances of MP are proportional justice, trade, tithing, and prostitution. People in a MP relation are concerned with maximizing utility by exchanging different services or resources. To do so, people need to reduce the components of the exchange to a single utility metric that allows the comparison of qualitatively diverse resources and define equality with references to ratios on this metric. For this reason, MP relations can be modelled on a ratio scale. MP relations are construed through *arbitrary symbols* such as numerical representations of ratios, rates, prices, or moral utilities, and they often involve money as transaction medium. Unlike the previous RMs, MP does not have any obvious phylogenetic precursor (Haslam, 1997). Furthermore, despite the principle of proportionality in moral calculus is ubiquitous in the ethnographic record (cf. Baumard, André & Sperber, 2013), the same cannot be said for other instantiations of MP, such as bilateral trade, suggesting that, instead of representing a panhuman adaptation, they may be the outcome of convergent cultural learning spurred by labor specialization (cf. Chapman, 1980). Since we are primarily interested in exploring the human in-built repertoire of RMs in the resource-sharing domain, we will leave MP out of our analysis (similarly to Thomsen & Carey, 2013).

In addition to these four models, Fiske (1992) describes two other limiting cases that do not involve any coordination rule: asocial interactions, in which an individual exploits others as animate objects or means to an end[19]; and null interactions, in which two or more individuals never adapt their actions to each other despite living in the same space.

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[19] Departing from Fiske (1992; 2004), who limits AR to prestige-based asymmetries, we argue that interactions based on aggressive contests for resource access also qualify as building blocks of AR relationships (cf. Chapais, 2015;

1.8.2 Identifying the adaptive domains of CS, AR, and EM

In section 1.2.1, we presented four evolutionary models of sharing: KS, TS, RA, and CoSi. We showed that each model appeals to a different source of benefits to justify the immediate costs of sharing, and that it reflects into a different (if any) diachronic development of the sharing interaction over time. When the costs of sharing can be recouped in terms of inclusive fitness (hence, *indirect* benefits), as in KS, a transfer-based relationship can be maintained even if systematically biased in favor of one of the sharing partners. Instead, when the costs of sharing can only be offset by direct but *future* benefits, as in RA, the transfer-based relationship can persist over time only if reciprocal. In the TS and CoSi case, on the other hand, sharing can be explained by appealing to *immediate* direct benefits for the donor (i.e., harassment reduction in one case, audience attraction in the other), making the continuation of the interaction unnecessary. However, as the "chimpanzee model" suggested, in socially gregarious species the social costs of rebuffing have-nots may be larger than the costs of protracted scrounging (see 1.2.1). A similar argument can be fashioned also to explain the perpetuation of dominance-based relationships (as suggested in the previous footnote): if the social environment is such that avoiding dominants would have substantially higher fitness-reducing effects for the subordinates (as this would require, for instance, leaving the resident group) than repeatedly forgoing resource access to the dominants' advantage, it would be then profitable for the subordinates to "accept" the terms of a relationship systematically skewed in the dominants' favor.

These distinct ways of patterning benefit exchange between interactants over time, we argue, approximate the directive standards which the CS, EM, and AR models are regulated onto, and identify the corresponding adaptive domains where these models likely emerged (i.e., interactions between kin, nonkin peers, and individuals of different ranks: Haslam, 1997). In detail, relationships supported via KS, which are characterized by non-contingent fluctuations of resource flow (Gurven, 2004a) can be reasonably assimilated to the CS' normative orientation, according to which "people take what they need and contribute what they can, without anyone attending to how much each person contributes or receives" (Fiske, 1992). Similarly, relationships supported via RA, which are defined by a high contingency of given and received services (Jaeggi & Gurven, 2013) are structured in a way closely paralleling EM's regulatory principle, according to which "people are primarily concerned about whether an EM relationship is balanced, and keep

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Dubreuil, 2010). What distinguishes asocial relations from dominance-based ones is therefore not the type of action involved, but whether the encounter represents an isolated episode of resource contest or an instance of power asymmetry tolerated because of the even larger fitness-negative consequences that avoiding interactions with the dominant altogether would for the individual (Mazur, 2009).

track of how far out of balance it is. […] The idea is that each person is entitled to the same amount as each other person in the relationship, and that the direction and magnitude of an imbalance are meaningful" (Fiske, 1992). Finally, relationships based on power asymmetries, which are characterised by dominant-skewed resource flow (Smith et al., 2016), resemble to a certain extent the AR's directive force in that "superiors appropriate or preempt what they wish." (Fiske, 1992).

1.9 Connecting modes of transfer to RMs

In the preceding section we argued that, in the domain of transfer-based interactions, the directive standards regulating the CS, AR, and EM models specifies patterns of long-term benefit distribution which resemble those produced by the evolutionary strategies recruited to stabilize repeated interactions with kin, dominants, and nonkin, as suggested by the evolutionary models of sharing earlier discussed. Under this hypothesis, for instance, CS' focus on group membership as exclusive source of interpersonal obligations and the absence of reciprocity expectations are consistent with KS-based sharing, which only requires donors to selectively target genetically related group members. On the other hand, EM's focus on additive differences and the conspicuous reference to the principle of even balance mirror the expectation of reciprocity that motivates donors to provide benefits to nonkin under the RA model. The normative orientations of different RMs, therefore, reflect the adaptive domains in which the corresponding relationships these schemata were employed for first emerged.

Additionally, we argued that at the core of RMT lies the hypothesis that humans are equipped with an in-built sensitivity to a set of behavioral or perceptual indicators which allows them to be inferentially productive with respect to the long-term patterning of the occurring relationships. In the sharing domain, such indicators correspond to what we previously referred to as "modes of transfer" (e.g., giving, taking, letting someone's take). On these premises, we thus hypothesized that interactions revolving around possession-related behaviors should be spontaneously interpreted as episodic instantiations of relationships pertaining to different RMs, which are probabilistically inferred on the basis of the mode of transfer observed.

1.9.1 Developmental evidence of AR cues in resource-contest scenarios

Consistently with our hypothesis, recent developmental evidence suggests that human infants may interpret interactions based on possession-related behaviors as indicative of specific RMs. For instance, 15-month-olds familiarized with an event where an agent (B) let another (A) take possession of an object that B previously collected (in the absence of A) later expected A to prevail over B when the two agents were shown to simultaneously approach a new object (Mascaro

& Csibra, 2012). Infants thus spontaneously inferred the existence of a power asymmetry between two agents from a priority-of-access scenario, and expected the prevailing agent to dominate over the other in a new situation of goal conflict. Importantly, infants represented dominance as a property of a specific dyadic relationship, rather than as an individual's trait, as suggested by the finding that they did not expect A to dominate over an agent (C) that A never interacted with before (Study 3). Moreover, infants expected A to dominate over B in a scenario involving the acquisition of rival goods even when previously familiarized to an event involving the monopolization of a different type of resource (a small enclosure: Study 2), thus suggesting that infants' concept of dominance may be sufficiently abstract to encompass different types of zero-sum contest situations. Remarkably, infants' ability to re-identify the dominance relationship at test was crucially influenced by the shape of the social structure that said relationship was part of. Infants produced dominance-consistent expectations (A > B) only when they could integrate dyadic relationships incrementally, so that A > B was followed by B > C and then C > D. (Study 1; Mascaro & Csibra, 2013). A similar selectivity was found for structures that could be linearly ordered: when the three dominance-based pairs were presented as forming a circular structure, infants proved unable to correctly re-identify the dominance relation within the first dyad at test (Study 2).

These studies provide a first, tentative answer to the question of which interaction cues prime different RMs in the domain of transfer-based relationships, by showing that priority-of-access behaviors prompt the representation of relationships exhibiting key properties of the AR model (i.e., asymmetricity and dependence on linearly ordered social structures). Corroborating this claim, another study (Gazes, Hampton, & Lourenco, 2015) found that 10- to 13-month-olds produced transitive inferences of dominance (A > C) – another defining property of AR structures (Fiske, 1992; Bolender, 2010) – after a single exposure to three dyadic interactions (presented as sequentially happening on the same stage: A > B > C) based on forceful object expropriation (i.e., taking an object away against the possessor's will, as inferable by the possessor's struggle to resist the Taker's attempt and her subsequent display of sadness). Complementing Mascaro & Csibra (2012), this study thus adds an additional mode of transfer (i.e., forceful taking) to the set of candidate indicators of AR relationships[20].

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[20] Despite here we focused exclusively on RMs cued by actions involving the transfer or acquisition of objects, there is already evidence that infants spontaneously exploit other cues, such as body size (a proxy of physical formidability: Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011) and relative group size (a proxy of coalitional support: Pun, Birch, & Baron, 2016) to produce AR-consistent expectations. Interestingly, dominance (operationalized as prevailing over someone in a situation of conflicting goals) was recently found to elicit expectations of favoritism in a third-party distribution in 17-month-olds, corroborating the claim (put forth by Mascaro & Csibra, 2012) that infants' concept of dominance is abstract enough to license expectations about the outcome of zero-sum games across domains (Enright,

Taken together, these studies buttress the general proposal that, from a very young age, humans are predisposed to infer the presence of social relations corresponding to the RM classification on the basis of different types of transfer-based interactions. Building on these premises, our research seeks to explore which other cues infants are predisposed to treat as diagnostic of other RMs (CS and EM) in the sharing domain. The primary target of our investigation is to experimentally test the hypothesis borne out of the evolutionary conjecture sketched in 1.2. To briefly rehearse its tenets, we argued that giving was exapted in the domain of nonkin interactions under RA-like pressures to scaffold the formation of exchange relationships, which became necessary due to an increasingly interdependent foraging niche characterised by asynchronous resource acquisition (Kaplan et al., 2012; Kaplan & Gurven, 2009). Given that the cost-benefit logic of RA hinges on the expectation of future (direct) reciprocation, we argued that the principle regulating the resource flow within these relationships neighbors the criterion of even balance characteristic of EM relations (Fiske, 1992). On the basis of the evolutionary connection between giving and EM-like relations, we thus hypothesized that humans may have an early-developing propensity to infer from giving-based interactions the existence of underlying EM relationships.

Our hypothesis is grounded onto two distinct assumptions: firstly, infants must possess the representational machinery required to interpret giving-based interactions; secondly, they should be similarly endowed with a conceptual repertoire of RMs, which include notions of equality, dominance, communal sharing, and so forth (cf. Thomsen & Carey, 2013). Since our hypothesis posits a diagnostic dependency between a specific mode of transfer (giving) and its corresponding model (EM), the ability to represent both elements need to be sequentially verified.

1.10 Overview of the studies

Having fleshed out the basic hypothesis guiding our investigation, we will proceed here to describe the steps taken towards its validation. All the studies reported in this dissertation are based on the same paradigm (violation of expectation), use the same dependent measure (looking times), and were subjected the same type of data analysis. For this reason, we reserved the following chapter (II) to shortly explain the rationale for this experimental procedure and of our data-treatment choices. As noted above, the first question that has to be experimentally addressed is

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Gweon, & Sommerville, 2017). It is worth noting however that infants in this study expected an *unrelated* third-party (distributor) to favor the dominant, which seems to presuppose an understanding of dominance as trait (generalizable to new agents, such as the resource provider, who may have consequently biased the division in the dominant's favor as a sign of affiliation or appeasement towards a higher-ranking individual).

whether infants are capable of representing interactions based on giving. Despite the existing developmental literature already provides a tentatively positive answer to such question, we sought independent support for this claim, by investigating which are the minimal cues responsible for eliciting the representation of a giving action, and how specific such representation is (Chapter III). To briefly preview our results, the studies described in Chapter III corroborate the claim that infants possess a knowledge system specialized for interpreting social interactions based on active transfer. This system, which we characterise as a dedicated action schema, relies on a set of minimal cues that constitute (a) necessary and (b) sufficient conditions for its deployment. An implication of (b) will be directly tested in Chapter IV by exploring the effects that the mere presence of an agent, acting as potential recipient of a transferred object, exerts on infants' goal attribution. If the "sufficiency thesis" is true, the presence of a beneficiary should be able to influence the teleological interpretation of a giving-like outcome, even if this could be readily disregarded as the side effect of an action sequence directed towards a different goal. As we shall see, it does, and to a surprising extent.

Having showed that infants are indeed proficient interpreters of interactions based on active transfer, in Chapter V we will finally move onto the relational level, to address the question whether infants would infer from the observation of a giving episode the existence of an enduring EM-like relationship. We will do so by evaluating whether the representation that infants set up after being briefly familiarized to these interactions contains information that supports their re-individuation across time and contexts, and, crucially (given the RM considered), minimal forms of bookkeeping. Since the EM standard makes welfare imbalances a socially significant event for the stability of the relationship, we expect information functional to track imbalances between participants to be registered specifically for interactions priming EM. In order to assess the selectivity of infants' encoding strategies, we will compare (similarly to Chapter III) the informational content of the representations that infants set up after having observed interactions based on giving vs. superficially similar (but functionally different) taking actions. The two kinds of bookkeeping-relevant information considered here are (a) the direction of transfer (who gave to whom), and (b) the identity of the transferred object (what was given), which will be explored in Chapter V and VI, respectively. The results of the studies presented in these two chapters will not only provide supporting evidence for our main hypothesis concerning giving as evolved prior of EM relationships, but also for the intriguing possibility that other transferring actions (i.e., tolerated taking), which were not the primary target of our experimental focus, may be also interpreted as cues to different RMs (such as CS). Lastly, given that directive standards do not determine only how interactions are encoded and remembered, but also the types of sociomoral expectations recruited within each RM, we sought to explore whether the expectation of equality, which infants are sensitive to already by their first year, is specifically elicited by distributive interactions based on giving, but not by other allocation procedures (e.g., taking from a common pool) in conditions of comparable resource entitlement (Chapter VII). Concluding our discussion, Chapter VIII will be primarily reserved to discuss how our account of infants' naïve sociology relates to the current existing approaches in the field of developmental social cognition, with a privileged focus on studies concerning the early attribution of trait-like sociomoral dispositions to third parties (and their role in scaffolding incipient forms of partner choice: e.g., Hamlin, 2015a; Hamlin, 2015b) and the representation of tag-based coalitions (e.g., Liberman Woodward, Sullivan, & Kinzler, 2016).

Chapter 2. Methodology

2.1 Looking times in infancy research

All the studies reported in the present dissertation employed the same general procedure and design, experimental paradigm (violation of expectation), dependent measure (looking time), and type of data analysis. To avoid redundancies, the present chapter aims at describing and providing a rationale for these methodological commonalities.

Since Fantz's pioneering work (1964), which first documented that infants are sensitive to changes in their visual environment, measuring looking times (henceforth, LTs) has become one of the most frequently used behavioral techniques in infancy research (for reviews: Aslin, 2007; Colombo, 2001). The success of this technique is partly due to the ease of eliciting looking behavior in infants. Unlike other behavioral measures which require training (e.g., non-nutritive sucking rates: Semb & Lipsitt, 1968) or rely on behaviors which can be reliably produced only in the second half of the first year (e.g. reaching: Thelen, Corbetta, & Spencer, 1996; uttering words: Fenson et al., 1994), visual inspection occurs spontaneously, and already at the neonatal stage.

LTs have been used in various paradigms, for instance, to measure which of two simultaneously presented stimuli infants prefer to visually inspect (preferential looking: e.g., Kinzler, Dupoux, & Spelke, 2007; Smith & Yu, 2008), to assess the processing of accompanying auditory stimuli or multimodal matching (e.g., Gogate & Bahrick, 1998), and to test whether infants develop expectations about states of affairs they have been exposed to by presenting them with events that would confirm or violate these expectations (e.g. Csibra, 2008a). In the context of the present discussion we will focus exclusively on the last paradigm, better known as the violation-of-expectation (henceforth, VoE) method.

2.1.1 The VoE paradigm

A typical VoE study begins with an exposure phase, during which a set of stimuli is presented for a certain number of times (trials) to the infants. Depending on the technique used, infants may be familiarized or habituated to such stimuli. In the first case, infants are exposed to the stimuli for a fixed number of times; in the second, infants are presented with the stimuli until a certain habituation criterion, specific to the individual infant, is reached (typically when the total LT to the last three trials reaches half of the length of the first three trials: e.g., Hamlin & Wynn, 2011). After the exposure phase is over, the test phase begins. During this phase, infants are sequentially shown two test events, one consistent with the representation elicited during the exposure phase and the other inconsistent with said representation.

The measure of interest here is the amount of time that infants spend looking at each test, typically measured at the end of the event (to exclude that motion cues would influence visual engagement), until a certain amount of cumulative looking is reached or until infants cease to look at the test event for a certain period of time (typically 2 s of visual disengagement; but see Wilcox et al. 2014, Yoon, Johnson, & Csibra, 2008 for studies adopting a "first-look away" criterion). Crucially, since the VoE paradigm rests on the hypothesis that the representation elicited during the exposure phase causally influenced the infants' differential looking at the two test events, the researcher needs to ensure that infants paid equal attention to the events displayed during that phase. This is typically done by monitoring infants' looking throughout the familiarization or habituation trials and excluding those infants who failed to observed the event enough times to reasonably conclude that the representation of interest has been successfully elicited.

2.1.2 What do we mean by "violation of expectation"?

The consistency relation mentioned earlier between the state of affairs presented at test and the representation that infants should have formed during the exposure phase can be characterized as a form of "conceptual priming" (Mandler, 2004): assuming that the exposure phase succeeded in engaging a hypothesized knowledge system (e.g., for representing objects), this should spontaneously activate a number of assumptions about its representational target (e.g., solid objects are impenetrable) which may or may not be satisfied in the test events. When the observed state of affairs does not satisfy these assumptions, a "violation of expectation" is said to occur. As it appears, the notion of expectation used here clearly differ from its corresponding folk concept: i.e., the belief that a certain event will occur in the future (in philosophical terms, a doxastic attitude having predictions as its content: Rakoczy, 2012). Rather, "expectation", as routinely used in developmental science, is best characterized as a postdictive assessment of the conceptual overlap or compatibility existing between two representations: one, formed during the exposure phase, and another set up while observing the test events. Put otherwise, "expectation" refers to the likelihood that a given state of affairs, instantiated during the test phase, may have been activated by a previously elicited representation. Throughout the text, we will always use the notion of "expectation" in the sense above specified.

The working assumption of the VoE paradigm is therefore that infants should attend longer to events that bear little or no conceptual overlap with the events they have been familiarized or habituated to (inconsistent test event), compared to those that have a stronger overlap (consistent test event), because the former retain a higher informational value for the infants, as they consist in a state of affairs violating previously held assumptions (for a similar perspective in computational neuroscience: Montague, 2007). Apart from a few VoE studies that reported longer looking to consistent test events (Meristo & Surian, 2014; Kuhlmeier, Wynn, & Bloom, 2003; for a recent discussion about why younger infants may be more likely to exhibit this inverted looking pattern, see: Powell & Spelke, 2016), the vast majority of studies using this paradigm conforms to the above logic that inconsistent test events should produce longer looking. All the predictions about the direction of (looking-time) difference presented in this dissertation rest on the same assumption.

2.1.3 Further considerations about designing a VoE study

Since in a VoE study the main measure of interest is the difference of LTs between two test events, these should be designed to be as similar as possible under all dimensions but the one being investigated, so to rule out the possibility that perceptual factors irrelevant to the hypothesis being explored may produce differential looking. Factors such as the saliency and complexity of a visual stimulus (e.g., Hood et al., 1996; Tellinghuisen & Oakes, 1997), as well as its relative novelty or familiarity (e.g., Houston-Price & Nakai, 2004; Yurovsky et al., 2010), are well known to profoundly influence infants' looking. Furthermore, a VoE study typically necessitates of a number of control conditions to corroborate the conclusion that the infants' looking response at test is specifically influenced by the representation hypothesized to be elicited during the exposure phase. This can be accomplished by presenting infants with events that, albeit being superficially similar to those used in the experimental condition, lack elements deemed necessary for the target representational system to be engaged.

Despite the fact that VoE paradigms can be implemented in a between-subject design (where two different samples of infants are each presented with only one of the test events: e.g., Hespos & Baillargeon, 2008), within-subject comparison is by and large the most used design, not only because it requires fewer participants, but also because it efficiently deals with the fact that baseline LTs vary considerably across infants (Gilmore & Thomas, 2002). All the studies reported here conform to a within-subject design: infants were always first presented with a familiarization phase, which consisted in one (or more, as in: Chapter III and IV) event repeated a fixed number of times, and then shown two test events (consistent and inconsistent) one after the other.

For all the studies reported, the sample size was pre-set to 16 participants on the basis of previous experiments employing a similar paradigm (e.g., Sloane, Baillargeon, & Premack, 2012; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011; Martin, Onishi, & Vouloumanos, 2012; Schlottman, Surian, & Ray, 2009).

2.2 Commonalities between studies

All the studies presented complied to the following procedure. Infants and their parents were welcomed to the lab and briefly explained by the research assistant (RA) what a LT study generally consisted in and which were the minimal rules of conduit that parents should have followed during the experiment: i.e., keeping their eyes closed through the whole procedure, holding the infant in an upright position, refraining to talk to and/or soothe the infant (unless instructed otherwise), and avoid constraining the infant's attentional reorienting away from the presentation screen. Parents were additionally asked to provide an informed written consent, which they were free to withdraw at any time. Once the briefing phase was over, the RA accompanied the parent (only one caregiver was allowed in the testing area) and the infant into the lab.

Infants were tested in a dimly lighted, soundproof room. They sat on the parent's lap, 100 cm away from the presentation screen (a 102 cm wide-screen LCD monitor set on a 1920 x 960 resolution). A hidden camera mounted under the screen recorded infants' looking behavior at 25 frames per second temporal resolution. The camera and the stimuli were both remotely controlled by the Experimenter, who was sitting in a booth behind the screen fully concealed by black curtains. Before the experiment started, the RA made sure that the parent was sitting comfortably and at the right distance from the screen, and reminder her to close her eyes and to avoid interacting with the infant during the testing. The parent was also asked to remove any toy that the infant was orally or manually manipulating in the testing area. After the testing, the parent was briefly shown the video recording of her infant and explained (by the Experimenter or the RA) the rationale of the study.

The stimuli were always displayed using Keynote software 5.0. These consisted of 2D animations (designed in Flash Professional CS5), 3D animations (designed in Blender, version 2.65), or videos (edited in Final Cut Express, version 4.5), depending on the study. All the stimuli contained sounds, which were played by two speakers placed behind the presentation screen.

LTs during familiarization and test trials was always measured from the beginning of the event to its end. The length of exposure to these events was always preset, with the exception of the studies reported in Chapter VI, which involved an infant-controlled familiarization. During the test trials, the measure of interest consisted in the amount of looking from when the test event finished (corresponding to the moment when the agents and objects observed stopped moving) to when the infant looked away for more than 2 s or looked cumulatively more than 60 s. The duration of looks-away was established manually by the Experiment.

For each study, 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 analysis, infants were required to satisfy criteria of minimal looking specific to each set of studies (see Methods in the following chapters). Besides insufficient attention to the stimuli, other common causes of exclusion were: technical failures, maternal intervention, and infants being mistakenly retested on the same counterbalancing order. Data were also excluded if offline coding revealed that infants had been underexposed (because the trial was interrupted before a 2-s look-away) or overexposed (because infants were still presented with the same test event despite they had already looked away for more than 2 s) during the test phase.

2.2.1 Data analysis

All statistical tests used were two-tailed. Parametric statistics were always performed on log-transformed LTs data to better approximate a normal distribution. For ease of reading, the LT means are reported before log transformation. For the effects of main interest, non-parametric statistics are also reported. No outlier rejection was performed in any of the studies.

It is important to note that the log-transformation was performed on raw LT data regardless of whether the data were found to be non-normally distributed. As recently shown by Csibra, Hernik, Mascaro, Tatone, & Lengyel (2016) on a large set of studies conducted by members of our laboratory and a representative set of published studies (149 in total) from the infant research literature, the distribution of LTs systematically deviates from normality, whether or not this is evident, or statistically demonstrable, in experiments conducted with the small samples sizes typical of infancy studies. This implies that not applying log-transformation, rather than doing so only when justified by referring to the skewness of the data or to a test of normality, is the methodological choice that should require justification. We refer the readers to the publication above for further details on the argument.

Chapter 3. Give-take study

3.1 The giving action schema

The comparative evidence presented in the Introduction informed our hypothesis 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 (Frankenhuis & Barrett, 2013; Goodman, 1980). The activation of this "giving action schema", like any other schema, depends on the processing of a specific set of high-validity cues (Barrett, 2005a; 2005b). 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 vs. 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 relevant to the event representation (Gentner, 1975; Langacker, 1987).

3.1.1 Input conditions of the giving action schema

On an abstract level of description, GIVING[21] 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 (Newman, 2005; Tomasello, 1992). '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 potential agents could (Kummer, 1991; Kummer & Cords, 1991; Stake, 2004; Brosnan, 2011). As such, it is conceptually different from ownership, which could be defined as a socially and normatively

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[21] 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.

stipulated form of object control able to survive to temporary changes of possession (Blake & Harris, 2011; Friedman, Neary, Defeyter, & Malcolm, 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 'give' features among the verbs allowing 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 an 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.

3.1.2 Developmental evidence of infants' understanding of giving

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; Schlottmann et al., 2009; Southgate & Csibra, 2009) or helping (Hamlin et al., 2007; Kuhlmeier et al., 2003). 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 LTs 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 and 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 & Stilwell, 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, 2013). 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 et al., 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 appears to be not sufficient: the change of possession should also be interpreted as the Giver's goal. In a study by Schöppner, Sodian, and Pauen (2006), 12-month-old infants, habituated to a puppet giving a flower to another one showed a recovery of LTs 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, 2012; 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?

3.1.3 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 and Surian (2011), and Meristo and 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 (cf. Beggan & Brown, 1994). On this basis, if possession is defined as having control over the fate of an object, the agent closer to the object should be the one 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).

3.2 Aim of 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 been shown to be capable of such a feat (e.g., Kuhlmeier et al., 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 the action is also the one acquiring possession of the object. 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 agent acquiring the object coincides with the agent producing the change of possession rather than with the patient (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, we submit that 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 in fact 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 patient (a potential Givee or Takee) would equally influence the selection between social and nonsocial 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 socially significant consequences for the welfare of a social partner (Fry, 2006). Therefore, evidence of reciprocity expectation may be taken as suggesting that the action to be reciprocated (giving) was interpreted as resulting in a benefit gain for the Givee. Studies 5 and 7 addressed this question.

3.3 General procedure

All the studies reported here had the same design structure and procedure. 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.

In all studies 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.

	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

Table 1. The table provides all the relevant information about differences and commonalities across Studies 1-8.

3.3.1 Stimuli

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.

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.

A short (1.5 s) attention-getting animation was presented before each familiarization and test trial.

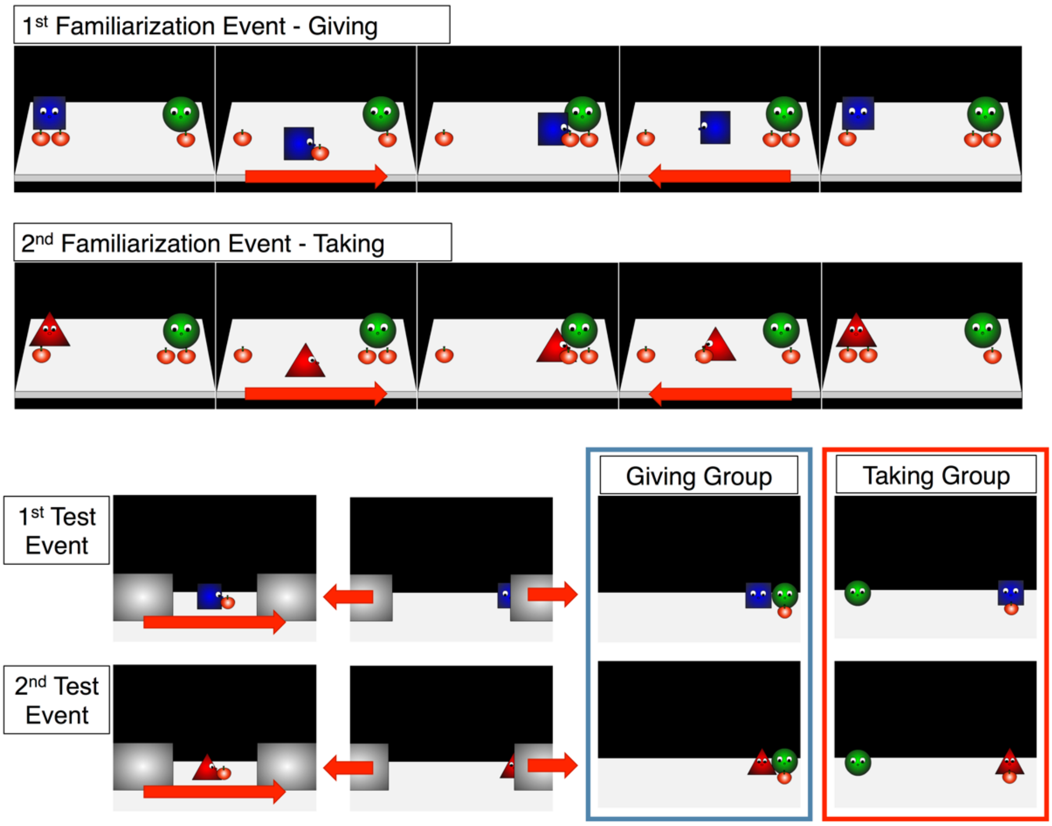

Figure 1. Schematic visualization of the object-transfer events shown in Study 1. The arrows indicate direction of movement of the agents/objects present on the scene.

3.3.2 Coding and data analysis

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). LT 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. 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: $r = .997$).

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-s look away and until the end of the familiarization). We found no difference in LTs 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.

3.4 Study 1. Action role encoding

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 LT than what they would display to the familiarized actions.

3.4.1 Methods

3.4.1.1 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 ($n = 1$).

3.4.1.2 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 Givee and the Takee were the same agent (B). At the start of the giving actions, A had two apples and B had one, whereas the taking actions started with B having two apples and C having one. The passive agent B (Givee and Takee) was represented as 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.

3.4.2 Results and Discussion

LTs during the test trials are depicted in 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 LT 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 rapidly form 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.

3.5 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 agents.

3.5.1 Methods

3.5.1.1 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 ($n = 3$).

3.5.1.2 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).

3.5.2 Results and Discussion

A repeated-measure ANOVA performed in the same way as in Study 1 revealed a significant interaction between test trial and group, $F(1,14) = 4.860$, $p = .045$, $\eta_p^2 = .258$ (Fig. 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 LT 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 LTs 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.

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 LTs 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 interaction (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 (Boseovski & Lee, 2006; Kalish, 2002; Rosati et al., 2001; Sabbagh & Shafman, 2009).

Differently from 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.

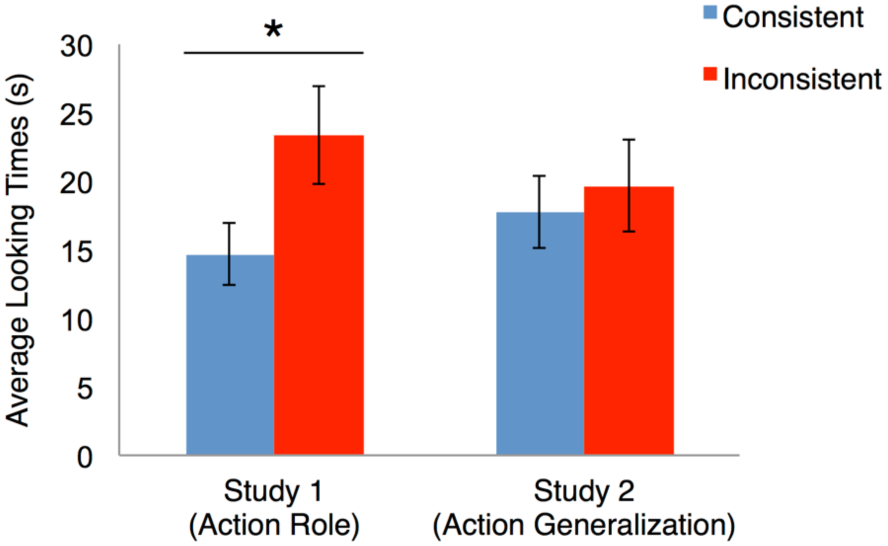

Figure 2. Average looking times during the test trials in Studies 1 and 2. Error bars indicate standard error. Asterisks represent statistically significant differences between the two test trials (*p < .05).

3.6 Study 3. Giving vs. 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.

3.6.1 Methods

3.6.1.1 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).

3.6.1.2 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.

3.6.2 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.

3.7 Study 4. Taking vs. 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.

3.7.1 Methods

3.7.1.1 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).

3.7.1.2 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.

3.7.2 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, η_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 2-4 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.

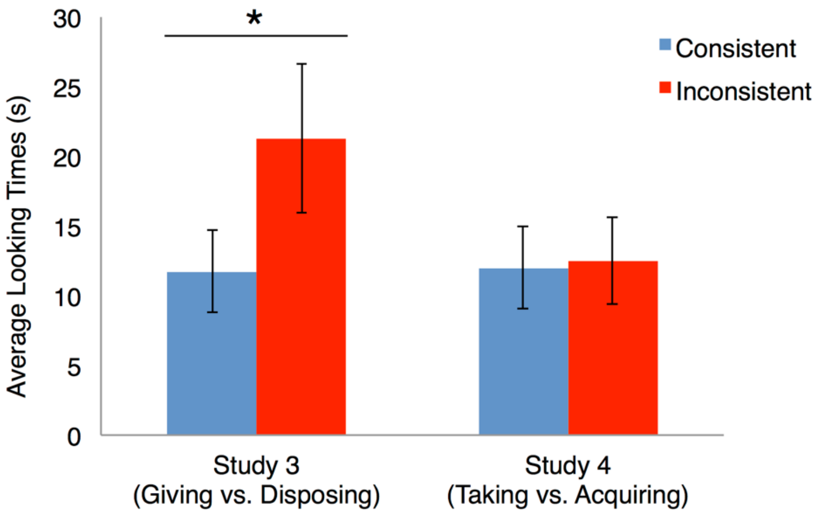

Figure 4. Average looking times during the test trials in Studies 3 and 4. Error bars indicate standard error. Asterisks represent statistically significant differences between the two test trials (*p < .05).

3.8 Study 5. Reciprocity expectations

Recent findings in the developmental literature seem to suggest that infants and young toddlers are guided by reciprocity considerations. In a study by Olson and 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 preferred to help an experimenter who displayed the intention to give them a toy (whether or not she was 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 expected the target of a prosocial or antisocial action to reciprocate in kind with an action of different form but similar valence, thus suggesting that, by their second year, infants may already expect reciprocity on the basis of a general valence-matching rule, encompassing return of favors as well as retaliation.

Given the above evidence, and the arguments laid down in the General Introduction (1.9), here we intended to test whether giving primes reciprocity expectations. We did so by familiarizing 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 (cf. Studies 3-4), we would still observe a different reaction to the two test events in both experimental groups. This is because the expectation that giving should be reciprocated 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).

3.8.1 Methods

3.8.1.1 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).

3.8.1.2 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.

3.8.2 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 patient 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 very similar to ours, Meristo and Surian (2013) and Geraci and 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 distributors were not interpreted as positively affecting the recipients' welfare. Absent any information about the value of the resource transferred, infants thus seem to interpret by default a giving action as bestowment of material benefits. It is likely that infants deployed this benefit-based representation of giving also in our study, but without expecting favors to be returned.

Another possibility is that giving, while interpreted as other-benefiting, did not lead infants to expect reciprocity because they failed to interpret the action as occurring between equal peers. The expectation that favors should be returned is a normative signature of transactions between equal peers, but not of other social interactions similarly established through the proactive delivery of material resources (e.g., mother-infant one-way provisioning). Thus, if the event failed to supply infants with information about the identity and relative status of the two interactants that made welfare imbalance a socially relevant event (for the relationship assumed), the giving action itself would not have been sufficient to induce reciprocity expectations. We find this hypothesis highly unlikely, for the same argument presented above. Absent any information about the identity of two agents, infants seem to default on interpreting them as having equal status – or at least equal entitlement to distributed goods (cf. Geraci & Surian, 2011).

Alternatively, giving may failed to prime reciprocity expectations because returning a favor may be more readily understood by infants as a means of partner choice than of partner control. This certainly seems to be the case with older children. Despite three-year-olds struggle to modify their allocation decisions contingently on their partner's behavior in simple bargaining games (House, Henrich, Sarnecka, & Silk, 2013), younger children succeed in forced-choice paradigms when confronted with agents differing in their cooperative attitudes (Dunfield, Kuhlmeier, & Murphy, 2013; Dunfield & Kuhlmeier, 2010). 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 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.

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: 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.

3.9 Study 6. Action role encoding 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 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 eating 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 (by the acquisitor: Taker or Givee), disappeared from the scene by the end of the event. Given that in all the previous studies the number of apples in the scene during familiarization (three) was different from the number of apples in the test (one), in this study we sought to make the number of objects numerically equivalent by reducing the apples in the familiarization to one. We reasoned that this may facilitate the expectation of reciprocity by making action and reciprocation perfectly equivalent in terms of number of objects possessed and distributed. Moreover, if infants perceived the transition from possessing nothing to possessing one object as resulting in a greater benefit gain than from one object to two, this may contribute to make the material gain of the Givee/Taker (and, conversely, the loss of the Takee) more salient. However, this modification would also present infants with an additional challenge. Given that the apple would disappear immediately after the transfer, infants could not exploit the lasting perceptual evidence of the object's final position to encode the direction of object transfer. The replication of Study 1 was therefore primarily conducted to test whether infants could encode giving and taking actions even in absence of any reminder of the occurred transfer.

3.9.1 Methods

3.9.1.1 Participants

Sixteen infants participated in the experiment (8 females; mean age = 356 days; range = 329-369 days). An additional seven infants were excluded from the analyses for crying during the test (*n* = 4), and inattentiveness (*n* = 3).

3.9.1.2 Stimuli

Infants were tested with the same procedure as in Study 1, with the following exceptions. At the start of the familiarization events, not three but only one apple was available for the Giver or the Takee. The animation of the object-transfer events were the same as in Study 1 up to the moment when the Giver/Taker moved back to its initial position (however, this last motion segment was shorter in the clips used in Study 6, totaling 3 s). At this point, either the Taker (in taking trials) or the Givee (in giving trials) was shown approaching the apple and eating it in three bites (a mouth below the agent's nose appeared during this short sequence). Every opening and closing of the mouth was accompanied by a chewing sound. After all apple pieces had been eaten, the agent moved back to its initial position. The overall running time of these animations was three seconds longer than that of the animations used in previous studies (24 s).

The test events were exactly the same as in Study 1.

3.9.2 Results and Discussion

An ANOVA with test trial as within-subjects factor and group as between-subjects factor revealed a significant main effect of test trial, $F(1,14) = 5.586$, $p = .033$, $\eta_p^2 = .285$; p = .017 by Wilcoxon signed rank test, and no interaction. As in Study 1, infants looked longer at the inconsistent test trial (M = 12.79 s, SD = 8.83 s) than the consistent test trial (M = 8.72 s, SD = 4.29 s). This pattern was evident also at the individual level: 14/16 infants looked in the predicted direction.

The results of Study 6 closely replicated the looking-time pattern found in Study 1, 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.

3.10 Study 7. Reciprocity expectations 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.

3.10.1 Methods

3.10.1.1 Participants

Sixteen infants participated in the experiment (10 females; mean age = 359 days; range = 344-379 days). An additional six infants were excluded from analyses for crying during the test (*n* = 3), experimenter's error (n = *1*), and inattentiveness (n = *2*).

3.10.1.2 Stimuli

The familiarization trials were the same as those used in Study 6. The test trials were the same as those used in Study 5.

3.10.2 Results and Discussion

An ANOVA performed in the same way as in the previous studies revealed no main effect of the test event factor, $F(1,14) = 0.359$, $p = .559$, neither an interaction between test factor and group, $F(1,14) = 0.503$, $p = .490$. There was no difference in LTs between Consistent (M = 15.30, SD = 8.08 s) and Inconsistent test trials (M = 14.82, SD = 11.65 s).

As in Study 5, infants did not look longer to the inconsistent test event in any of the two groups (Figure 5). 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.

3.11 Study 8. Action role encoding 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. Nevertheless, 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.

3.11.1 Methods

3.11.1.1 Participants

Sixteen infants participated in the experiment (11 females; mean age = 363 days; range = 351-375 days). An additional four infants were excluded from the analyses for crying during the test (*n* = 2), and inattentiveness (*n* = 2).

3.11.1.2 Stimuli

Infants were tested with the same procedure as in Study 1, with the following exceptions. Before the familiarization events, infants were exposed to a new animation showing only the Givee pushing an apple around an empty stage. This additional event was intended to convey cues of animacy for the Givee, which was otherwise completely motionless during the subsequent familiarization events. The movie started by showing the Givee (green ball) few centimeters away from an apple in the right corner of the platform. After 2.75 s, the Givee moved towards the apple and established contact with it. Immediately afterwards, the Givee started pushing the apple (sideways) in multiple directions, changing path and direction four times in total without stopping. After 18 s, the Givee finally stopped in the middle of the platform, facing frontally, with the apple located on its right.

The giving and taking familiarization events were identical to those used in Study 1, except for two differences: (1) the pupils of the agents were fixed, as if the characters were gazing at the floor, and never moved during the event (this was also the case for the pre-familiarization event described above); (2) the Givee did not move toward the middle of platform, as it did in Study 1, but was completely still throughout the transfer. As a consequence, the event segment immediately preceding the transfer, in which the Givee was seen moving towards the Giver/Taker and back, was removed altogether, resulting in an overall animation length of 15 s. The duration, speed and kinematics of the two animations were exactly the same as those used in Study 1.

The test events were exactly as those used for the Taking group in Study 1. Since the hypothesis to be tested here specifically concerned the representation of the giving action, which could have been formed not on the observed transfer, but rather on cues of shared attention (such as the convergent gazing on and tracking of the transported object), we employed test events – as those of the taking group – where the only change to be detected concerned the Giver's behavior.

3.11.2 Results and Discussion

Infants looked reliably longer to the Inconsistent test event (M = 25.2 s, SD = 14.21 s) than to the Consistent test event (M = 13.65 s, SD = 10.7 s), *t*(15) = -3.557, $p = .003$, $r^2 = .86$; $p = .008$ by Wilcoxon signed ranks test. This pattern was evident also at the individual level: 14/16 infants looked in the predicted direction.

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.

However, these results do not tell us whether infants did so also in the test of any of the studies presented. Two elements in fact constantly co-varied in the test events of the two experimental groups: the type of object-transferring action observed (giving vs. taking) and the spatial arrangement of the agents (giving: close together; taking: far apart). It is thus conceivable that infants' looking behavior in the test did not reflect expectations about specific action roles in the context of transfer-based interactions, but rather about patterns of affiliation/disaffiliation inferred from these very same interactions. In other words, having been exposed to an instance of prosocial behavior on the part of the Givee (towards the Giver), infants may have expected that the Giver will attempt again to affiliate with her social partner, for example, by attaining physical proximity with the other individual. This is a plausible hypothesis, especially in light of recent evidence suggesting that even 9-month-olds could form expectations about valenced interpersonal behavior on the basis of shared evaluations (Liberman, Kinzler, & Woodward, 2013).

However, two lines of evidence make this account unlikely. First, as the main effect of test type reported in Studies 1 and 6 indicates, infants' looking behavior was comparable across the two experimental groups, suggesting that 12-month-olds tended to allocate more attention to both types of inconsistent test trials (i.e., Giver taking and Taker giving). While, according to our reading, infants' longer looking to the 'Taker giving' test event was primarily induced by the action change, this alternative affiliation-based account would necessarily have to posit that infants represented the taking action in interactive terms in order to detect the violation of the expected disaffiliating behavior on the part of the Taker (towards the Takee). This conclusion was not supported by Studies 2 and 4. Second, the hypothesis that infants inferred affiliative motives on the basis of the giving action and expected them to influence the Giver's behavior in the test seems at odds with the negative evidence concerning reciprocity expectations (Studies 5 and 7). A quintessential structural feature of affiliative interactions is their symmetricity (i.e., 'A is friend with B implies that B is friend with A'; for a formal analysis: Martin, 2009). Had infants represented the interaction between the two agents in these terms, they should have expected the Givee to 'befriend' (i.e., approach with the apple) the Giver – an expectation they could have formed regardless of whether they detected at test the reversal of action roles.

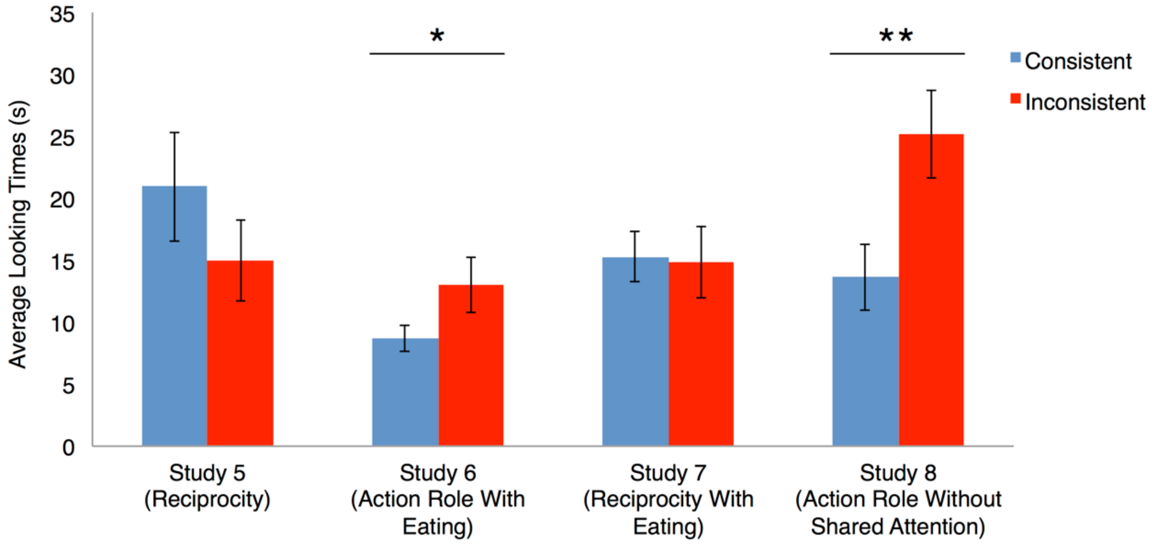

Figure 5. Average looking times during the test trials in Studies 5–8. Error bars indicate standard error. Asterisks represent statistically significant differences between the two test trials (*p < .05; **p < .01).

3.12 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-negligible interpretive 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, affiliating), 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).

3.12.1 Caveats about infants' interpretation of taking

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; Brosnan, Schiff, & de Waal, 2005; 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 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 such interpretation, 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 actions alone 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 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: under 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.

3.12.2 The “illusion” of giving

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” – i.e., an illusion of social interactions guided by the ascription of social goals (Berry & Springer, 1993; Jacob & Jeannerod, 2005) – 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, Upshaw, & Loucks, 2012; Sommerville & Woodward, 2010). 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 abstract enough to apprehend in 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.

3.12.3 A case of goal bias?

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 served as goals rather than sources (Lakusta & Landau, 2012; Lakusta, Wagner, O'Hearn, & Landau, 2007; Papafragou, 2010), as well as to make more fine-grained spatial distinctions at event endpoints than at event beginnings (Regier & Zheng, 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.

3.12.4 Conclusions

We proposed 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 of fitness-relevant relationships (Baumard, André, & Sperber, 2013; Barclay, 2013; McCullough et al., 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, 1996). 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 et al., 2003; 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).

Chapter IV. Social goal study

4.1 Introduction

In the previous chapter we provided empirical evidence to support the claim that humans possess a specialized cognitive adaptation for understanding resource exchange. We characterized this knowledge system as a giving action schema, and specified the minimal number of cues that said schema must be sensitive to in order to reliably distinguish its representational target (giving) from functionally different actions. These cues included: (1) an object as transfer medium; (2) an animate agent as recipient; and (3) a causal-teleological relation between the giver's action and the transfer of object possession to the recipient. As showed in Chapter III, infants' representation of giving actions is crucially dependent on the availability of the above cues. Infants' propensity to identify giving-based interactions does not in fact generalize to events containing only a subset of these cues, such as social interactions that do not require the presence of objects (hugging: Gordon, 2003); transfer events featuring inanimate recipients (Geraci & Surian, 2011); instances of resource procurement that are not related causally to the agent's actions (Sloane et al. 2012); and cases of inefficient object delivery (e.g., acts of object displacement that do not result in a possession change: Schöppner et al. 2006). Thus, whenever any of the constituents of giving is missing, or when the interaction between the participants of the transfer is not well-formed in causal and teleological terms, the conditions for the activation of the schema fail to obtain.

At the same time, however, this literature shows that infants are unprejudiced about the kinds of interactants and effectors that a giving event should contain, readily representing giving-based interactions occurring between humans, puppets, or limbless geometrical characters (e.g., Meristo & Surian, 2013). Remarkably, even a transfer event devoid of any communicative cues and receiving behaviors can reliably induce the representation of a giving interaction in 12-month-old infants (Study 8, Chapter III). Thus, if infants' selectivity shows that the deployment of the giving schema is indeed dependent on the availability of the above cues (suggesting that these cues are *necessary*), their propensity to perceive giving in impoverished transfer events, stripped of any but the relevant cues, reveals how mandatory the activation of the schema can be (suggesting that these cues are also *sufficient*).

The above argument yields the prediction that infants should not be able to resist representing an agent as having the goal of giving even when her actions can be readily interpreted as directed at a different goal. If the cues listed above are truly sufficient in triggering the giving schema, they should exert a detectable interpretive pull even if the observed event affords alternative hypotheses about the agent's goal. This is precisely the scenario we created to explore infants' susceptibility to cues of giving.

4.2 General procedure

The design structure was identical in the two studies: infants were first presented with 8 pre-familiarization trials, followed by 4 familiarization trials, and 2 test trials. A short attention-getting animation was presented before every pair of trials.

During the pre-familiarization phase, infants were presented with four trials of target-approach events involving agent A, and four trials of target-approach events involving agent B. Agent A was presented with objects X and Y, and it consistently approached object X. Agent B was presented with objects W and Z and consistently approached object W. The locations of the two objects were the same during the first two trials, and then were swapped for the 3rd and 4th trial. The agent order (A first vs. B first) was fully counterbalanced across infants.

During the familiarization phase, infants were exposed to four trials presenting the same ambiguous object displacement. Depending on the condition, infants saw either agent B (Giving) or object Z (Disposing) on the lower platform. Thus, as a result of agent A's action, infants saw object W falling close to either agent B or object W.

During the test phase, infants were presented with two trials involving incomplete actions (Straight Path, Turn Path). The test order (Straight vs. Path) was fully counterbalanced across participants.

4.3 Study 1. Disposing vs. object approach

In Study 1 we presented infants with ambiguous events in which an agent produced two outcomes via a single action in a comparably efficient manner: the displacement of an object (X) and the approaching of another (Y). By making object X block direct access to Y, we designed the event so that the action causing the displacement of X could be interpreted as functional to enabling the approach of the Y. In other words, we gave infants the opportunity to discount the end location of the displaced object X as a side effect of the agent's pursuit of a different outcome (approaching Y). The crucial manipulation was whether the displacement could be interpreted as an instance of giving. To this aim, we only varied the type of the entity which X object landed near to due to being displaced: an inanimate object (Disposing condition) or an animate agent (Giving condition). This manipulation allowed us to investigate whether the availability of a giving-diagnostic cue (i.e., the presence of an animate recipient: cf. Sloane et al., 2012) would compel infants to interpret the outcome of the displacing action (the end location of object X) as its goal rather than a by-product of the agent's goal-directed approach towards object Y. We tested goal ascription by modifying the landscape, so that only one of the two outcomes (displacing object X, reaching object Y) could be achieved, and measured which outcome infants expected the agent to realize.

We predicted that in the Disposing condition infants would interpret the displacing action as functionally enabling the approach of object Y and consequently represent this outcome as the agent's goal, while dismissing the change of location of object X as irrelevant side effect of the displacing action. In contrast, the presence of giving-diagnostic cues in the Giving condition should solicit an interpretation of the displacing action as directed not solely at enabling the approach of object Y but also at realizing the transfer of object X to a social partner, therefore forcing infants to either entertain both goal hypotheses or to randomly choose between them.

4.3.1 Methods

4.3.1.1 Participants

Thirty-two 15-month-olds participated in the study, half of them in the Giving condition, the other half in the Disposing condition. The mean age of the final sample was 464 days (range: 456-472 days) in the Giving condition and 476 days (range: 452-479 days) in the Disposing condition. An additional 12 infants were excluded from the analysis for crying during the test phase (*n* = 2), not meeting the minimal-looking criteria (*n* = 5), and experimenter error (*n* = 5).

4.3.1.2 Stimuli

The stimuli consisted in computer-generated animations designed in Blender. Three types of events were presented to the infants: target approach (during the pre-familiarization phase), ambiguous object displacement (during the familiarization phase), and incomplete actions (during the test phase). Besides landscape items, two self-propelled agents (A and B) and four inert objects (X, Y, W, and Z) featured in these events. The agents were a red cuboid and a blue dome-like shape, both equipped with a pair of eyes; object X and object Y were a green cube decorated with lilac stripes and a green truncated cone with three orange spheres protruding from it, whereas object W and object Z were a small pink cylinder with two horizontal white stripes and an upside-down yellow T-shape with two scrambled "eyes" of inverse polarity. Respective roles (A vs. B, X vs. Y, W vs. Z) and appearance were counterbalanced across participants.

Target approach (Pre-familiarization phase). The event started by showing A, X and Y positioned in a triangular configuration on an olive-colored platform imposed on a black background (see Figure 6). Objects X and Y occupied the opposite ends of a short checkered wall running on the horizontal midline of the platform. After a 1.15 s long still frame, A started moving towards the middle of the wall in a straight line, then turned left and detoured the wall to reach object X. The movement lasted 6.35 s, with the last frame kept for an additional 4.5 s, totaling a 12 s trial length. Upon reaching the end, the trial was automatically terminated. Infants were shown this target-approach event four times. In the last two pre-familiarization trials objects X and Y swapped places, and agent A changed the direction of its approach accordingly to the new position occupied by X. Infants were then presented with four additional approach events involving agent B choosing between W and Z. As for the previous agent, B first reached object W on its left side twice, and then approached W from the right after the two objects swapped positions. The approach events involving the two agents were equated for length, speed, and extent of the agents' motion. Two beeping sounds (0.5 s) were played at the start of each action, and a third sound (1 s) was played when the agent contacted the approached object.

These actions were intended to induce a representation of the agents' approaching behavior as goal-directed. We provided a host of cues known to elicit such interpretation: flexible target pursuit (the agents changed their approach route according to the object location), outcome selectivity (the agents consistently approached one object over another: Luo & Baillargeon, 2005), and efficient approach (the agents reached the object through the shortest detouring path: cf. Hernik & Southgate, 2012). Additionally, the detouring action was functional to demonstrate the short wall as an obstacle that the agents could not pass through or jump over (a similar wall was also used in the incomplete actions to interrupt the agents' actions; see below).

Ambiguous object displacement (Familiarization phase). The event started by showing agent A at one end of an elevated and narrow corridor, and oriented towards object X placed at the opposite end. At the corridor's midpoint, a slope connected the corridor to a lower platform. Object W was located on the edge of the slope, partly obstructing A's path to X. Depending on the condition, infants saw at the end of slope either agent B (Giving Condition) or object Z (Disposing Condition). After a 0.8 s long still frame, agent A moved through the corridor in a straight path until it bumped against object W (1.2 s). Then, it slid backwards before colliding with the object two more times. Each of the collision events resulted in object W being pushed closer to the slope's edge. On the third collision (3.60 s), the object finally slid down the slope, allowing agent A to move unimpeded to the other end of the corridor until reaching object X. Once object W slid off the slope, it landed in close proximity of agent B or object Z (Figure 6). All motions were kinematically identical across the two conditions. The two outcomes of the action (object W landing near agent B, and agent A stopping in front of object X) completed at the same time, 1.36

s after the agent successfully displaced the obstructing object. The entire action lasted 5 s, with the last frame kept still for an additional 5 s, totaling a 10 s trial length. Upon reaching the end, the trial was automatically terminated.

Three different sounds were played during the familiarization events: a short beeping sound (0.5 s) at the beginning of the trial, a bumping sound (0.2. s) each time the agent impacted against the object, and a swooshing sound (1 s) when the object W slid down the slope.

Incomplete actions (Test phase). These events involved the same characters and unfolded in a similar landscape as in the familiarization. One of the differences in the landscape was that the slope, rather than being directly attached to the corridor, was connected to a short lateral platform, branching out perpendicularly to the midpoint of the corridor (see Figure 6). A second difference was that the agent's path to the objects was obstructed by low walls (featurally similar to the one shown in pre-familiarization). Agent A and object X were in the same position as in the familiarization. However, as a result of the landscape change, object W, despite still leaning on the slope's ledge, was now positioned on a lateral platform, thus not blocking anymore the agent's path through the corridor.

There were two types of incomplete actions. In the Straight Path event, agent A moved unimpeded in a straight line until contacting the wall in front of object X. In the Turn Path event, agent A moved along an L-shaped path, turning to the lateral corridor until contacting the wall in front of object W. The actual distance from the corridor's branching point to the two walls was the same. The onset and duration of motion during test were equated between the two events. In both, the agent started moving after a 1.15 s pause and reached one of the two goal objects after 3.85 s. A sound (1 s) was played at the beginning of each test event. Depending on the Condition, the test events showed either agent B or object Z at the end of the slope.

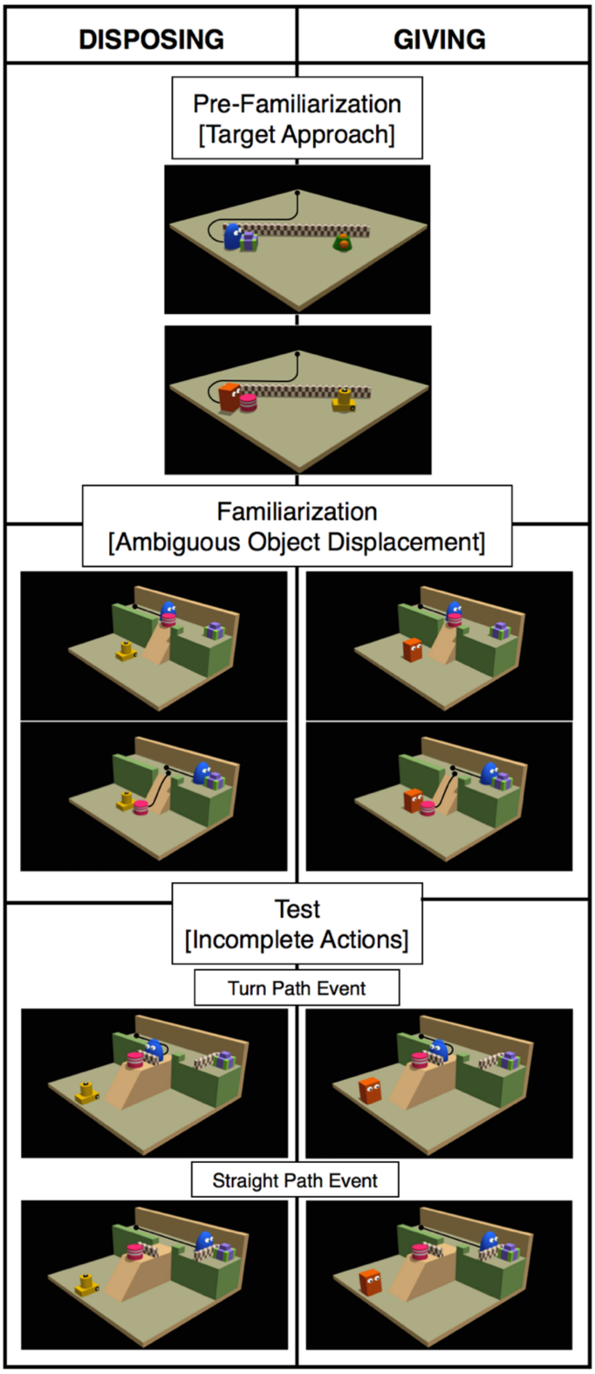

Figure 6. Schematic visualization of the events shown in Study 1. Black lines indicate the motion paths of agents and objects and were not visible to the participants.

4.3.1.3 Coding and data analysis

To be included in the final data analysis, infants had to satisfy the following pre-set minimal-looking criteria: (1) for each of the two agents (A and B), look at 1 out of 2 pre-familiarization trials for each of the two objects' spatial configurations (goal object on the left vs. on the right), for at least 50% (3.75 s) of the action's duration (from the beginning of the trial to the moment when the agent contacts the object); (2) look at 3 out of 4 familiarization trails for at least 50% (2.5 s) of the displacing action's duration (from the beginning of the trial to the moment when the agent stopped in front of the object at the end of the corridor); (3) look continuously at the agent's movement in both trials of the test phase.

LTs during test trials were measured from when the agent reached one of the two walls to the moment when the infant looked away for more than 2 s or looked cumulatively for 60 s. The same coding criteria were applied in Studies 1 and 2.

For both studies, the entire sample (32/32 infants) was re-analyzed by a second coder blind to the experimental hypothesis. The inter-coder agreement was excellent (Study 1: $r = .992$; $r = .990$; Study 2: $r = .996$; $r = .991$, for the test events of the Disposing and Giving conditions, respectively).

4.3.2 Results and Discussion

No difference between conditions emerged in how long 15-month-olds attended to the familiarization events (Disposing: M = 8.12, SD = 1.26; Giving: M = 8.40, SD = 1.32), $F(31) = .378$, $p > .250$.

An ANOVA with test trial type (Straight vs. Turn Path) as within-subject factor and Condition (Disposing vs. Giving) as between-subject factor revealed no main effect, but a strong interaction, $F(1,30) = 9.25$, $p = .005$, $\eta_p^2 = .245$. Infants in the Disposing condition looked reliably longer at the Turn (M = 16.82, SD = 12.59) than at the Straight Path test trial (M = 10.88, SD = 10.67), $p = .014$ by Wilcoxon signed-rank test; $F(1,30) = 4.10$, $p = .052$ by planned contrast. On the contrary, infants in the Giving condition looked longer at the Straight (M = 11.20, SD = 7.26) than at the Turn Path test trial (M = 6.85, 5.67), $p = .026$ by Wilcoxon signed-rank test; $F(1,30) = 5.18$, $p = .030$ by planned contrast (see Figure 7). This pattern was confirmed at the individual level: 13/16 infants in the Disposing condition looked longer at the Turn Path test event, whereas 12/16 infants in the Giving condition showed the opposite looking behavior ($p = .004$ by Fischer's exact test).

Consistently with our predictions, infants in the Disposing condition interpreted the agent's behavior as directed at approaching the object at the end of the corridor. This finding validated the use of the familiarization event to induce goal attribution, and provided a useful 'interpretive baseline' for evaluating the effects of the giving cue. Remarkably, the mere presence of an animate recipient in the Giving condition, rather than simply introducing ambiguity, produced a complete reversal of expectations. Having observed the displacing action resulting in a transfer of possession, infants spontaneously adopted this outcome as the agent's goal, apparently disregarding the alternative teleological interpretation that infants in the Disposing condition consistently availed.

This is especially striking given that a number of cues were available to induce the representation of the agent's action as a goal-directed target approach. First, infants could have identified the approached object as the same object that the agent selectively approached in the pre-familiarization. Second, they could have relied on the agent's persistent object-directed behavior in familiarization as a further cue that arrival at the object was its goal. Lastly, infants could have computed the statistical information about the relative occurrence of the two outcomes (across the two phases, infants saw the agent approaching an object 12 times, but giving only 4 times). While we do not know which of the above cues infants used, the results of the Disposing condition unambiguously show that the familiarization events did contain sufficient cues to support a teleological interpretation opposite to the one formed in the Giving condition.

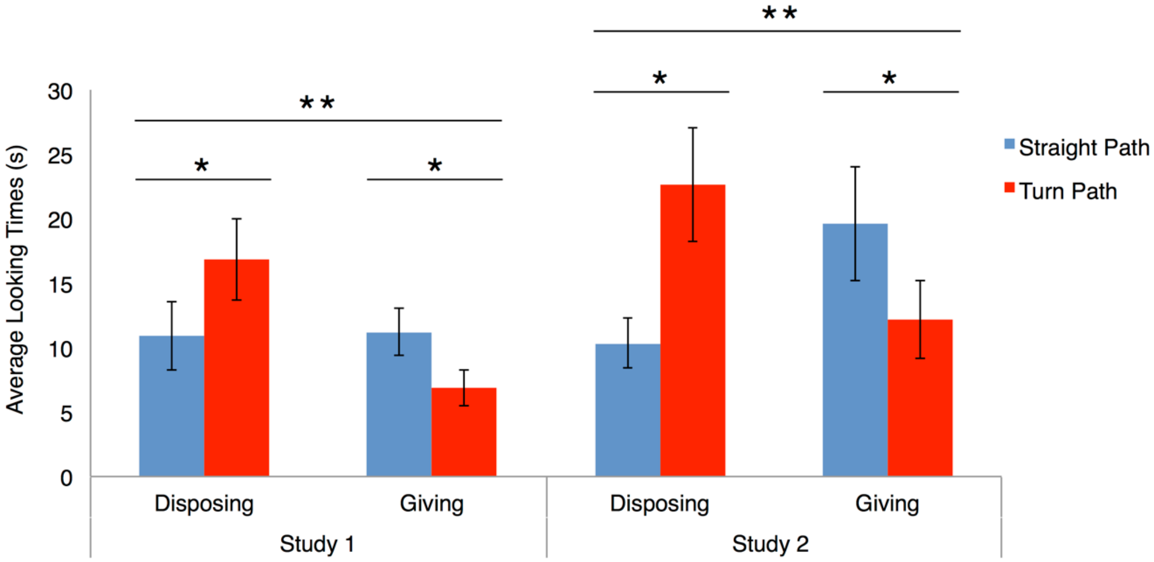

Figure 7. Average looking times during the test trials as a function of conditions in Studies 1 and 2. Error bars indicate standard errors. Asterisks represent statistically significant differences and interactions (*p < .05; **p < .01).

4.4 Study 2. Giving vs. object approach

The aim of Study 2 was twofold. First, given the unexpectedly strong (and unexpected) findings of Study 1, we sought to assess the robustness of the observed effect by attempting to replicate it. Secondly, we wanted to test whether infants' teleological interpretation of the displacing action in the Giving condition could have been due to the particular status of the transferred object, which was the same one that the recipient selectively approached during the pre-familiarization phase. Had infants identified in the displaced object during familiarization the target of the recipient's goal-directed behavior, they could have thus represented the object displacement as concomitantly fulfilling the recipient's goal. In our account, this additional information is unnecessary for licensing goal ascription because the presence of a beneficiary of the transfer should have sufficed to support the representation of the displacing action in goal-directed terms (cf. Study 5, Chapter III). To test this hypothesis, we simply changed the identity of the object approached by the recipient during pre-familiarization so that the object displaced during familiarization would no longer be the one previously approached by the recipient (see Table 2).

	Study 1		**Study 2**	
Phase	Disposing	Giving	Disposing	Giving
Pre-familiarization	A approaches X over Y B approaches W over Z		A approaches X over Y B approaches Z over W	
Familiarization	A transfers W to Z	A transfers W to B	A transfers W to Z	A transfers W to B
Test	A approaches X A approaches W		A approaches X A approaches W	

Table 2. The distribution of agents and objects as a function of Study and Condition.

4.4.1 Methods

4.4.1.1 Participants

Thirty-two 15-month-olds participated in the study. The mean age of the infants included in the final sample was 469 days (range: 454-477 days) in the Giving condition and 467 days (range: 452-479 days) in the Disposing condition. An additional 11 infants were excluded from the analysis for not meeting the minimal-looking criteria (*n* = 7), crying (*n* = 1), and experimenter error (*n* = 3).

4.4.1.2 Procedure

Study 2 differed from Study 1 only in one respect. In the pre-familiarization phase agent B consistently approached object Z (instead of W: see Table 2). With this change, the object pushed down the slope during familiarization (W) was different from the one that agent B approached during pre-familiarization (object Z).

4.4.2 Results and Discussion

No difference between conditions emerged in how long 15-month-olds attended to the familiarization events (Disposing: M = 8.94, SD = 0.91; Giving: M = 8.61, SD = 0.94), $F(31) = 1.001$, $p > .250$.

An ANOVA ran in the same way as in Study 1 revealed a strong interaction between test trial type and Condition, $F(1,30) = 2.24$, $p = .004$, $\eta_p^2 = .239$. Similarly to Study 1, infants in the Disposing condition looked reliably longer at the Turn (M = 22.67, SD = 17.75) than at the Straight Path test trial (M = 10.34, SD = 7.65), $p = .002$ by Wilcoxon signed-rank test; $F(1,30) = 11.40$, $p = .002$ by planned contrast. On the contrary, infants in the Giving condition looked longer at the Straight (M = 19.60, SD = 17.65) than at the Turn Path test trial (M = 12.16, SD = 12.02), $p = .030$ by Wilcoxon signed-rank test. However, this effect was not significant by parametric analysis: $F(1,30) = .94$, $p > .250$ by planned contrast. The pattern was also evident at the individual level: 12/16 infants in the Disposing condition looked longer to the Turn Path test event, whereas 11/16 infants in the Giving condition exhibited the opposite looking behavior ($p = .034$ by Fischer's exact test).

Given the lack of significance of the parametric analysis in the Giving Condition of Study 2, we sought to assess the consistency of infants' reactions to the Disposing and Giving test events across studies. To this end, we performed an omnibus ANOVA with Study (1 vs. 2) and Condition (Giving vs. Disposing) as between-subject factor and test trial type (Straight vs. Turn Path) as within-subject factor. The analysis revealed a strong interaction between test trial type and Condition, $F(1, 60) = 18.64$, $p < .001$, $\eta_p^2 = .237$, and no main effect of, or interaction with, Study.

The results of Study 2 closely replicated the effect found in Study 1. Again, the presence of a potential recipient led to a striking reversal of expectations about which of the two outcomes the agent should have realized. Furthermore, the consistency of the results between the two studies despite the change of the recipient's goal object in the pre-familiarization confirmed that infants did not require to represent the outcome of the displacing action as realizing the recipient's previously ascribed goal in order to represent the transfer as goal-directed.

4.5 General discussion

The present studies were devised as to provide a stringent test of the hypothesis that the giving-diagnostic cues discussed in Chapter III are indeed sufficient to trigger the corresponding action schema. This hypothesis was tested by investigating whether the processing of these cues would compel the ascription of a giving goal despite the availability of alternative interpretations for the production of an outcome resulting in a transfer of possession. As a demonstration of the interpretive pull that these cues can exert on the infants' teleological system, we showed that the mere presence of a motionless animate recipient is sufficient to shift the interpretation of an object transfer from side effect to the agent's primary goal. The same state of affairs that infants in the Disposing conditions readily discounted as a by-product of the agent's approaching action, once supplied with a missing cue of giving, fostered the adoption of a goal hypothesis that proved impossible to dismiss. Crucially, our manipulation left the context and kinematics of the action unaltered across conditions. Thus, whichever cue may have prompted infants to represent the agent's behavior as a goal-directed approach in the Disposing condition could have equally biased their interpretation in the Giving condition. In spite of this, 15-month-olds in both studies consistently privileged the displacing action as the most plausible goal hypothesis when it resulted in a transfer of possession.

While we expected the presence of an animate recipient to interfere with the teleological interpretation used in the Disposing condition, we did not predict infants to prioritize the ascription of the giving goal over its alternative. We propose two explanations to account for this finding. According to one reading, infants may have represented both outcomes as candidate goal states (as initially predicted), but expected the object displacement to be realized first due to having considered one sequence of outcome attainment (i.e., displacement first, approach second) as more efficient than the opposite. Notice that, despite the geometrical length from the platform's junction to the two walls (in the landscape layout used at test) was identical, the non-isometric projection of the stimulus may have made infants perceive the path from the junction to the wall next to the ramp as slightly shorter than the path to the other wall. If this were the case, infants would have expected the agent to displace object X first because the total path length that the agent needed to travel to attain the two outcomes (which required displacing object X, moving back to the junction, and then approaching object Y) was shorter than if the agent approached the farthest object (Y) first. This account presupposes that infants can establish representations of action sequences and evaluate their aggregate efficiency – abilities which may already be in place by the first year of age: 12-month-olds can perceive the causal structure of action sequences (when construed according to means-end relations: Sommerville & Woodward, 2005), whereas 14-month-olds expect two agents participating to the joint goal of moving an object from one location to another to minimize the aggregate costs of their individual carrying and retrieving actions (Mascaro & Csibra, 2014).

4.5.1 Efficiency as net-benefit maximization

The previous account suggests that the giving goal did not supplant the other goal, but merely complemented it. However, another possibility is that infants might have assigned goal status only to the giving outcome due to the higher inferable benefits (for the agent) associated with its realization compared to the other. This account rests on two fundamental assumptions, which constitute the theoretical backbone of our cost-benefit account of how infants represent social relations.

The first assumption is that the principle of rational action, which guides and constrains infants' teleological reasoning (Gergely & Csibra, 2003) by providing a criterion of well-formedness for evaluating goal hypotheses, is based on a concept of efficiency as net-benefit maximization. Two normative expectations can be derived from this concept: (1) when a certain state of affairs can be realized through multiple means (varying in costs), agents should select the less costly means (since lower costs necessarily translate in higher residual benefits of outcome production); (2) conversely, when several states of affairs (varying in benefits) can be realized via the same means, agents should select the most beneficial outcome[22].

Csibra and colleagues produced a conspicuous body of evidence supporting the claim that infants, when confronted with agents facing situations structurally similar to (1) spontaneously adopt a cost-minimization criterion to adjudicate whether an observed action is goal-directed or not (reviewed in: Gergely & Csibra, 2013). Importantly, in situations such as (1), infants need not to consult any other information besides performance costs in order to evaluate whether an agent's behavior is efficiently related to an observed state of affairs. However, in situations such as (2), which structurally mimic the events shown in our study (where on agent produces two outcomes in a comparably efficient manner), relying exclusively on cost information would not be sufficient to secure a specific goal hypothesis, since the costs of outcome production would not allow infants to select any of the observed outcomes as more efficiently produced than the others. In such cases, to avoid interpretive impasses, we argue that infants resort to consulting information about the benefits generated (for the agent) by the observed outcomes (when available), assigning goal status to outcome associated with the highest benefits.

Note that, just as Csibra & Gergely's efficiency analysis presupposes that infants possess a database of cost-diagnostic cues (e.g., pathway length), this complementary inferential route similarly presupposes in-built sensitivity to a number of benefit-diagnostic cues (which expands through development). One of such cues, we contend, is object possession, as it enables future or

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[22] These two principles can be rendered formally as follows: (1) if $c_1 < c_2$, then $b - c_1 > b - c_2$, and (2) if $b_1 > b_2$, then $b_1 - c > b_2 - c$ (where *b* and *c* respectively indicate the benefits and costs of outcome production).

immediate resource use. As discussed in Chapter III, young infants form sociomoral evaluations on the basis of how agents affect the possession status of others (cf. Hamlin & Wynn, 2011), suggesting that they perceive the possibility of exercising control over resources as potentially beneficial. Actions establishing possession relations should therefore elicit inferences about potential benefits for the actors standing in these relations.

Note however that in a giving action, the agent who enjoys the benefits of resource possession is not the one paying the costs of the transfer. From the perspective of the Giver, giving thus only result in a net cost expenditure, making this action an unsuitable candidate for goal ascription. Yet, our results revealed that when an outcome resulted in possession transfer (and thus could be interpreted as beneficial – but for the recipient), it was consistently privileged as goal state. These findings, we content, suggest that infants are disposed to treat giving as generating benefits for the Giver herself. But which benefits can such a costly prosocial action bring to its actor?

4.5.3 Conditions leading to relational inferences

Answering this question allows us to introduce our second assumption: to interpret social interactions, infants adopt the same principle of efficiency that they use for assessing the teleological status of non-social instrumental actions. This implies that when explaining the 'social rationality' of other individuals, infants are geared towards expecting that their contribution to an interaction results in a beneficial outcome for those very individuals. This normative expectation is obviously satisfied when interactions can be interpreted as producing immediate gains to the parties involved: such is the case of mutualistic where the participation costs are offset by the benefits of joint outcome production (and exploitation). However, when the interaction is one-sided (i.e., it involves agents and patients) and the costs and benefits are asymmetrically distributed between the participants, this expectation is not *locally* satisfied (as in the case of giving). In these circumstances, further assumptions about non-local benefits are needed to interpret the individuals' contribution to the interaction as beneficial to the actor[23]. By *non-local* benefits we mean any types of benefits that do not accrue to individuals as immediate consequence of her social

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[23] The assumption of non-local benefits generates an important difference between the normative expectations that infants hold for instrumental actions vs. social interactions. According to Gergely & Csibra (2003), infants simply discard (or fail to generate) a goal hypothesis when presented with inefficient non-social actions – they do not posit unobservable benefits that may salvage the rationality of the observed actions. Under our account, on the other hand, infants are prone to posit precisely such non-local benefits when the interpretation of social interactions is at stake. Such asymmetry creates a potential (and not yet accounted for) difficulty for our thesis that the same mechanistic account of action understanding formalized by Csibra and colleagues similarly undergirds infants' representation of the social world.

behavior: these may be direct but delayed (e.g., future reciprocation) or indirect (e.g., increasing one's own fitness by helping kin). In either case, these non-local benefits presuppose the existence and/or continuation of a long-term relationship between the parties involved. On these premises, we propose that when confronted with asymmetric interactions that may only be interpreted as efficient by positing non-local benefits, infants automatically assume their participants to stand in an enduring relationship (through which these benefits can be reaped over time)[24].

In the Introduction, we already previewed that the three relational models (CS, AR, and EM) appeal to different cost-benefit logics to explain why it may be beneficial for an agent to participate in an interaction that requires her to suffer net immediate costs. In CS, the costs of a costly prosocial action are offset by the inclusive fitness benefits that the accrue to the actor by helping kin. In AR, on the other hand, the costs of willingly submitting to another individual (e.g., by relinquishing resource access) can be counterfactually justified by appealing to the even greater costs that the subordinate would have to pay if she attempted to challenge the dominant (as we argued in 1.9.3). Finally, in EM the costs of benefiting a partner are offset by the prospect of later reciprocation by the beneficiary. In sum, different models are associated to specific ways in which costs and benefits are locally distributed between agents. Because of this, we should expect infants not only to merely assume the existence of enduring relationships between agents standing in asymmetric interactions, but also to identify the specific RMs governing these interactions by analyzing their cost-benefit distributions and intentional structure.

In the domain of sharing, we propose that three types of possession-related behaviors may prime, at least probabilistically, these distinct RMs (see also: General Discussion, Chapter V). If an agent willingly gives up resources without resistance to another individual whom she is positively affiliated to, the interaction should be interpreted as conforming to the CS model (cf. unresisted taking: Chapter V). If, on the other hand, the agent relinquishes her endowments reluctantly (or forgoes altogether the option of harvesting rival goods if in the presence of another individual), the interaction should be interpreted as aligned with the AR model (cf. priority of access: Mascaro & Csibra, 2012). Finally, if the agent proactively transfers her possessions to another individual (paying the double costs of transfer and resource loss), this should be taken as evidence that the two agents are participants in EM-like relationship (cf. proactive giving: Chapter V).

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[24] Differently from other scholars (e.g., Krasnow, Delton, Tooby, & Cosmides, 2013) who persuasively argued that, due to the demographic structure of the human ancestral social niche, our common-sense psychology may default on assuming that any interaction has a higher-than-zero probability of recurring, here we claimed that infants would *selectively* posit the existence of a lasting relationship when an agent's social behavior would be considered otherwise inefficient, if analyzed only in terms of local cost-benefit distributions.

4.5.4 Goal ascription on the basis of delayed benefits

The intentional structure of this last interaction is vaguely reminiscent of the interaction between agent A and the motionless recipient that infants inferred in our familiarization events. Had infants interpreted agent A's act of object displacement as a well-formed instance of giving, as our findings suggest, they should have concomitantly posited the existence of a long-term relationship through which the costs of giving are eventually recouped through the benefits of later reciprocation.

Summing up, two assumptions have been jointly evoked to explain how and why 15-month-olds formed the expectations revealed in our studies. First, the proposal that benefit information can be consulted for efficiency analysis was invoked to account for how infants may produce goal hypotheses in situations where exclusive reliance on costs would not lead to unambiguous interpretive solutions. Second, the hypothesis that infants expect two agents participating in asymmetric interactions to stand in long-term relationships (which directly followed from the extension of the efficiency criterion to the social domain) served to explain under which conditions infants would hypothesize the continuation of an interaction through time. A crucial corollary of this hypothesis was that, rather than vaguely representing the agents as participating in otherwise undetermined relationships, infants could produce contentful inferences about the specific RMs regulating these relationships by analyzing the cost-benefit profile of the interactions observed. In the case of our familiarization events, the interaction (giving) created a cost-benefit distribution which we argued to be a cue of EM relationships. On these premises, the finding that infants prioritized the giving outcome over the other suggests that infants represented this outcome, despite its immediate costliness, as generating a higher benefit yield (for the Giver) compared to an isolated episode of resource acquisition (as in the approach outcome). This estimate, we contend, reflects an appreciation of the long-term benefits that accrue to the Giver by participating in a reciprocally patterned relationship. Consistently with this hypothesis, in the next chapter we will present evidence compatible with the claim that infants interpret giving as a cue of EM-like relationships.

4.5.5 The side-effect effect and its precursors

The evidence that certain outcome properties (such as the presence of benefits) may make previously discounted states of affairs become candidate goal states strongly resonates with some of the recent developments in the literature on the side-effect effect (SEE). In the first study reporting this effect (Knobe, 2003), subjects told about an action with an intended goal (i.e., implementing a new plan for a company to make profit) and a foreseen side effect (helping vs.

harming the environment) tended to judge the production of this side effect as 'more intentional' when it produced morally negative, rather than positive, effects. This intriguing asymmetry was first championed by Knobe (2006) as evidence that "moral considerations are playing a role in the fundamental competencies underlying our use of the concept of intentional action". Crucially, this effect has been also found across cultures (Knobe & Burra, 2006) and in children as young as four (Leslie, Knobe, & Cohen, 2006), strengthening the case for its universality.

However, further studies proved the restriction of the SEE to the moral domain unwarranted. The SEE has in fact been reported for a number of scenarios involving prescriptive and descriptive norms (e.g., Uttich & Lombrozo, 2010; Holton, 2010; Hindriks, 2014). Building on these new results, Machery (2008) proposed a more general account of the SEE that does not involve neither moral valence nor moral responsibility. According to his "trade-off hypothesis", whenever costs can be conceptualized as a means to benefits, the former will be automatically considered as intentionally incurred for producing said benefits. In the words of Uttich & Lombrozo (2010): "the fact that an agent is willing to incur a cost provides evidence that the agent has a reason to perform the action that is sufficiently strong to outweigh the cost". In other words, the perception of a functional relation between costs and benefit represents a sufficient evidential prior in favor of the hypothesis that the benefit-bearing outcome was produced intentionally. Corroborating this 'rationalist' account, a recent study found that 4-year-olds show the SEE for both moral and conventional violations, suggesting that cost-based diagnostic reasoning for intention attribution may represent an early-developing feature of our cognitive makeup (Rakoczy et al., 2015).

Given these recent findings, it is tempting to trace a connection between infants' early susceptibility to benefits-bearing outcomes in the domain of goal ascription (as shown in this chapter) and the later-developing sensitivity to cost-benefit relations in the domain of intentionality judgment. Broadly considered, these two phenomena may constitute similar manifestations of a common system of diagnostic reasoning that starts off ontogenetically with an explanatory toolkit of cost-benefit relations deployed for the purpose of goal attribution and later expands its scope to also include intentionality judgment. Corroborating this proposal, recent developmental evidence shows that children employ a so-called 'naïve utility calculus' (i.e., a generation model of human behavior based on the core assumption of utility-maximization: Jara-Ettinger, Gweon, Schulz, & Tenenbaum, 2016; Lucas et al., 2015) to support a wide range of inferences – e.g., about preferences, behavioral competencies (Jara-Ettinger & Gweon, 2015), and moral status (culpability: Jara-Ettinger, Tenenbaum, & Schulz, 2015).

4.5.6 Caveats about the "sufficiency thesis"

Complementing the previous studies (Chapter III), the data presented here provide further support for the abstract nature of infants' representation of giving. Had infants apprehended the object-displacing action as a well-formed instantiation of giving, this would show that, contrary to Schöppner et al. (2006), hand-to-hand transfer is not among the necessary cues for eliciting the representation of giving actions. Despite agent A (the Giver) did not have continuous control over the fate of the object, her causal contribution to the outcome of possession transfer seemed here sufficient for supplying a social interpretation to this (admittedly unusual) transfer event.

This evidence however should not be taken to suggest that infants would exclusively rely on these cues to identify prosocial goals in resource-transfer events. It is in fact known that infants can make use of additional cues to assess the prosocial disposition of resource providers. For instance, 21-month-olds presented with two adults who both provided them with a toy, one (Successful Actress) by explicitly handing it over, and the other (Ambiguous Actress) by placing it on the edge of a tabletop and making it fall down to the infant, robustly preferred to return an out-of-reach object to the former (Dunfield & Kuhlmeier, 2010). Similarly, 10-month-olds exposed to a puppet (Intentional Helper) which pushed down a shelf to make an out-of-reach object become available to another agent compared to another puppet (Accidental Helper) which produced the same outcome by bumping into the shelf (while running to get an object), consistently chose the former in a manual-choice task (Le, 2011). As these studies show, despite both agents were causally responsible for producing a transfer of possession, their underlying prosocial intentions were differently evaluated on the basis of additional cues (such as: body orientation, monitoring and control over of the transfer, and even structural relations between the giving outcome and other concomitant goals) onto which infants later based their partner-choice decisions.

Chapter V. Reciprocity study

5.1 Introduction

In Chapter III we discussed findings supporting the hypothesis that infants are endowed with an action schema for representing social interactions based on giving. In the present chapter, we will present a set of studies designed to investigate our second hypothesis, according to which giving may be a cue of EM relationships. Succinctly, this hypothesis entails that, upon observing a giving action, infants should spontaneously infer the presence of a stable social relation between the agents participating in the transfer – a relation conforming in content and normative force to the EM model.

As pointed out in the Introduction (1.9.1), EM relations are structured on the directive standard of even balance. Leaving aside single episodes of resource distribution (which we shall explore in Chapter VII), this standard regiments how material favors are dispensed within a dyad in the long run. Even balance in this case is not a property of local interactions, singly considered, but of their patterning through time. This explains why EM relations based on asymmetric benefit delivery are, by necessity, reciprocal: only the deployment of prosocial acts contingently on the receipt of favors can ensure that welfare asymmetries would be evened out.

Despite the fact that short-term imbalances are inherent to EM relations, the possibility of defection (congenital to any non-enforceable asynchronous exchange) makes them necessary to be tracked. An individual who does not keep books of who owes what to whom would be unable of detecting, and reacting accordingly to, an underinvesting partner, making herself susceptible to exploitation. This argument well explains why EM relationships, despite being symmetrical in the long run, require local welfare asymmetries to be registered. What motivates such encoding is not simply the fact that two agents occupy complementary action roles (this would be in fact the case for any agent-patient interaction: Golinkoff & Kerr, 1978), but rather that this information acts as a proxy of the indebtedness relation on the basis of which balance-restoring actions have to be modeled.

Crucially, indebtedness is a non-transferable obligation[25] (Greenberg, 1980; de Cooke, 1992). That is, if A owes to B, and B owes to C, the fact that A later benefits C does not clear off

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[25] Something that young children seem already well aware of, since by three years of age, they seem already able to understand that bestowing resources to someone entitles them to obtain future benefits from the beneficiary, as shown by the children's selective requesting of resources to their previous sharing partners (Paulus, 2016) This suggests that young children can monitor the social capital (indebtedness) acquired in previous social interactions and strategically trade such capital to their own benefit (see also: Sebastián-Enesco & Warneken, 2015).

the debts she had with B. This entails that the indebtedness relation binding two exchange partners needs to be segregated and independently book-kept from other co-occurring relations.

These properties of EM relations allow us to make precise predictions concerning the type of information that the representation of interactions instantiating such relations should contain: namely, (a) the identity of the participating agents and type of actions relating them, necessary to track the assumed relationship among others; and (b) the direction of resource transfer, necessary to detect changes in the resource flow within the relationship.

A number of studies (reviewed in 3.8, Chapter III) support the idea that acts of giving may engender direct reciprocity early in development (see: Olson and Spelke, 2008; He et al., 2011). Different from this research, the primary motivation of the studies presented here is to explore whether infants' representation of social interactions based on giving contains information socially relevant under an EM model. If this is the case, such representation should support cognitive operations consistent not only with the ascription of (a) stable and particularistic relationships, but also of (b) EM relations specifically (i.e., supporting the tracking of welfare imbalances). In order to assess whether these encoding strategies are specifically induced by giving, or more generally by any interaction based on object transfer, we will compare the content of the representations elicited by giving and taking actions (as in Chapter III).

5.1.1 Why did infants not expect reciprocation?

The studies described in Chapter III, while strongly supporting the claim that infants can interpret giving actions, failed to provide evidence that the representation of the transfer-based interaction could support relational inferences in 12-month-olds. As the null results of Studies 5 and 7 showed, the representation of giving did not afford expectations about the behavior of the Givee/Takee: 12-month-olds looked equally to consistent and inconsistent reciprocation events. Importantly, the evidence that infants could differentiate between the two transferring actions and link them to the appropriate agents (see Studies 1 and 6) suggests that infants in Studies 5 and 7 could have re-identified the two previously acting agents (as Giver or Taker) at test on the basis of their surface appearances, and yet did not use this information to set up reciprocity-consistent expectations about the patient's action (which, according to our hypothesis, should have been primed by the occurrence of the giving action). Why so?

One possibility is that the mere occurrence of an interaction may not constitute a sufficient reason for the infants to produce relational inferences. The function of these inferences, as we noted, is to organize the social space by segregating interactants into distinct relational units. Given such function, it is conceivable that infants may not produce such inferences unless given evidence of a social arena where relations (and their non-generalizable sets of obligations/entitlements) need to be kept separate one from another. This, we believe, may have been the case in Studies 5 and 7. Recall that the familiarization consisted in two dyadic interactions presented isolatedly one from the other. Despite both involved a featurally identical patient, which could have acted as common element for the two (partially) overlapping relational units, visualizing this structure would have required infants to combine the representation of two spatiotemporally separate interactions through the shared patient – which presupposes in turn that they also interpreted the two featurally identical patients as the same individual presented twice. However, given the findings that infants omitted the patient from the representation of taking actions (studies 2 and 4: Chapter III), one of the terms necessary to construe this identity relation (hence to represent a common patient) may have been missing, making infants unable to structurally connect the two interactions (cf. Goldwater & Gentner, 2015).

Relatedly, as we previously discussed (3.8.2), a growing body of evidence suggests that contingent reciprocity may be initially used as a means of partner selection – i.e., in a context where selective prosociality helps sorting through partners of different social value (e.g., Warneken and Tomasello, 2013; for similar evidence in capuchin monkeys: Tiddi, Aureli, Polizzi di Sorrentino, Jackson, & Schino, 2011). Adopting such "partner-choice hypothesis" to the representational level, it is hypothesizable that, if infants represented the patient as standing in only one interaction (since the taking action was interpreted in object-directed terms), there were no other social partners that the patient could have been contrasted with (and chosen amongst), making it unnecessary to set up expectations about selective reciprocation. Both accounts hold that infants should be prone to engage in relational inferences when given evidence of multiple interactions to compare among. However, the latter account restricts these inferences to conditions in which the focal agent can selectively affiliate, by means of reciprocation, with one of the agents she previously interacted with.

Following these accounts, in the present studies we exposed infants with a relational structure similar to the one adopted in the previous studies (i.e., two partly overlapping dyadic interactions), but with the two transfer events occurring sequentially on the same stage. This should have dispensed infants from the task of memorizing and combining together the representations of spatiotemporally separate interactions, as well as to individuate shared relational elements (i.e., patients or agents) solely on the basis of their featural similarity between distinct occurrences – a computational challenge which may have overburdened infants' processing in the previous studies.

5.1.2 Interpreting taking as a patient-directed action

The above hypothesis proposes that infants would engage in relational inferences when exposed to contrasted interactions. This presupposes however that giving and taking actions would be both represented in a three-argument structure. Yet, in Chapter III we found that infants, when presented with two separate interactions, represented giving and taking in structurally different terms, omitting the patient altogether from the representation of the taking event (Studies 2-4). Given these results, it seems that before even assessing the contribution of contrasting social interactions on infants' representation, we would first need to ensure that the two interactions are defined in structurally isomorphic terms.

This, however, may not be necessary. Presenting giving and taking in the same perceptual space may in fact by itself obviate to the problem. As Gentner & Markman (1997) suggested, perceptually matching relational structures in item pairs should scaffold similarity comparisons about the common underlying structure that these pairs instantiate. The similarities in the spatial distribution and kinematic profile of the agents and objects featuring in the giving and taking actions may therefore foster the mapping and projection of one event structure onto another: in other words, the alignment of the two interactions may prompt the use of the structural schema underlying giving, which infants – as we saw in Chapter III (Studies 1, 4, and 5) – spontaneously interpret as including a recipient, onto the taking event, thus producing two structurally isomorphic representations (with regards to the number of arguments contained; for a recent defense of the role of structural alignment in learning about social relations, see: Christie, 2017).

To summarize, across eight studies, we attempted to test: whether (1) providing contrastive information of dyadic interactions could help 12-month-olds to set up representations of stable social relations (i.e., representations that would allow infants to track the components of a social relation – its participants and type of interaction – across time and contexts: Studies 1-5); and (2) whether these representations additionally support the detection of in-kind reciprocation within the represented relations (Studies 6-7). Since we hypothesized that giving specifically, by cueing an EM model, should elicit representations functional to the bookkeeping of material favors, we assessed the specificity of these representations by comparing the encoding strategies used to track giving- and taking-based relations.

5.2 General Procedure

The design structure was the same for all the studies: infants were presented with four familiarization trials followed by two test trials. The familiarization events showed three agents involved in two partly overlapping dyadic interactions (based on giving and taking). The two interactions either shared a common active agent (Studies 1-3 and 8) or a common patient (Studies 4-7). At test, infants were shown either two giving or two taking actions. Except for Studies 6 and 7, the only difference between the two test events consisted in the identity of the patient of the object-transferring action (Figure 8).

5.2.1 Stimuli

The stimuli consisted in animations designed in Flash Professional CS5.5 and presented using Keynote (version 5.0). A short (1.5 s) attention-getting animation was presented before each familiarization and test trial. Fig. 1 depicts the structure of the stimuli used in Study 1, and Table 4 lists the variants of factors that changed across studies.

Familiarization events. There were two types of familiarization events: common-agent and common-patient events. In the common-agent events, the agent participating in the two overlapping interactions was the Giver/Taker; in the common-patient events it was the Givee/Takee. Each familiarization event (common agent: 29 s total running time; common patient: 21 s) involved three agents (12 x 12 cm) placed on a green trapezoid-shaped platform (80 x 75 x 45 cm) superimposed on a yellow background. The three agents were represented as a chicken (yellow), a dog (brown), and a cat (grey). Each agent had the same pair of large eyes (4.5 x 4.5 cm), a distinctive nose, and bilaterally symmetrical appendages (wings or ears).

Both familiarization types started by showing the three front-facing agents spatially disposed in a triangle-like configuration: the dog occupied the apex, whereas the other two agents (chicken and cat) occupied the base vertices. The scene contained also two identical apples (5 x 5 cm): in the common-agent familiarization these were respectively placed next to the dog (on its right) and to the cat (on its right), whereas in the common-patient familiarization they were placed next to the chicken (on its left) and next to the dog (on its left). The two characters interacting with the common agent or common patient swapped locations in the last two familiarization events.

Common-agent familiarization. The familiarization (29 s total running time) started by displaying three motionless agents for 2.7 s. Afterwards, the Giving event started: the dog oriented itself sideways towards the apple and approached it (0.6 s). Upon contacting it, the Giver started pushing the apple towards the recipient (3.4 s). Once receiving the apple, the chicken turned to the dog and both agents stood still facing each other for 1 s. Afterwards, the dog moved back to its initial position (facing away from the chicken), while the chicken resumed its original frontal orientation 1 s after the dog started moving. Once reaching its initial position (3.4 s), the dog resumed its frontal orientation. This completed the giving event. After a pause (2 s), the taking event started: the dog approached the cat (3.4 s) and established contact with the apple. As in the giving case, the cat immediately turned to the dog, and the two agents held still facing each other for 1 s. Then the dog moved back (3.4 s), and the cat resumed its frontal orientation 1 s after the dog started moving. The dog released the apple in a position specular to the location occupied by the first apple and finally moved back to its initial position (1.6 s). At this point, the three agents remained motionless until the end of the clip (5 s). In sum, the familiarization event showed an agent (dog) engaging in two different object-transferring actions (giving and taking) targeting two different patients (chicken and cat, respectively).

Two sounds were played during the familiarization: one at the beginning of the event (2.5 s) and another when the active agent contacted the taken apple and released the given apple (0.5 s).

Besides modifying the interaction pattern, we also made other small changes to the stimuli for the common-agent familiarization. Specifically, we (1) increased the speed of each transferring action, thus shortening the total length of the events (21 s total running time); (2) added a third sound to the transfer; and (3) changed the background from yellow to grey. These changes were made after having noticed that some of the infants tested with the previous familiarization stimuli (Studies 1-3) tended to scratch their eyes and disengage from the screen during the agent's motion, suggesting they may have found the stimuli too bright and/or not interesting enough. As evidenced by the smaller rejection rate of Studies 4-8, these changes seemed to have produced the desired effect. These changes were applied to all the studies featuring the common-patient familiarization (Studies 4-7), as well as study 8, in which the common-agent familiarization type was used.

Common-patient familiarization. The familiarization events started by showing three motionless agents for 2.7 s. After this pause, the giving action started: the chicken oriented itself sideways towards the apple and approached it (0.4 s). Upon contacting it, the chicken started pushing the apple towards the dog (2.1 s). Once receiving the apple, the dog turned to the chicken and both agents stood still facing each other for 0.8 s. Afterwards, the chicken moved back to its initial position (facing away from the chicken), while the dog resumed its original frontal orientation 0.2 s after the chicken started moving. Once reaching its initial position (2.1 s), the chicken resumed its frontal orientation. This completed the giving action. After a pause (2.7 s), the taking event started: the cat approached the dog (2.1 s) and established contact with the apple. As in the giving case, the dog immediately turned to the cat, and the two agents held still facing each other for 0.8 s. Afterwards, the cat moved back (2.1 s), and the dog resumed its frontal orientation 1 s after the cat started moving. The cat released the apple few cm away from his body and finally moved back to its initial position (0.4 s). At this point, the three agents stood motionless until the end of the clip (3.4 s).

Three sounds were played during the familiarization events: one at the beginning of the event (2.5 s), a second one when the active agent first touched the given apple and released the taken apple (0.5 s), and a third when the agent released the given apple and first contacted the taken apple (0.5 s).

In both familiarization types, the giving and taking actions were equated for duration, speed, and extent of motion of the agents. 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 participants in all studies.

Test events. There were two types of test events: giving and taking (11 s total running time). The giving test event started by showing the Givee oriented sideways next to an apple on the left side of the platform, and a grey screen (35 x 23 cm) on the right side. After a 2.7 s delay, the Givee started pushing the apple towards the screen, until disappearing behind it. The whole action lasted 5.4 s. After a 0.2 s delay, the screen slid away from the platform (3 s), revealing either the Giver or the Takee behind. The event ended with the two agents facing each other, with the apple in between, but still in contact with the Giver. The taking test event started by showing only the grey screen on the right side of the platform. After 2.7 s, the Takee emerged from behind the screen while pushing an apple and moved towards the opposite side of the platform (5.4 s). After a short delay, the screen slid away (3 s) to reveal either the Taker or the Givee behind it. The taking event ended with the Takee and the Taker/Givee placed at the two opposite sides of the platform, the first with an apple and turning its back to the second. The two test events (within each test type) were equated for length, speed, and extent of the agent's motion. Two sounds were played during the test: one at the beginning of each test event (2.5 s), and another when the screen started moving (1.2 s).

The order of test events was fully counterbalanced.

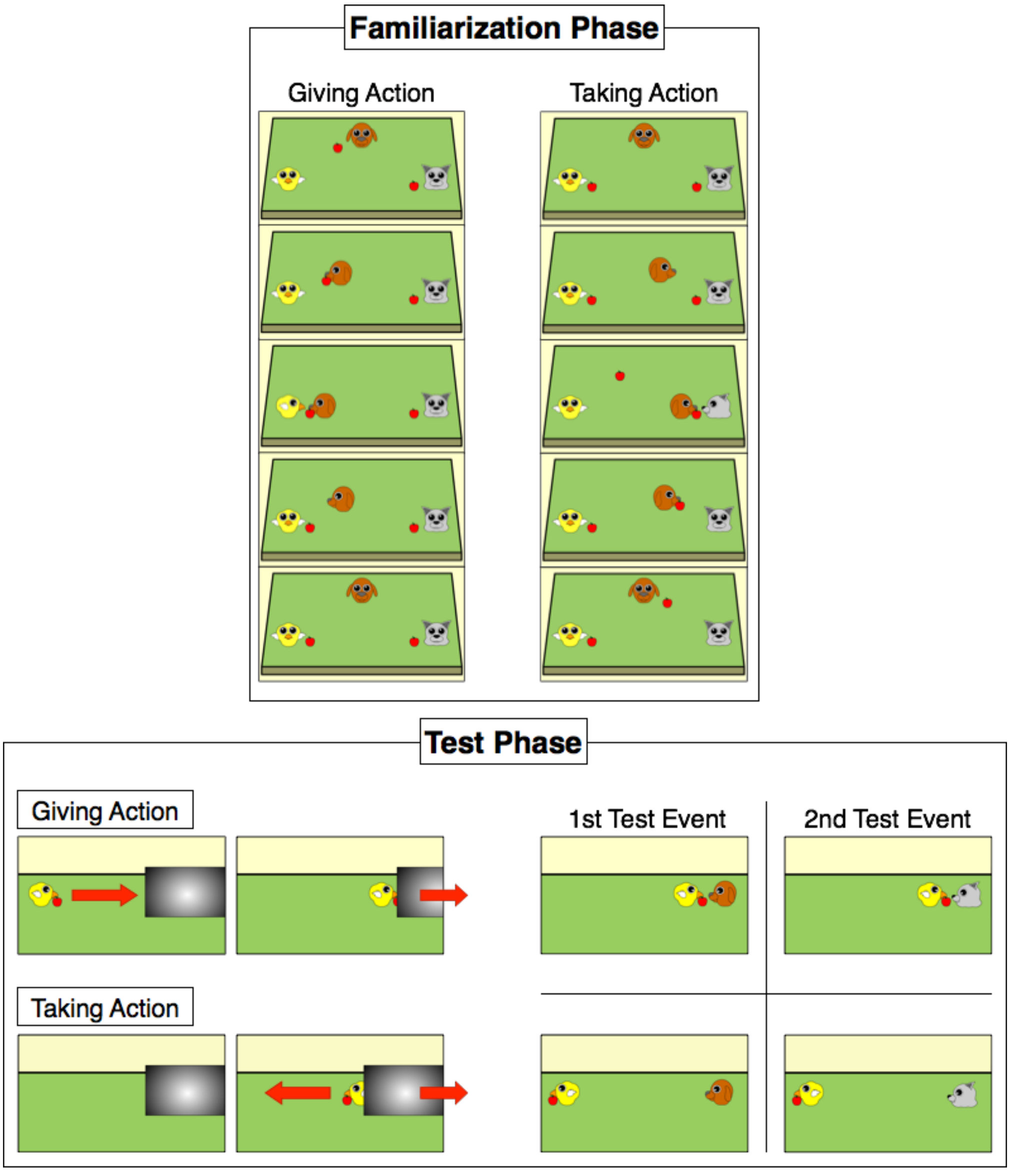

Figure 8. Schematic visualization of the events shown in Studies 1 and 3. The arrows indicate the direction of movement of the agents/objects present on the scene. Despite being presented here as separate, the giving and taking actions occurred within the same event.

5.2.2 Coding and data analysis

We performed an off-line frame-by-frame analysis of infants' looking behavior. To be included in the final data analysis, infants had to satisfy the following criteria: (1) look at each transfer action in the four familiarization events for at least 50% of its overall duration, from when the agent starts moving to when it reaches back its initial position (Studies 1-3: 4.9 s; Studies 4-8: 2.9 s); (2) look at each test trial for at least 50% of its duration, from the beginning to the moment when the barrier starts sliding away (4.15 s).

LT during test trials was measured from when the screen started sliding away to the moment when the infant looked away for more than 2 s or looked cumulatively more than 60 s.

For each sample, 10/16 infants were randomly selected and re-coded by a coder blind to the hypothesis. The inter-coder agreement was overall excellent, as indicated by the consistency measures of the intra-class correlational coefficient (Study 1: *r* = .988; Study 2: *r* = .984; Study 3: *r* = 991; Study 4: *r* = 983; Study 5: *r* = .989; Study 6: *r* = .992; Study 7: *r* = .993; Study 8: *r* = .996.

There was no order effect of test trials on infants' looking behavior during test in any of the studies reported. Additionally, there was no difference in how long infants attended to the giving and taking actions during familiarization (from the beginning of the Giver/Taker's movement to when it finally moved back to its initial location: 9.8 s in Studies 1-3; 5.8 s in Studies 4-8).

Studies		**Familiarization**	**Test Event 1**	**Test Event 2**
1	**Reciprocal Giving**	Common Agent: A Gives To B A Takes From C	B Gives To A	B Gives To C
2	**Reciprocal Interaction**		C Gives To A	C Gives To B
3	**Reciprocal Taking**		C Takes From A	C Takes From B
4	**Reciprocal Giving**	Common Patient: A Gives To B C Takes From B	B Gives To A	B Gives To C
5	**Reciprocal Taking**		B Takes From C	B Takes From A
6	**Giving Direction**		A Gives To B	B Gives To A
7	**Taking Direction 1**		C Takes From B	B Takes From C
8	**Taking Direction 2**	Common Agent	A Takes From C	C Takes From A

Table 4. The table provides all the relevant information about differences and commonalities between the studies.

5.3 Study 1. Reciprocal giving (common agent)

Study 1 tested whether providing evidence of different co-occurring transfer-based interactions could induce infants to establish a representation functional to the tracking of giving-based relations. Since giving-based (EM) relations, as we hypothesized, are based on reciprocal exchange, their representation should also allow infants to re-identify a relational unit in cases of reciprocation. To this end, we exposed infants to the common-agent familiarization stimuli and showed at test the Givee reciprocating in-kind to the Giver or giving to the unrelated agent. If infants formed a representation of the above kind of the giving-based relation, they should be able to recognize in the reciprocity-consistent outcome an instantiation of a familiar relation.

5.3.1 Methods

5.3.1.1 Participants

Sixteen 12-month-olds participated in the study (9 females; mean age = 366 days; range = 352-381 days). An additional 7 infants were excluded from the analyses due to inattentiveness (*n* = 5), technical failure (*n* = 1), and experimental error (*n* = 1).

5.3.1.2 Stimuli

During familiarization, infants were presented with two transfer-based interactions (common-agent familiarization): agent A giving to B (Givee) and taking from C (Takee). At test, infants saw B giving an apple either to A (Reciprocation event) or to C (New Interaction event).

5.3.2 Results and Discussion

Twelve-month-olds looked longer to the New Interaction (M = 15.92, SD = 4.55) than to the Reciprocation event (M = 9.23, SD = 7.83), $t(15) = -2.422$, $p = .029$, $r^2 = .214$; $p = .030$ by Wilcoxon signed ranks test (Figure 9). The effect was visible also at the individual level, with 13/16 infants looking in the predicted direction.

The LTs found in Study 1 suggest that the reciprocal event was perceived as a closer match to the previously represented relation between A and B than the alternative test event. Compared to the results of Studies 5 and 7 (in Chapter II), where infants presented with isolated giving and taking actions failed to identify an episode of in-kind reciprocation, these findings suggest that providing contrastive evidence of different interactions may have been crucial to allow for the re-identification of a giving-based relationship (role reversed).

However, the looking-time pattern found in Study 1 could also be interpreted as showing that infants established a representation of the interaction between A and B merely based on agent A's approaching action rather than on the transfer. Under this reading, infants would have thus found the outcome of the reciprocal action event, which depicted A and B close to each other, as more compatible with said representation than the alternative event, which depicted two agents who never approached each other standing now in close proximity.

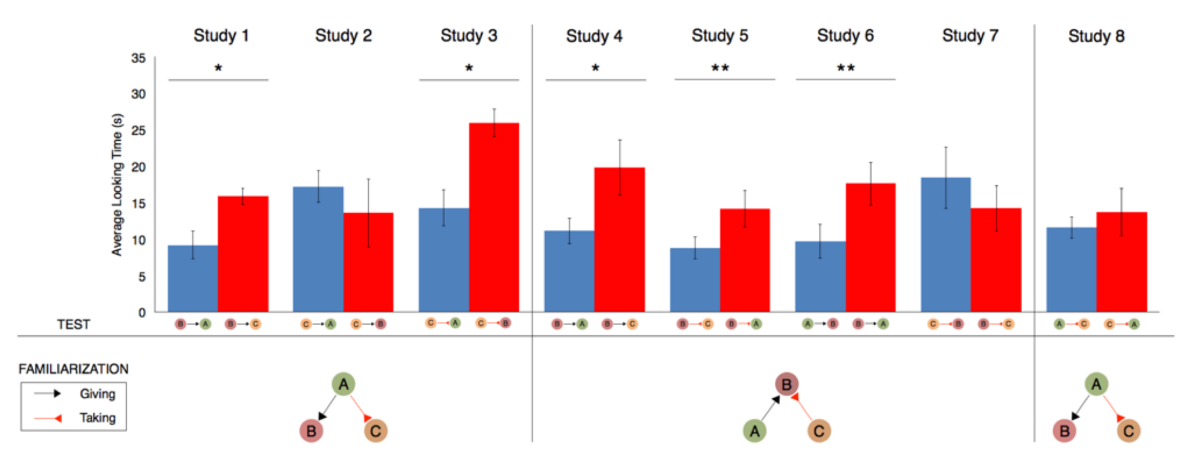

Figure 9. Average looking times during the test trials in Studies 1–8. Error bars indicate standard error. Asterisks represent statistically significant differences between the two test trials (*p < .05; **p < .01). The arrows and letters represents the agents and actions shown during the familiarization and test phase.

5.4 Study 2. Reciprocal interaction (control)

Study 2 tested whether infants' representation of the giving relation was based on the agents' approaching behavior or on the type of transfer occurring between them. To this end, we presented infants with the same familiarization used in Study 1, and at test we showed two isolated giving interactions, this time involving the Takee (C) delivering an apple either to A or to B. The two test events therefore represented an inconsistent reciprocal action (i.e., the Takee's action did not match the action she was previously targeted with) between related agents (B and C), and an interaction between unrelated patients (C and A).

If infants inferred a relationship between A and B in Study 1 on the basis of A's approaching behavior, we expected them to do so also for the taking interaction (between B and C), since both interactions displayed the same approaching behavior. The test interaction between agents B and C should therefore be perceived as a closer match with this representation than its alternative regardless of whether it represented an episode of consistent or inconsistent reciprocation. On the contrary, if infants encoded the specific transferring action relating B and C during familiarization, they should react similarly to the two test events, as neither would match the representation of the inferred taking relation.

5.4.1 Methods

5.4.1.1 Participants

Sixteen 12-month-olds participated in the study (6 females; mean age = 363 days; range = 349-376 days). Seven additional infants were excluded from the analyses due to inattentiveness ($n = 5$) and experimental error ($n = 2$).

5.4.1.2 Stimuli

Infants were presented with the same familiarization events of Study 1. At test, they were shown two giving events involving C transferring the apple either to A (Reciprocation event) or to B (New Interaction event).

5.4.2 Results and Discussion

Infants looked equally to the Reciprocation (M = 17.25, SD = 10) and the New Interaction event (M = 13.62, SD = 7.71), $t(15) = 1.272$, $p = .223$, $r^2 = .037$. An ANOVA with test trial type (Reciprocation vs. New Interaction) as within-subject factor and Study (1 vs. 2) as between-subject factor revealed an interaction, $F(1, 30) = 7.256$, $p = .011$, $\eta_p^2 = .195$, and no main effect.

There was no difference in how long 12-month-olds attended to the two familiarization events between Studies 1 and 2, as revealed by a one-way ANOVA with averages of total looking-time: $F(1, 30) = .489$, $p = .490$, $\eta^2 = .016$.

Compared to the findings of Study 1, these results suggest that the representation of the relationship that infants set up during familiarization was not merely based on the agent's approaching action, but on the type of transfer produced. *Prima facie*, the results of Study 2 are compatible with the possibility that infants may have represented the taking interaction and therefore perceived the inconsistency of the reciprocal action – despite this occurred between previously related agents. However, the null results may also indicate an overall failure to represent the interaction between B and C. Supporting this alternative, in Chapter III we showed that infants did not include the patient (Takee) in the representation of an isolated taking event, privileging an interpretation of this action as purely object-directed.

5.5 Study 3. Reciprocal taking (common agent)

To test whether infants set up a representation of the taking action as a social interaction, complete with information about the identity of the agents involved and the action performed, in Study 3 we familiarized infants to the same stimuli used in the previous studies, and showed at test the Takee reciprocating in-kind to the Taker or taking from the unrelated agent. Applying the same logic of Study 1, if infants formed a representation of the taking-based relation, the reciprocation event should provide a closer match to said representation than the other event.

5.5.1 Methods

5.5.1.1 Participants

Sixteen 12-month-olds participated in the study (7 females; mean age = 359 days; range = 352-381 days). An additional 7 infants were excluded from the analyses due to inattentiveness (n = 4), crying (n = 1), technical failure (n = 1), and experimental error (n = 1).

5.5.1.2 Stimuli

The familiarization events were identical to those used in Study 1. At test, infants were shown C taking an apple away either from B (Reciprocation event) or from A (New Interaction event).

5.5.2 Results and Discussion

Infants looked longer to the New Interaction (M = 25.99, SD = 18.89) than to the Reciprocation event (M = 14.33, SD = 8.81), $t(15) = -2.285$, $p = .037$, $r^2 = .135$; $p = .034$ by Wilcoxon signed ranks test. The effect was visible also at the individual level, with 11/16 infants looking longer to the Inconsistent test event. An ANOVA with test trial type (Reciprocation vs. New Interaction) as within-subject factor and Study (1 vs. 3) as between-subject factor revealed a strong main effect, $F(1, 30) = 11.074$, $p = .002$, $\eta_p^2 = .270$, and no interaction. There was also a between-subject effect of Study, $F(1, 30) = 5.408$, $p = .027$, $\eta_p^2 = .153$. An additional ANOVA ran in the same way between Studies 2 and 3 revealed an interaction but no main effect, $F(1, 30) = 6.695$, $p = .015$, $\eta_p^2 = .182$.

There was no difference in how long 12-month-olds attended to the two familiarization events between Studies 1 and 3, as revealed by a one-way ANOVA with averages of total looking-time: $F(1, 30) = .378$, $p = .544$. Similarly, no difference was found between Studies 2 and 3: $F(1, 30) = .022$, $p = .883$.

These findings reveal that, unlike in the studies reported in Chapter III (Studies 2 and 4), infants spontaneously set up a representation of the taking action *qua* interaction. The similarity of results between Studies 1 and 3 strongly suggests that contrastive information of different transfer-based interactions may have played an equally crucial role in “upgrading” the representation of taking as patient-directed action, and in supporting the re-identification of a relationship in role-reversed interactions.

5.6 Study 4. Reciprocal giving (common patient)

Our goal in Study 4 was twofold: (a) to replicate our initial findings, especially those concerning the representation of taking, which fell outside the scope of our initial hypothesis; and (b) to obtain positive evidence that the representations of the two transfer-based relations included information about the occurring mode of transfer – a claim so far supported only indirectly by a null result (Study 2). In Study 4 we provided a more stringent test of infants' ability to detect action changes in a transfer-based relation by using the *same* interaction structure adopted in the studies discussed in Chapter III. Infants were familiarized with agent A giving an apple to agent B, and agent C taking an apple from agent B. In other words, infants were exposed to the same two transfer-based interactions already use, but now having a patient in common. Differently from Studies 1-3, both test events depicted reciprocal interactions between previously interacting agents (the patient and the Giver or Taker), but only one represented an instance of consistent reciprocity. Thus, the only difference between test events that infants could have reacted to was whether the type of action performed by the reciprocating agent matched the action performed in familiarization (within the same relation) or not.

5.6.1 Methods

5.6.1.1 Participants

Sixteen 12-month-olds participated in the study (9 females; mean age: 361 days; range = 351-375 days). An additional 6 infants were excluded from the analyses due to inattentiveness (*n* = 4), crying (*n* = 1), and technical failure (*n* = 1).

5.6.1.2 Stimuli

During familiarization, infants were presented with two transfer-based interactions, as described in the Procedure section (common-patient familiarization): agent A (Giver) gives to B and agent C (Taker) takes from B. At test, the infants were presented with B giving an apple either to A (Consistent Reciprocation event) or to C (Inconsistent Reciprocation event).

5.6.2 Results and Discussion

Infants looked longer to the Inconsistent (M = 19.86, SD = 15.28) than to the Consistent Reciprocation event (M = 11.18, SD = 7.05), $t(15) = -2.763$, $p = .017$, $r^2 = .117$; $p = .017$ by Wilcoxon signed ranks test.

These results provide clear evidence that infants encoded the type of transferring action in the representation of the giving relation. Had infants in fact inferred social relations solely on the basis of the agents' approaching behavior (as earlier suggested), they would have reacted equally to the two test events, since they were both compatible with the previously observed approaches.

5.7 Study 5. Reciprocal taking (common patient)

In Study 5 we applied the same logic of the previous study to test whether infants' representation of the taking relation included information about the type of transferring action observed.

5.7.1 Methods

5.7.1.1 Participants

Sixteen 12-month-olds participated in the study (9 females; mean age: 363 days; range = 351-374 days). An additional 7 infants were excluded from the analyses due to inattentiveness (n = *4*), crying (n = *1*), maternal intervention (n = *1*), and technical failure (n = *1*).

5.7.1.2 Stimuli

The same familiarization stimuli of Study 4 were used. At test, infants were shown B taking an apple away from either C (Consistent Reciprocation Event) or from A (Inconsistent Reciprocation event).

5.7.2 Results and Discussion

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), $t(15) = -3.170$, $p = .006$, $r^2 = .092$; $p = .007$ by Wilcoxon signed ranks test. 14/16 infants looked in the predicted direction. To assess the consistency of these results with the findings from Study 4, an ANOVA with test trial type (Consistent vs. Inconsistent Reciprocation) as within-subject factor and Study (4 vs. 5) as between-subject factor was conducted, revealing a strong main effect, $F(1, 30) = 16.407$, $p < .001$, $\eta_p^2 = .354$, and no interaction.

There was no difference in how long 12-month-olds attended to the two familiarization events between Studies 4 and 5, as revealed by a one-way ANOVA with averages of total looking-time: $F(1, 30) = 1.485, p = .233, \eta^2 = .049$.

Taken together, Studies 4 and 5 provide convincing evidence that infants encoded the type of transferring action, for giving and taking alike. These findings corroborate the hypothesis that direct evidence of contrasted interactions may be necessary to motivate the representation of these interactions as instantiations of enduring social relations. Consistently with this proposal, despite having used the same interaction pattern (common patient familiarization) in the studies discussed in Chapter III, but presenting the giving and taking actions as spatiotemporally separate events, we found no evidence that infants could distinguish between instances of consistent and inconsistent reciprocation.

5.8 The seeming isomorphism of giving and taking

Studies 1-5 showed that infants represented giving and taking in structurally isomorphic terms (as three-place relations involving a specific agent and patient). This suggests that infants' propensity to infer social relations on the basis of resource transfer episodes is not restricted to altruistic acts of resource donation but may encompass a wider vocabulary of action cues.

The similarity of infants' reactions to the giving and taking test events may be taken as evidence that the representation of the two transfer types was content-wise identical. This was presumably the case with respect to (a) the identity of the agents involved and (b) the action relating them: infants could not have possibly detected the patient (Studies 1 and 3) and action change (Studies 4 and 5) in the giving and taking dyad, had they not registered this information for both types of transfer. However, it remains an open question whether the direction of object transfer (or the agents' complementary action roles) was also encoded. The evidence that an episode of consistent reciprocation provided a closer match to the familiarization events than interactions occurring between unrelated agents (Studies 1 and 3) or instances of inconsistent reciprocation (Studies 4 and 5) does not conclusively demonstrate that infants recognized the test actions as reciprocal. Infants in fact could have detected equally well any change in the type of action and agents involved within the inferred relations, even if they had not noticed the role reversal at test. Thus, we do not know whether the direction of object transfer was part of infants' representations of the observed interactions – and, if so, of which.

Our initial hypothesis was grounded on a fundamental tenet of computational efficiency (Montague, 2007): since information encoding is costly, representations should contain only as much information as necessary to detect changes in dimensions relevant to the inferred social relations, so to optimize the computational expenditure. By *relevant* here we refer to any dimension onto which depends the stability and development of a given relationship.

Rather obviously, this representation should necessarily include information about the identity of the agents involved, no matter the type of relationship considered. Since a social relation is by definition the emergent property of repeated interactions (Hinde, 1976a; 1976b), it follows that, to be tracked over time, it needs to be re-identified in its episodic instantiations.

Noteworthily, encoding information about the identity of the interacting agents alone is already sufficient to represent relations based on simple association. These relations do not support any contentful inferences about the specific actions that could occur between its participants, and yet can avail assumptions of temporal stability (i.e., agents A and B are likely to remain in relation X) and 'irreplaceability' (i.e., A may have relations of the type X with any other agent, but these do not supplant the relation X that A has with B: Martin, 2009). However, social relations in humans have typically further entailments: being in a social relation often requires its participants to express interpersonal attitudes of one kind or valence (Rai & Fiske, 2011). These rules of conduit capture the different coordination rules which make repeated interactions with different social actors (kin, nonkin, dominants) possible. The evidence that infants spontaneously encoded the transferring actions in Studies 4 and 5 thus suggest that they interpreted this information relevant to the representation of the corresponding relationships, plausibly because indicative of the set of non-generalizable obligations that each of them entailed (Fiske, 2004).

In the Introduction, we predicted that infants would spontaneously encode the direction of object transfer, even if not indispensable to track the two transfer-based relationships. This follows from our hypothesis that giving may prime the representation of a relationship based on the directive standard of even balance *in the long term* (EM: Fiske, 1991; Blau, 1964; Molm, 2003; 2010), therefore soliciting the encoding of the direction of transfer (and the subsequent detection of eventual welfare-equalizing acts).

5.8.1 Sensitivity to role reversal

How can we apply the same reciprocating logic to the taking-based relation? One intuitive possibility is to equate the reciprocation event to an instance of retaliation. According to this view, infants interpreted taking as a fundamentally anti-social action inflicting a cost to the Takee by depriving the patient of her possessions, and thereby motivating a Tit-for-Tat reaction[26].

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[26] Interestingly, adults and toddlers playing giving and taking variants (in which the subject has to decide how much to take from her partner) of the repeated dictator game seem to be influenced by such interpretation, as they tend to reciprocate less generously towards takers than givers, despite the identical resulting distributions (Keysar, Converse, Wang, & Epley, 2008; Vogelsang & Tomasello, 2016).

The animations used in Studies 1-6 however seem unlikely candidate for inducing such negatively valenced action interpretation. The Takee's reaction (i.e., a brief turning towards the Taker) may have been interpreted as an act of passive acknowledgment of the occurring transfer, but hardly as a sign of distress for/resistance against the resource loss. Moreover, similar animations in the studies presented in Chapter III induced 12-month-olds to represent the taking action as primarily directed to acquiring an object, making them omit the patient altogether from the represented event – evidence that infants failed to perceive the 'affectedness' (Newman, 1996) of the Takee as a consequence of the Taker's action. These reasons make us doubt that the particular direction of transfer could have been interpreted as a meaningful dimension of the inferred relation, hence worth encoding.

On the other hand, we argue that taking (specifically, the type of 'unresisted' or 'facilitated' taking that infants observed) may have primed the representation a social relation characterized by high social tolerance and the absence of normative standards concerning the long-term leveling of inequalities – a social relation where "people simply take what they need and contribute what they can, without anyone attending to how much each person contributes or receives" (Fiske, 1992). This, as we suggested in 1.9, closely approximate the type of coordination rule implemented in CS relations.

It is worth noting that, despite the absence of bookkeeping, CS still requires infants to segregate the representation of a relation from existing others, since it confers to its participants a set of entitlements (i.e., need-based resource appropriation) that cannot be extended to other agents. However, tracking the history of transactions would provide no additional information about the status of the relationship over time, given that CS relationships do not require contingent benefit exchange to be stabilize. On this basis, we expect the representation of (unresisted) taking actions, unlike giving, to not include any information about the direction of object transfer, while still allowing for the efficient tracking of the correspondent relational dyad (i.e., Taker and Takee).

5.9 Study 6. Encoding of transfer direction (giving)

In Study 6 we tested whether the representation of a giving event included information about the direction of resource transfer. To do so, we compared infants' reaction to an interaction matching the direction of transfer of the familiarized giving event with a case of consistent reciprocation. Had infants encoded the direction of resource flow, they would detect its reversal in the reciprocation event, thus attend longer to this test outcome[27].

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[27] The reader may have noticed that the event that we predicted to elicit longer looking is the same that produced the opposite results in Study 4, as if suggesting that infants in Study 6 would *not* expect reciprocation. This contradiction

5.9.1 Methods

5.9.1.1 Participants

Sixteen 12-month-old infants participated in the study (10 females; mean age: 362 days; range = 352-380 days). Six additional infants were excluded from the analyses due to inattentiveness ($n = 4$), crying ($n = 1$), and experimental error ($n = 1$).

5.9.1.2 Stimuli

Infants were presented with the same familiarization used in Studies 4 and 5. At test, infants saw A giving an apple to B (Repetition event) or B giving an apple to A (Reciprocation event).

5.9.2 Results and Discussion

As predicted, infants in the Giving condition looked longer to the Reciprocation (M = 17.63, SD = 11.89) than to the Repetition event (M = 9.73, SD = 9.43), $t(15) = -3.689$, $p = .004$, $r^2 = .119$; $p = .005$ by Wilcoxon signed ranks test. The effect was visible also at the individual level, with 13/16 infants looking in the predicted direction.

Infants' reaction to the reversal of transfer direction suggests that this information was available to be queried during the test phase. Applied to the previous findings, these results suggest that infants perceived the consistent test interaction of Studies 1 and 4 as genuinely reciprocal.

5.10 Study 7. Encoding of transfer direction (taking)

In Study 7 we applied the same logic of Study 6 to explore infants' representation of taking actions. As before, we assessed infants' reaction to taking actions matching the direction of transfer of the familiarized taking event or displaying a reversed resource flow. Had infants omitted the information about the direction of transfer from the representation of the taking relation, as we surmised, both test events should have represented state of affairs compatible with the inferred relation, thus eliciting similar looking.

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can be easily dispelled with a methodological clarification about the VoE paradigm. As argued in Chapter II (section 2.1.2), LTs provide a measure of the match between the representation of the interactions set up during familiarization and the interaction observed at test (under the assumption that, the closer the match, the shorter infants would look). Under this reading, despite infants in Study 4 looked less to reciprocal giving actions (because they provided a better match to the familiarization event than inconsistent reciprocal taking actions), infants in Study 6 should look more at the *same* action (despite consistent with their "expectations"), when contrasted with another action even more similar to the familiarization event because with the same transfer type and direction.

5.10.1 Methods

5.10.1.1 Participants

Sixteen 12-month-old infants participated in the study (8 females; mean age: 363 days; range = 352-381 days). Four additional infants were excluded from the analyses due to inattentiveness ($n = 1$), crying ($n = 2$), and experimental error ($n = 1$).

5.10.1.2 Stimuli

Infants were presented with the same familiarization of Study 6. At test, infants were shown C taking an apple away from B (Repetition event) or C taking an apple from A (Reciprocation event).

5.10.2 Results and Discussion

Differently from Study 6, 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), $t(15) = .370$, $p = .716$, $r^2 = .019$. An ANOVA with test trial type (Repetition vs. Reciprocation) as within-subject factor and Study (6 vs. 7) as between-subject factor revealed an interaction, $F(1, 30) = 5.083$, $p < .032$, $\eta_p^2 = .145$, and no main effect.

There was no difference in how long 12-month-olds attended to the two familiarization events between Studies 6 and 7, as revealed by a one-way ANOVA with averages of total looking-time: $F(1, 30) = .069$, $p = .794$, $\eta^2 = .002$.

As predicted, infants did not differentiate between the two test events. The lack of infants' reaction to the change of direction in Study 7 supports our hypothesis that this information may have not been encoded in the representation of the taking-based relation.

5.11 Study 8. Encoding of transfer direction (control)

In Study 8 we tested whether the null results of Study 7, instead of reflecting the representational requirements of the relational frame that taking induced, were due to a particular encoding strategy adopted to determine the direction of transfer at the end of the familiarization. According to this hypothesis, during the observation of the familiarization events infants may have only encoded the respective side where the two different transfer-based interactions took place and used the final position of the apples to determine in which direction the object was transferred within each relation. For instance, had infants represented A and B as standing in a giving interaction (on the left) and later observed that on that side there was an apple next to B, they could have retrospectively assigned B the role of Givee, and, on this basis, inferred that the apple must have been given by A. If infants applied this heuristic also to the taking interaction, however, they would not have been able to determine who was the Taker, since both agents (B and C) had an apple at the end of the familiarization event (B received an apple from A, whereas C took an apple from B). Thus, because of the presence of the two apples next to the two agents, extrapolating the direction of object transfer from exclusive possession relations would not have been possible.

We tested this hypothesis by exposing infants to the familiarization used in Studies 1-3 (common agent) and at test to the same events used in the previous study: a repetition of the taking action vs. its reciprocation. Crucially, the final outcome of the common-agent familiarization showed only one agent participating of the taking interaction (B) close to an apple. Therefore, if the above hypothesis is correct, infants, differently from Study 7, should be able to determine the direction of transfer and consequently detect its reversal at test.

5.11.1 Methods

5.11.1.1 Participants

Sixteen infants participated in the study (6 females; mean age = 359 days; range = 349-367 days). Six additional infants were excluded from the analyses due to inattentiveness (n = 5), and experimental error (n = 1).

5.11.1.2 Stimuli

Infants were presented with the same familiarization used in Study 1 (common-agent), but modified so to match the timing of the events shown in the common-patient familiarization (see General Procedure). Infants were thus shown agent A giving to B (Givee) and taking from C (Takee). At test, infants saw either A taking an apple from C (Repetition event) or C taking an apple from A (Reciprocation event).

5.11.2 Results and Discussion

Infants looked equally to the Reciprocation (M = 13.77, SD = 13.13) and to the Repetition event (M = 11.63, SD = 6.07), $t(15) = .431$, $p = .673$, $r^2 = .010$. The null results rule out the alternative hypothesis described above to account for the findings of Study 7, strengthening our proposal that infants' lack of reaction to the change of transfer direction may be indicative of a social relation where favors need not be equalized, and hence bookkept.

5.12 General Discussion

Across eight studies we showed that 12-month-olds are able to form representations of social relations based on giving and taking actions. These representations included information about: (a) the identity of the participating agents, (b) the type of transferring action, and, specifically for giving actions, (c) the direction of object transfer. Encoding (a) and (b) allowed infants to differentiate and track distinct relational units across time and contexts, whereas (c) additionally supported the detection of changes in the resource flow within a certain relation.

Importantly, infants were able to recognize new instantiations of the assumed relations at test, despite being always presented with role-reversed interactions (Studies 1-2 and 3-4). This suggests that infants' representation of the two transfer-based relations was compatible with the possibility of reciprocation. As Studies 6-7 demonstrated, however, such compatibility was underpinned by different mechanisms for the two transfer types: in taking, reciprocal interactions were consistent with the inferred relation because infants simply did not detect the reversal of action roles (since this information was not part of the representation of the taking-based relation); in giving, on the contrary, test interactions were consistent with the inferred relation because genuinely recognized as reciprocal.

These findings differ markedly from the null results discussed in Chapter III (Studies 5 and 7). In those studies, infants of the same age exposed to two agents differently interacting with a common patient (via giving and via taking) failed to exhibit reciprocity-consistent expectations about the patient's actions (for either action). Importantly, such relational structure was identical to the one adopted in a subset of the current studies (common-patient familiarization: Studies 4-7), albeit with one crucial difference: the interactions did not take place in the same event but across two spatiotemporally separate transfer episodes. The difference in looking behavior between the two sets of studies therefore suggests that providing direct evidence of different social interactions might have been critical to scaffold infants' relational inferences.

5.12.1 The role of contrasting social interactions

Why did such evidence help? For one, the presence of co-occurring interactions might have eased infants from having to memorize and combine two sequentially presented events into a unified (triadic) relational structure. Moreover, by enabling an online comparison of the two interactions, the familiarization stimuli might have induced infants to represent giving and taking in structurally isomorphic terms. Recall that, when presented in isolation, the two actions were interpreted in radically different ways: the former as a transfer-based interaction, the latter as an object-directed action (see Studies 2-4, Chapter III). Here, on the other hand, both actions were represented in a three-argument structure. The spatial juxtaposition of giving and taking seem thus to have produced two effects: (1) it allowed infants to interpret both actions as patient-directed (plausibly through a process of structural alignment: Gentner & Markman, 1997); and, by providing evidence of multiple different and partly overlapping interactions (2), it may have motivated infants to deploy representations functional to segregate these from one another.

With regards to (1), a vast literature inspired to the "structure-mapping theory" suggests that spatially aligning the predicates of two relational items can promote a form of "schema abstraction" – i.e., the extraction of an abstract structural template under which the items can be compared and differentiated (Gentner, 2010). According to Goldwater & Markman (2010), this occurs when the similarity of "role categories" (in our case, action roles) between relational items is made salient – for instance, by providing their respective referents with a common label (Namy & Gentner, 2002) or by making a single referent occupy the same role for both items (as in our familiarization stimuli). Applied to our study, this account suggests that, if giving, which infants interpret obligatorily as a social interaction (Studies 1, 6, and 8; Chapter III), provided the structural template to relate together the event constituents of the taking action (agent, object, patient), the common action role represented the bridging element that induced the mapping of said template from one action on the other (a similar hypothesis can be found in: Christie, 2017).

This two-step hypothesis yields specific and easily testable predictions concerning the condition under which taking should be represented as a social interaction: (a) when contrasted with another interaction involving three event constituents; and (b) when the two interactions share at least one of these elements. The present data do not allow us to conclude which conditions – (a), (b), or both – must obtain for representing taking in patient-directed terms. We don't know in fact whether comparing taking with a social interaction that does not involve objects (e.g., hugging: Gordon, 2003), or presenting non-overlapping giving and taking interactions would have produced the same effects.

5.12.2 The role of transfer acknowledgment

There are two further differences between the familiarization events used in the studies discussed in Chapter III and here. First, since each of the four familiarization events involved both transferring actions, infants received twice as much exposure to giving and taking in comparison to the previous studies. Second, unlike in the previous studies, the patient here did not move prior to the transfer, but only when the object possession changed (i.e., when the Giver relinquished the object and the Taker first contacted it). Specifically, infants would observe the patient turning towards the agent and engaging in mutual eye contact for a brief period. Despite the main rationale for introducing this action was to parse the transfer events while concomitantly providing animacy cues for the (otherwise motionless) patient, this behavior may have been additionally interpreted as a form of minimal "acknowledgment" of the possession transfer. Under this reading, the Takee, by looking at the other agent when the object was about to change possession, signaled her consent to having the object taken away. Had that cue licensed such interpretation, this may have helped infants to distinguish this type of taking from superficially similar cases in which the possessor does not react to the expropriation of her endowments because, for instance, indifferent to their fate – i.e., "a null relation" (Fiske, 1992) in which agents do not coordinate with reference to any shared and binding principle.

Given children's propensity to spontaneously use cues such as mutual gaze to chunk the social space in distinct relational units (Stahl & Feigenson, 2014) and, later on in development, infer friendships (Nurmsoo et al., 2012), it is not far-fetched to hypothesize that infants may have exploited a similar cue to interpret the taking event as an interpersonally coordinated action. Under this interpretation, this cue alone might have sufficed to make infants adopt the same relational template for giving and taking. The spatial alignment of the two interactions would be therefore unnecessary, insofar as the relational meaning of the taking action is not supplied via the structural mapping of one action onto the other, but exclusively via the Takee's behavior.

It should be noted, however, that, despite this account can convincingly dispense of the use of contrastive information in representing taking as a social interaction, it does not so in explaining why these representations supported the detection of reciprocity-consistent outcomes. The reader may recall that giving, which infants in Chapter III represented as a social interaction (i.e., involving a specific recipient) without contrastive information, failed to guide reciprocity-consistent expectations (Studies 5 and 7). This objection vindicates our earlier hypothesis that comparing different social interactions may have been crucial to scaffold relational inferences.

5.12.3 Evaluating the "partner-choice hypothesis"

It is worth emphasizing here that 12-month-olds formed representations of social relations for both types of familiarization structure, i.e., regardless of whether the focal patient participated in only one of these relations (common-agent) or both (common-patient). This observation is critical, inasmuch as it allows us evaluate the merits of the two accounts earlier proposed to explain why contrasted interactions should support relational inferences. According to the "partner-choice hypothesis", infants may first use (and expect others to use) reciprocity as a means of partner selection (cf. Warneken & Tomasello, 2013). Following this hypothesis, infants should be prone to form representations of social relations in situations in which, by reciprocating in kind, an agent can selectively associate with a particular individual among those she had previously interacted with. Studies 4-5 were modelled precisely onto such situation: the common patient was observed interacting with two different agents during familiarization (Giver and Taker) and reciprocating in kind with only one of them at test. However, reciprocity-consistent expectations were also found in Studies 1-2, where the familiarization phase involved a reciprocating patient who had previously interacted with only one of the two other agents. Here infants could not have differently evaluated the two reciprocation targets on the basis of their patient-directed actions (since only one agent actually interacted with the patient), and therefore should have lacked the information necessary to set up expectations about the patient's reciprocating behavior. However, contra the "partner-choice hypothesis", the co-occurrence of the two interactions proved sufficient to make infants detect reciprocity-consistent outcomes, even when no partner selection *sensu stricto* took place.

The generality of these results is more consistent with our second account, according to which infants are motivated to deploy representations of social relations whenever presented with multiple interactions, which, to be efficiently tracked, require to be segregated from one another. This, we argue, should be especially the case when these interactions (a) involve only a subset of the available social actors (i.e., show a high degree of selectivity), and (b) are defined by non-generalizable obligations.

5.12.4 Encoding strategies reflect different coordination rules

It should be reminded that, for infants to be capable of detecting the initiation of new interactions at test (at least in Studies 1-3), they could have conveniently registered the identity of the patient selectively approached by the common agent, without registering the type of action performed (i.e., "A is with B"). Yet, they did encode this additional information. Following the principle of computational efficiency earlier articulated, we suggest that the type of transferring action had been thus encoded for purposes other than to immediately differentiate between the two dyads. Beyond merely mapping selective affiliations (Rhodes et al., 2015), infants' encoding strategies reflected an incipient appreciation of relations governed by different coordination rules.

By specifying which features of a relation are relevant for interpersonal coordination, these rules define what is relevant to be encoded. Consistently with this proposal, Studies 6-7 showed that, despite the structural similarities between giving and taking, only the former afforded the encoding of the direction of object transfer. This particular encoding strategy could not have been induced by differences at the interaction level: both actions in fact required the specification of complementary action roles to be carried out. The reported asymmetry, on the other hand, reveals different assumptions about the long-term patterning of the relation. The evidence that infants registered information functional to the detection of reciprocation for giving, but not for taking, indicates that within-relation changes of resource flow represent an interpersonally relevant feature only in relations elicited by the former transfer type. Only the representation of giving included information exploitable to bookkeep welfare imbalances. This is fully consistent with our original proposal, according to which giving is a cue to EM relations.

The taking action, on the other hand, afforded the representation of the mode of transfer and the identity of the interactants, but not of the direction of transfer. As suggested earlier, this representational content is suggestive of a relation that (a) confers entitlements proxied by the information about the transfer type (which would be otherwise redundant to encode simply to track a dyadic association over time), but (b) lacks a directive standard that regulates the patterning of exchange, which makes integrating information about the transaction history (e.g., direction of transfer) unnecessary. Such relation seems to partially approximate the CS model: *partially* because, while CS defines a relation of generalized exchange in which individuals are both allowed to acquire and proactively offered resources (Fiske, 1992), the relation inferred by the infants in our studies was systematically circumscribed to only one mode of transfer (facilitated taking: see Study 3). For this reason, we characterized this relation as governed by a "need-based appropriation" rule. Such rule would allow individuals to take from others, without expecting active provisioning by the resource possessor. Tellingly, a similar conduit, reported in mother-infant chimpanzee dyads (e.g., Ueno & Matsuzawa, 2004), has been described as a manifestation of CS in the "primate grammar" of relational models (Haslam, 1997).

5.13 Symmetricity and transitivity in different RMs

The studies here described provided initial support to two interrelated hypotheses: (a) infants use transferring actions as cues to specific social relations; and (b) these social relations are consistent with the classification of RMs charted out by Fiske (1992). Consistently with (a), we showed that, upon observing the occurrence of a transfer episode, 12-month-olds spontaneously encoded information that allowed the tracking of transfer-specific associations through time and contexts. Consistently with (b), we further showed that this information was minimally sufficient to detect changes in relational properties relevant to the model assumed.

In formal sociology (Martin, 2009), a relationship akin to the one assumed to underlie the taking-based interaction is considered *symmetrical*, insofar as it did not prompt the encoding of the complementary action roles of its participants, suggesting a lack of need for differentiating their contributions to the relationship itself, whereas the giving-based relation would be considered *asymmetrical*, for the opposite reason. This type of asymmetry is typically contrasted with the *anti- symmetry* of AR-like relations. The difference, in this case, is that in AR relations the asymmetry is taken to be an enduring feature of the relation (i.e., dominants are expected to maintain their status over the subordinates), whereas in EM it represents a transient state of affairs, physiological to the dynamics of reciprocal exchange, and as such expected to be resolved. While we agree that AR and EM should both motivate the encoding of any within-relation asymmetries for fundamentally different reasons, we argue against labeling EM asymmetrical, as this seems to rests on a confusion between relational and interaction level. As a relationship, EM is in fact clearly symmetrical, as it rests on a principle of even balance *in the long run*, despite it is composed of imbalance-producing interactions. For this reason, we prefer to recast the difference between CS and EM as a difference between symmetrical relationships of different kind: one (CS), where the specific roles adopted by its participants at any given time are largely irrelevant for the stability of the relationship, and hence do not need to be encoded and retained; another (EM), where on the other hand such roles proxy the occurrence of imbalances, which, if not addressed, would cause the collapse of the relationship (and hence make their registration relevant). The symmetricity of an EM relation should be thus represented with a *term of difference* which tracks the presence of welfare imbalances, as this is not a property of the participants' common membership (a static relational feature), but the outcome of an exchange dynamics constantly amenable to be exploited.

Symmetricity, however, is not the only property characterizing distinguishing various RMs. Another relevant property is transitivity, which applies not to the relation itself, singly considered, but to the chaining of several relations of the same kind in a larger social structure. Following Fiske (1992), we should predict infants to expect AR and CS, but not EM, relations to be transitive. In the AR case, transitivity is a consequence of assembling dyadic dominance relations in a linear ordinal scale (cf. Mascaro & Csibra, 2012): if A > B, and B > C, it should follow that A > C. In CS, on the other hand, the assumption of transitivity derives from the relation being symmetric and its participants being socially undifferentiated (Fiske, 1992). If A is friend with B, and B with C, we can expect A to be friend with C since A and B are interchangeable. This "weak" type of transitivity (Martin, 2009) explains the phenomenon of triadic closure (Brashears, 2013; Janicik & Larrick, 2005), by which adults tend to misremember partly overlapping dyads as forming a "pure clique", i.e. a subset of individuals each of whom interacts with every other (Homans, 1961) – but, crucially, only when the networks to be memorized were composed of CS-like symmetric relations (e.g., friendships).

Differently from these models, the EM model "suppresses" any type of transitivity. As we said, this is due to the non-transferability of indebtedness relations (Greenberg, 1980): if A owes to B, who owes to C, the fact that A gives to C does not clear off her debts towards B. Consistently with this idea, the adults' tendency to "fill in the blanks" of open triadic relations is strongly inhibited when these are presented as (asymmetric) benefactor-beneficent relations (Freeman, 1992). *Pace* Heider (1958), this suggests that humans use "compression heuristics" (Picek et al., 1975) only when discarding information about the specific ties of a social network in favor of a "summary description" does not compromise the stability of its component relations.

In the case of dominance relations, the predictions of Fiske's model seem convincingly corroborated by the current developmental evidence. 15-month-old infants were able to memorize a dominance relation only when this was part of a social structure compatible with the transitivity principle (because assembled according to a linear ordering: Mascaro & Csibra, 2014). Similarly, when shown three puppets arranged in a physical line (consistent with a linear dominance order) establishing pair-wise dominant-subordinate relations, 10-month-olds readily produced transitive inferences of dominance about the outcome of a contest between the highest and lowest ranking puppets (Gazes et al. 2015).

Relational Model	**Action Cue**	**Symmetricity**	**Transitivity**
CS	Unresisted Taking	Yes	Yes [weak]
AR	Resource Monopolization	No	Yes [strong]
EM	Proactive Giving	Yes [with term of difference]	No

Table 5. The table describes the cues and formal properties associated with each relational model. Grey-colored cells indicate empirically untested predictions.

In the case of EM and CS, however, the predictions of Fiske's model await empirical testing[28]. Our studies can be easily modified to this end. As we discussed, human adults, when asked to memorize open triadic structures composed of two dyadic relations tend to close them by postulating a third, unobserved tie (i.e., if A is linked with B, and B with C, a link between A and C is drawn) – but, crucially, selectively for CS-like symmetric relations. The logic of triadic closure can be easily translated to our study. For instance, we could familiarize infants with A giving to/taking from B, and B to/from C, and at test present them with a familiar interaction (A giving to/taking from B) and a completely new one (A giving to/taking from C). If our hypothesis that giving and unresisted taking cue respectively EM (symmetric with a term of difference, intransitive) and CS (symmetric, transitive: see Table 5) relations is correct, we should expect infants to detect the initiation of the new interaction (A and C) only in the giving triad, in which the production of a transitive relation should be inhibited, but not in the taking triad. Such findings would provide further support to the contention that the relationships cued by these transferring actions closely conform (in terms of formal properties and representational demands) to the CS and AR models.

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[28] A recent study by Spokes & Spelke (2017) showed that 15-to-18-month-olds expected an agent ('child') comforted by another agent ('adult') to affiliate with a child comforted by the same adult rather than with a third child comforted by a different adult, despite neither of these interactions have been witnessed before. In other words, infants inferred affiliation between two individuals who never interacted directly on the basis of their mutual social partner (the same held for two adults comforting the same child: Study 5). Such inference, which was inhibited when physical and vocal cues of parent-child interaction were replaced with cues suggestive of interactions between equal peers (i.e., agents of the same size emitting in reciprocal calling), is intriguingly similar to the type of inference that adults produce when required to memorize incomplete triadic structures composed of symmetrical CS-like interactions.

Chapter VI. Object-encoding study

6.1 Introduction

In the previous chapter we put forth the hypothesis that infants may interpret the occurrence of a giving action as the episodic manifestation of an EM relation. As Fiske (1992) put it, EM relationships are based on the assumption that "each person is entitled to the same amount as each other person in the relationship, and that the direction and magnitude of an imbalance are meaningful". Differently put, welfare imbalances are a socially significant event in EM: the stability of the corresponding relation depends in fact solely on the ability of its participants to pattern the exchange compatibly with the directive standard of even balance.

On these premises, we argued that infants' representations of giving actions should be functionally designed to track welfare imbalances. A host of information can be exploited to this goal. Encoding the direction of object transfer (i.e., who gave to whom), for once, is necessary to detect changes in the resource flow across repeated interactions and therefore recognize when the reciprocation of an altruistic act has occurred. Consistently with this argument, we found that 12-month-old infants encoded the direction of transfer for giving, but not taking, actions (Studies 6 and 7, Chapter V).

The passage by Fiske reported above contains a further suggestion about what type of information can be queried to bookkeep and compare welfare imbalances: the magnitude of the delivered benefits. Despite the hypothesis that giving should induce the encoding of the number of resources transferred (a proxy for the magnitude of benefits) has never been explicitly tested, there is indirect evidence suggesting that this may indeed be the case. As we will see in more details in the next chapter, studies on distributive fairness suggest that infants spontaneously compare the number of resources delivered by a distributor to each of her two recipients (Sloane et al. 2012; Schmidt & Sommerville, 2011). More importantly, infants can also use this information offline to support later social evaluation of distributors who only differed in the partiality of their sharing (Meristo & Surian, 2013; Geraci & Surian, 2011). While we do not know how infants represented about these distributive events (i.e., they may have kept detailed records of the number of resources given to the two recipients or simply compressed this information in the form of evaluative tags: "fair" or "unfair"), these studies nonetheless show that infants can track differences in the number of resources transferred in triadic giving-based interactions, and query this information at later times to support individual-specific expectations.

If the direction and magnitude of delivered benefits are useful information for tracking welfare imbalances, so is the value of the exchanged resource. Keeping the number of resources exchanged constant, goods of higher value would (by definition) yield higher benefits for their possessors. Even strictly reciprocated acts of giving could therefore result in the accumulation of welfare imbalances between the parties, if the goods exchange are of different value. Therefore, we would expect the representation of giving actions to include information about the value of the transferred resources, which could be measured against later reciprocation.

When explicit knowledge of the agents' evaluation of a transferred object is lacking, the object's identity can be used as value proxy. Despite this information alone does not support contentful inferences on the magnitude of benefits that each resource yields, and therefore on their relative ranking, its encoding can nonetheless allow the detection of changes between numerically equivalent exchanges occurring in the same relation (i.e., A gave one X to B, and B subsequently gives one Y to A). Therefore, if the representation of giving actions is indeed designed for the bookkeeping of welfare imbalances, as we surmised, we would expect such representation to include information not only about who gave and how much, but also about what was given.

We tested this hypothesis across three looking-times studies by exploring whether 12-month-olds are able to detect the change of identity of a given object. As in the previous studies, we compared infants' reactions to giving and taking actions, in order to assess the specificity of the predicted effects.

6.2 General Procedure

The studies reported here had the same design structure. Infants were shown four identical familiarization trials followed by two test trials. During the familiarization phase, infants were presented with movies of giving (Study 1) or taking actions (Studies 2 and 3). At test, infants saw one of the familiarization events (Old Test Event) followed by a new movie (New Test Event). This movie showed either the same action as in familiarization but involving a new object (object change: Studies 1 and 2), or a new action involving the same object as in familiarization (action change: Study 3).

6.3 Study 1. Object encoding (giving)

The aim of Study 1 was to test whether infants would detect the change of object identity at test after being familiarized to a giving action.

6.3.1 Methods

6.3.1.1 Participants

Sixteen infants participated in the study (6 females; mean age = 363 days; range = 356-370 days). Four additional infants were excluded from the analyses due to inattentiveness (*n* = 3) and crying during the familiarization (*n* = 1).

6.3.1.2 Stimuli

Familiarization events. The familiarization events started with two female actors (A and B, respectively wearing a purple and a dark-green t-shirt) placed at the opposite ends of a table, equidistantly from an object located at its center. The object consisted either in a striped ball (X) or a plush dog (Y). To avoid that actors may have provided communicative cues, their heads were edited out from the videos.

The familiarization event (4 s total running time) consisted in the following action sequence: A reached for the object, grasped it, put it on the side of the table opposite to hers (right in front of B), and retreated her hand under the table (see Fig. 1). Actor B remained motionless throughout the transfer and never established physical contact with the transferred object. Thus, as in the previous studies, possession relations were defined exclusively in terms of the object's relative proximity to the actors. The movie ended with A and B facing each other, and the object placed next to B. The last frame was kept until infants looked away for 2 s or cumulatively for 60 s from the end of the action. A melody was looped for the whole duration of each familiarization event.

The identity (A vs. B) and side (left vs. right) of the actor transferring the object, and the identity of the transferred object (X vs. Y) were counterbalanced across infants.

Each familiarization event was preceded by an attention-getting animation consisting in a black frame juxtaposed on a grey rectangle. The frame would shake and emit a beeping sound every 0.7 s. The animation was played until the infant looked back at the screen. At the end of the fourth familiarization event, a filler (30 s) was played. This consisted in a series of pulsating and rotating checkered tiles emerging from a black background. The animation was accompanied by a melodic tune.

Test events. The Old Test Event showed the same action presented in familiarization (i.e., A gives X to B). The New test event consisted in a kinematically identical giving action but involving a new object (Y). The timing of the action components was identical in the two videos. The order of test events was counterbalanced across infants. Test events were terminated following the same criteria applied in familiarization.

The same familiarization and test factors were counterbalanced in Studies 1-3.

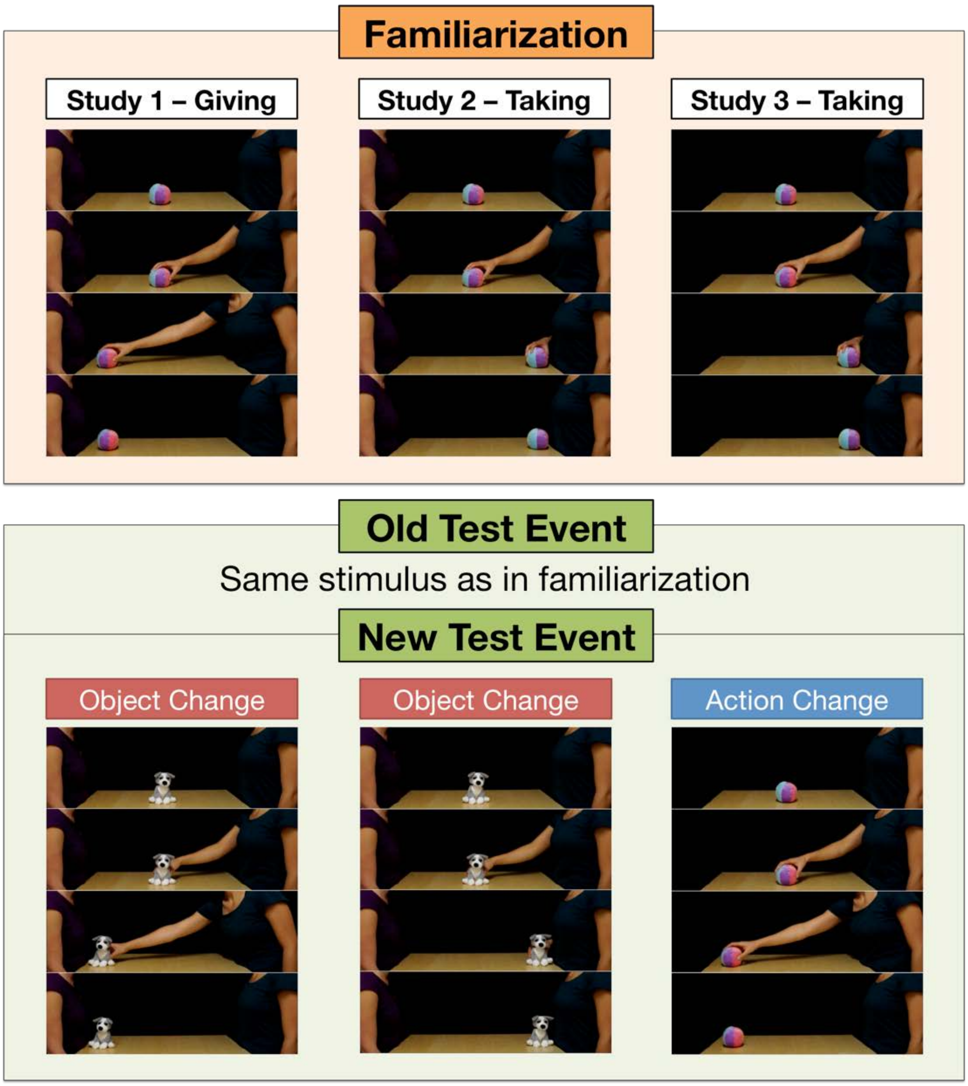

Figure 10. Schematic visualization of the design structure and stimuli material used in Studies 1-3. The screenshots show the essential segments of the action displayed.

6.3.1.3 Coding and Data Analysis

We performed an off-line frame-by-frame analysis of looking behavior. To be included in the final data analysis, infants were required to watch continuously each of the six events for the whole duration of the action (i.e., from the beginning of the movie to when the agent retreated her hand under the table: 3.4 s). Infants who failed to do so were labeled as "inattentive".

LTs in familiarization and test were measured from the end of the action to when the infant looked away from more than 2 s or looked cumulatively more than 60 s. The same coding and rejection criteria were adopted in Studies 1-3.

6.3.2 Results and Discussion

Infants looked significantly longer to the New (M = 21.23, SD = 12.55) than to the Old Test Event (M = 8.76, SD = 5.27), $t(15) = -3.773$, $p = .002$, $r^2 = 0.26$; $p = .001$ by Wilcoxon signed rank test. The effect was clearly visible also at the individual level, with 15/16 infants looking longer to the New test event. There was no effect of test order.

Infants strongly reacted to the change of object identity, thus suggesting that the representation of the giving action formed during familiarization included information about the identity of the transferred object.

6.4 Study 2. Object encoding (taking)

The aim of Study 2 was to ascertain whether the encoding of object features observed in Study 1 was specific to giving actions or would generalize to other transferring actions. To this end, we familiarized infants with taking actions and tested whether they would detect a change in the identity of a taken object.

6.4.1 Methods

6.4.1.1 Participants

Sixteen infants participated in the study (9 females; mean age = 362 days; range = 353-375 days). Four additional infants were excluded from the analyses due to inattentiveness ($n = 3$) and maternal intervention ($n = 1$).

6.4.1.2 Stimuli

The familiarization events were similar to the movies used in Study 1. The only difference was that actor A, after having grasped the object, put it close to the side of the table where she was standing, rather than close to B's. As a consequence of her action, actor A acquired possession of the object.

The familiarization movies of Studies 1 and 2 were equated for number of action segments, action timing, and amount of physical displacement of the object. At test, infants were presented with the same taking action shown in the familiarization (Old Test Event) followed by another taking action involving a new object (New Test Event).

6.4.2 Results and Discussion

Differently from Study 1, infants did not react to the object change, looking equally to the Old (M = 11.75, SD = 8.77) and the New Test Event (M = 11.73, SD = 10.76), $t(15) = .340$, $p = .739$, $r^2 < .001$. There was no effect of test order.

To compare infants' reactions at test between the two studies we ran an ANOVA with Test Type (Old vs. New) as within-subject factor and Study (1 vs. 2) as between-subject factor, which revealed a significant interaction: $F(1,30) = 6.801$, $p = .014$, $\eta_p^2 = .185$ (Figure 11).

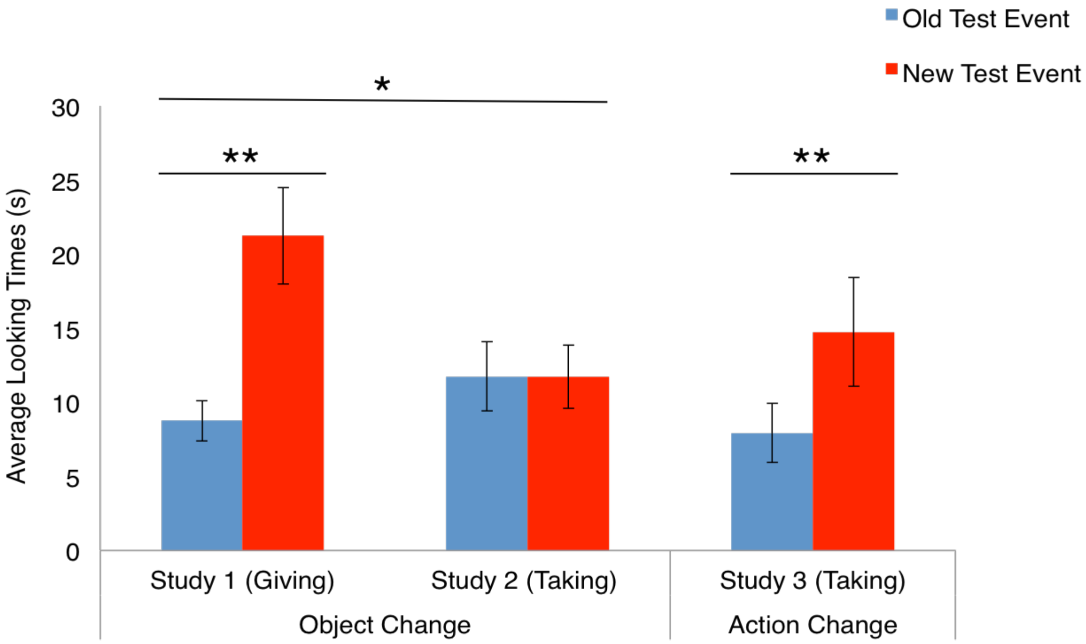

Figure 11. Average looking times during the test trials as a function of conditions in Studies 1-3. Error bars indicate standard errors. Asterisks represent statistically significant differences and interactions (*p < .05; **p < .01).

The different reaction to the object change in Study 2 suggests that the type of transferring action observed critically influenced infants' encoding strategies. Since both giving and taking actions produced a change of possession and the same amount of physical displacement of the transferred object, neither of these factors can account for why infants encoded the object identity in Study 1.

To assess infants' attention during familiarization between Studies 1 and 2, we compared the average LTs to the four familiarization events by means of a one-way ANOVA. The analysis revealed that 12-month-olds looked reliably longer to the familiarization events of Study 1 (M = 13.97, SD = 6.32) than of Study 2 (M = 8.47, SD = 3.65): $t(30) = 2.965$, $p = .006$, $r^2 = .213$.

It is worth clarifying that these results do not reflect differences in infants' attention to the two types of object-transferring actions during their execution: infants had to attend to the four familiarization actions in their entirety for them to be included in the final analysis. Rather, the LT difference refers to the amount of time that infants spent looking at the familiarization events after the action was completed. Despite not predicted, this result is fully compatible with the claim that the observation of giving, but not taking, actions may have induced the encoding of the object features. Under this interpretation, the longer looking at the familiarization events of Study 1 would constitute evidence of the additional computational work required to encode the identity of the given object.

6.5 Study 3. Action encoding (taking)

The findings of Study 1 clearly suggest that infants' representation of the giving action included information about the particular object transferred. It is unclear, on the other hand, whether the lack of reaction to the object change in Study 2 reflected a failure to register the object's features or to represent the goal of the taking action itself. Despite both accounts are fully compatible with the present data, we have reasons to doubt the plausibility of the latter. This in fact implies that infants, who can readily represent the goal of a giving action, at the same time would struggle to represent the goal of a structurally simpler action pertaining to the same domain (i.e., change of object possession).

The primary goal of Study 3 was to disambiguate between these two accounts. To this end, we familiarized a new group of infants with a taking action. At test, we presented the taking action shown during familiarization (Old Test Event) followed by a new action (putting away) involving an identical object (New Test Event). Had infants represented the goal of the taking action, as we suggested, they should react to the change of action in the New Test Event.

Study 3 allows also to clarify the nature of the looking-time difference to the familiarization events found between Studies 1 and 2. We argued that the longer LTs to the familiarization events in Study 1 reflected the additional computational work required to encode the identity of the given object. Thus, according to our proposal, the difference between giving and taking actions is not about whether these are teleologically intelligible or not (we submit that they both are), but whether they are represented as directed to a particular target object or not. However, the looking-time difference found in familiarization might also be interpreted as indicating a failure to represent the goal of the taking action, which would have caused infants to disengage from the familiarization events of Study 2. Under this interpretation, the short LTs in Study 2 would thus be a signature of the infants' inability to establish a teleological representation of the taking action.

These two accounts yield diverging predictions for Study 3. Albeit for different reasons, both accounts predict that infants should attend to the familiarization events as long as they did in Study 2, or comparably so. However, our account predicts that infants at test should also react to the action change, whereas the alternative, which suggests that infants failed to represent the goal of taking actions, predicts that they should not.

6.5.1 Methods

6.5.1.1 Participants

Sixteen infants participated in the study (10 females; mean age = 364 days; range = 353-374 days). Five additional infants were excluded from the final analyses due to experimenter's error (*n* = 2), inattentiveness (*n* = 2), and maternal intervention (*n* = 1).

6.5.1.2 Stimuli

The movies used in the familiarization phase of Study 3 were the same as in Study 2, with only the difference that actor B was edited out from the scene. During test, infants were presented with the taking action shown during familiarization (Old Test Event), followed by a new movie in which actor A placed the object used in familiarization to the opposite side of the table (New Test Event). This 'displacing' action was obtained by editing out actor B from the giving clips used in Study 1. The kinematics of the two actions shown in Study 3 was therefore identical to that of the actions shown in Studies 1 and 2.

The removal of actor B was justified on the grounds that the New Test Event would have otherwise showed a giving action, making the interpretation of the predicted results (i.e., infants looking longer at the New Test Event) ambiguous. Under our account, these results would be evidence that infants detected the change of action, presupposing that they were able to represent the goal of the taking action during familiarization. However, it may be also argued that infants attended longer to the giving action in the New Test Event only because this was the only action of the two that they could represent in goal-directed terms. By removing actor B, therefore, we made sure that the predicted results could not be interpreted as suggested by this alternative account. While the removal of actor B should have compromised the representation of the giving action, it should not have similarly affected the interpretation of the taking action as directed to the goal of object acquisition (cf. 'acquiring': Chapter III, section 3.7).

6.5.2 Results and Discussion

The LT data revealed that infants detected the action change, looking longer to the New (M = 14.83, SD = 14.75) than to the Old Test Event (M = 8.27, SD = 7.93), $t(15) = -3.7872$, $p = .002$, $r^2 = .014$; $p = .004$ by Wilcoxon signed rank test. The effect was visible also at the individual level, with 14/16 infants looking in the predicted direction. An ANOVA conducted in the same way as for the previous studies revealed a significant effect of test order: $F(1, 8) = 5.699$, $p = .032$, $\eta_p^2 = .289$. Exploring the interaction, we found that infants looked significantly longer at the New Test Event when this was presented first, $t(8) = -5.086$, $p = .001$, $r^2 = .14$, but not when it was presented second, $t(8) – 1.383$, $p = .209$, $r^2 = .032$. Given the overall tendency to look longer to the first test event that infants displayed in Study 3, $t(15) = 1.765$, $p = .098$, this bias may explain why infants produced longer looking to the new action only when this appeared first.

We compared infants' looking behavior during familiarization across the three studies by means of a one-way ANOVA (using LT averages), which showed a significant main effect of Study, suggesting that infants attended differently to the three familiarizations: $F(2, 45) = 4869$, $p = .012$, $\eta_p^2 = .42$. Planned comparisons revealed a nearly significant difference between Studies 1 and 3, $t(45) = 1.927$, $p = .060$, but not between Studies 2 and 3, $t(45) = -1.162$, $p = .251$. Infants exposed to taking actions (Studies 2 and 3) therefore tended to look overall less to the familiarization events than the infants exposed to giving actions (Study 1). This evidence, combined with the test results of Study 3, corroborates our interpretation of the LT difference to the familiarization events of Studies 1 and 2: the shorter looking to the taking action, rather than indicating lack of action understanding, may have reflected the lower computational work required to represent the action's goal without encoding its target object.

Nonetheless, the results of Study 3 remain open to a further interpretation, which, unlike our account, does not posit goal attribution. Because of the removal of actor B, the outcome of two test events of Study 3 differed in terms of the stimuli spatial distribution. While in the Old Test Event both object and actor clustered on the right side of the screen, in the New Test Event they were placed on the opposite sides. Because of this, the New Test Event could have elicited more gaze shifts (from the actor to the object) than the other event, potentially producing longer LTs.

Future studies should be designed to explicitly rule out this possibility, for example, by replacing actor B with an inanimate object. This would control for the effect of spatial clustering in the test movies, while also providing strengthening evidence that the encoding of the object features found in Study 1 was specifically due to the social effects of the action observed. If this were the case, this would provide convincing evidence that infants spontaneously adopt spatial heuristics to ascribe possession relations even for interactions involving familiar agents (humans) which, being devoid of any receptive behavior, diverge substantially from the richly communicative give-and-take dynamics that infants themselves are routinely exposed to (Hay, 1979).

6.6 General Discussion

Across three studies we showed that 12-month-old infants detected the change of identity of an object targeted by giving, but not taking, actions. These results are fully consistent with the hypothesis articulated in the previous chapter. If giving is a cue of EM relations, its representation should contain information functional to the tracking of welfare imbalances within the inferred relation. There is a host of information available in a giving action that could fulfills this tracking function: (a) the direction of resource transfer (who gave to whom); (b) the number of resources transferred (how much it was given); and (c) the type of resource transferred (what was given). Together with the set of studies reported in the previous chapter, we provided evidence that (a) and (c) are part and parcel of infants' representation of giving actions.

These findings have broader implications for the literature on goal attribution. A wealth of developmental studies using the influential Woodward paradigm has shown that young infants exposed to an agent repeatedly acting on one of two available objects, look longer when, reversed the location of the two objects, the agent is shown acting on the previously un-chosen object (Luo, 2011; Luo & Baillargeon, 2005; Woodward, 1998). Crucially, however, no longer looking to the change of target object is found when there is only a single available object that the agent can act on during familiarization (Luo & Baillargeon, 2007; Biro, Verschoor & Coenen, 2011). Differently from these null results, Study 1 showed that infants presented with a giving action targeting a single available object looked longer when presented with a new target object. Absent any outcome selectivity information, infants nonetheless encoded the featural information of a target object. On the other hand, the infants in Study 2, just as those in a single-target Woodward condition, did not react to the change of object identity. The difference in infants' reaction between Studies 1 and 2, suggests that the encoding of object features crucially depends on the type of object-directed action observed.

It should be noted here that we did not interpret the null results of Study 2 as indicating a lack of action understanding. Rather, we argued that the difference between Studies 1 and 2 concerned the different 'grain' of the goal representations that the observation of giving and taking actions respectively induced: the former, circumscribed to a specific target object ('A has the goal to give X to B'); the latter, specifying more generically the outcome that the action is typically directed at ('A has the goal to take Z', where Z stands for any object amenable to be acquired).

Consistently with this proposal, Study 3 showed that infants did set up a representation of a taking action that allowed to distinguish it from other object-displacing actions. While this may not constitute fool-proof evidence of goal ascription, it shows nonetheless that certain components of the taking action were indeed registered.

Going back to the literature above cited, our interpretation of Study 2 cast serious doubts on the idea of interpreting the Woodward paradigm as a diagnostic tool of goal attribution per se. Unlike Hernik & Southgate (2012), we argued that the lack of reaction to the target change need not reflect necessarily a lack of action understanding (see also: Kuhlmeier & Robson, 2012). If positive evidence of target encoding constitutes conclusive evidence of goal attribution, the same logic fails to apply to null results. Goal-directed actions can in fact be represented under different levels of description (Csibra, 2008b), which may vary with respect to the number of elements that are expected to fulfill the conditions for goal achievement.

In sum, our studies showed that, in absence of contextual factors known to induce target encoding, certain actions may afford registering the surface features of a manipulandum due to its perceived social significance.

A caveat is due here. Our findings support the hypothesis that giving affords the encoding of a target object, but do not provide evidence that this effect is specific to this particular action. Differently from the previous studies, the giving and taking actions used here could not be interpreted as two distinct types of transfer-based interactions. If the giving action produced a change of possession from one actor (A, who momentarily acquired possession of the object during the transfer) to another (B), the taking action did not (since actor B was never in possession of the object acquired by A). In other words, the taking action – similarly to the “acquiring” action presented in Chapter III (3.7) – was constitutively non-social.

Because of this difference, we do not know at the present moment whether the encoding of the target features was selectively induced by the giving action due to the relational frame that it should have primed (EM), or merely because this, unlike taking, could be interpreted as a form of social interaction. To disentangle between these competing accounts, future studies ought to explore whether infants would spontaneously adopt the encoding strategy used in Study 1 also when presented with taking actions producing a change of possession from one agent (Takee) to the other (Taker), and thus amenable to be construed in social terms.

Chapter VII. Distributive fairness study

7.1 Introduction

Our investigation in the previous chapters unfolded through progressively broader levels of analysis. Starting at the action level, chapters III and IV showed that infants possess a conceptual repertoire of distinct transferring actions, equipped with their own assumptions of teleological well-formedness. Moving to the relational level, chapter V and VI revealed that infants can use these action concepts to track and distinguish among different social relations based on resource transfer. In chapter VII, we finally approach the normative level to investigate what type of expectations about resource distribution these actions afford.

A number of developmental studies showed that, during the second year of life, infants (a) expect resources to be allocated equally between two recipients (Schmidt & Sommerville, 2011; Sloane et al., 2012; Sommerville et al., 2012; Meristo, Strid, & Surian, 2015), (b) prefer equal over unequal distributors (Geraci & Surian, 2011), and (c) expect third parties to reward or affiliate with equal distributors (Meristo & Surian, 2013; Geraci & Surian, 2011). In other words, infants not only have expectations about how goods should be distributed, but also appear to socially evaluate agents on the basis of their allocation decisions. Crucially, similar results have been found with different stimuli material – spanning different types of goods (crackers, milk, toys), agents (human and animated objects), resource amount (distribution of 2 vs. 4 items), and ratios of inequality (2/0 vs. 3/1) – providence evidence for the abstract nature of these expectations (Sommerville et al., 2012).

In spite of such variability, all these studies featured the very same type of interaction, consisting of a third party distributing resources to two recipients. Core characteristics of this interaction are: its triadic nature ('A is related to B and C': see Martin, 2009); the use of giving as transfer means; the role of the third party both as resource provider and distributor; and the complete relinquishment of the distributor's possession to the two recipients. The co-occurrence of all these factors across studies makes it difficult to draw conclusions about the range of interactions in which infants would display such expectations, and what do they reflect.

On one hand, these expectations may reflect a general tendency to assume that agents sharing resources have equal material entitlements over them (see Studies 1-3, Appendix). Under such reading, the third-party distribution would represent just one of the several scenarios involving resource sharing to which infants apply the directive standard of equality (van Dijk et al., 2010). On the other hand, the expectation of equal division may be a specific signature of third-party distributions, thus suggesting that these events prime interactions soliciting the adoption of equality as reference norm.

In Chapter V we advanced the hypothesis that giving is a cue to EM relations to derive predictions about the type of information that infants should encode to bookkeep the exchange history of two interactants. In that context, the EM frame regulated the long-term patterning of a social relation (by stipulating that favors should be balanced out in the long run). In the context of single distributive acts, on the other hand, the EM frame applies to the specific allocation outcome realized (by stipulating that shares should be matched across participants). Depending on the timeframe adopted, the normative yardstick of equality-matching can therefore support assumptions about the 'shape' of long-term interactions (Hinde, 1976a) or the outcome of isolated distributive episodes.

If the EM frame affected the way infants construed representations of social relations, as we showed in Chapter V, it should similarly affect their expectations about single distributive events. On these premises, we should expect infants' reaction to unequal allocations to be restricted to divisions involving actions priming an EM frame (giving). To test this prediction, we present three studies where we assessed infants' reactions to unequal outcomes brought about via different allocation procedures[29].

7.2 General Procedure

The three reported studies share the same design structure. Infants were presented with one video showing three female actors sitting around a rectangular table: a distributor (A), and two recipients (B and C). In all the three studies A brought four cookies to be divided between B and C. The division was then performed either by A (third-party distribution: Study 1), B and C simultaneously (via taking: Study 2), or B (second-party distribution). Crucially, infants could see who was performing the distribution but not the division itself. At test, the allocation outcome was revealed as consisting in either an equal (2/2) or an unequal (1/3) division. A short attention-grabber (0.5 s) was played before the Equal and Unequal test event.

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[29] Before proceeding further, a methodological note is due here. In the studies reported in the previous chapters we treated LTs as a measure of the match between the content of a mental representation set up during familiarization and the events displayed at test, eschewing whenever possible the often-misused folk notion of 'expectation'. In this chapter, on the other hand, we resume the use of such notion, because warranted by the studies design. In fact, unlike in all the previous studies, the test events used here represented the continuation of an ongoing interaction, and thus genuinely novel states of affairs. Any reaction to these outcomes therefore could have exclusively reflected infants' expectations, as intuitively interpreted: i.e., as reality-monitoring epistemic states based on the prospective development of present or future events.

7.3 Study 1. Third-party distribution

The goal of Study 1 was to investigate whether infants would show expectations of distributional fairness for third-party distributive events, as the literature previously reviewed suggests. The stimuli materials used in Study 1 were closely modeled after Schmidt & Sommerville (2011), one of the first studies to report infants' reaction to unequal allocations. Following that study, we tested infants from two age groups (12- and 15-month-olds) to explore developmental effects in their sensitivity to allocation outcomes.

7.3.1 Methods

7.3.1.1 Participants

Two separate groups of sixteen 12-month-old (10 females; mean age = 361; age range = 341-372) and 15-month-old infants (9 females; mean age = 465; age range = 460-479) participated in the study. In the group of 12-month-olds, four additional infants were excluded from the analyses due to inattentiveness (*n* = 2) and experimenter's error (*n* = 2). In the group of 15-month-olds, three were excluded due to inattentiveness (*n* = 2) and technical failure (*n* = 1).

7.3.1.2 Stimuli

Infants were presented with a video (22 s total running time) showing three female actors sitting around a rectangular table covered with a beige cloth. One actor (A, wearing a grey sweater) was sitting on the side of the table facing the infants, whereas the two others (B and C, wearing a red and a green t-shirt, respectively) occupied the two lateral sides, oriented sideways to the infants. Two plates were placed next to B and C (Figure 12).

Pre-allocation phase. The video started by showing B and C waving their right hands, smiling, and saying "Hello!" (in Hungarian: "Szia!") to each other. Afterwards, A put a white tray on the table with four cookies on it, and retreated her hands back under the table. B and C quickly turned their heads towards the tray and uttered with a surprised voice "Oh, cookies! I love cookies!" (in Hungarian: "Süti! Szeretem a sütit!"). While keeping their eyes on the tray, B and C grabbed their respective plates and place them close to the tray. This first sequence of events (14.5 s) was identical to all the three studies reported.

Allocation phase. As soon as B and C retreated their hands from the plates and put them under the table, A reached for the cookies and started to distribute them between the two plates. Before the cookies were reached, a black screen appeared. The screen was large enough to occlude tray and plates but it nonetheless allowed infants to see A's movements (consisting in two exaggerated putting actions) as she was dividing the cookies. During the division, B and C kept looking at the location occluded by the black screen. The whole sequence lasted 5.5 s. Once the division was over, A put her hand back under the table. The last frame showed the three actors staring motionless at the location occupied by the black screen. This frame was kept for an additional 4.5 s. The total length of the trial was 27 s. Two short sounds were played during the movie: one when A placed the tray on the table, and another when the plates were put down next to the tray.

The location of B and C and the plate which A put the cookies in first (left vs. right) were counterbalanced across infants.

Test phase. The test phase started by showing the three actors looking at the black screen, just as at the end of the allocation phase. After a 0.2 s pause, B and C reached for their plates behind the screen, grabbed them, and placed them in front of themselves. B and C always looked at their plates while these were being displaced. As soon as the plates were taken back, the screen was removed, revealing the empty tray. Depending on how A divided the cookies, the two plates would either contain two cookies each (Equal test event), or three and one (Unequal test event). Infants were presented to these two events sequentially. The same sound used in the previous phase to mark the placement of the plates next to the tray was also played when the actors put their plates back in front of them.

The test events were identical to the three studies reported. The order of test events (Equal first vs. second) and the identity of the advantaged actor (B vs. C) were fully counterbalanced across infants.

All the actions executed by B and C, including their utterances, were synchronously performed to strengthen the perception of the two actors as of similar status. To avoid that infants might have inferred privileged social relations between A and one of the two recipients through mutual-gaze cues (Numrsoo et al., 2012), A kept gazing down to the table throughout the movies.

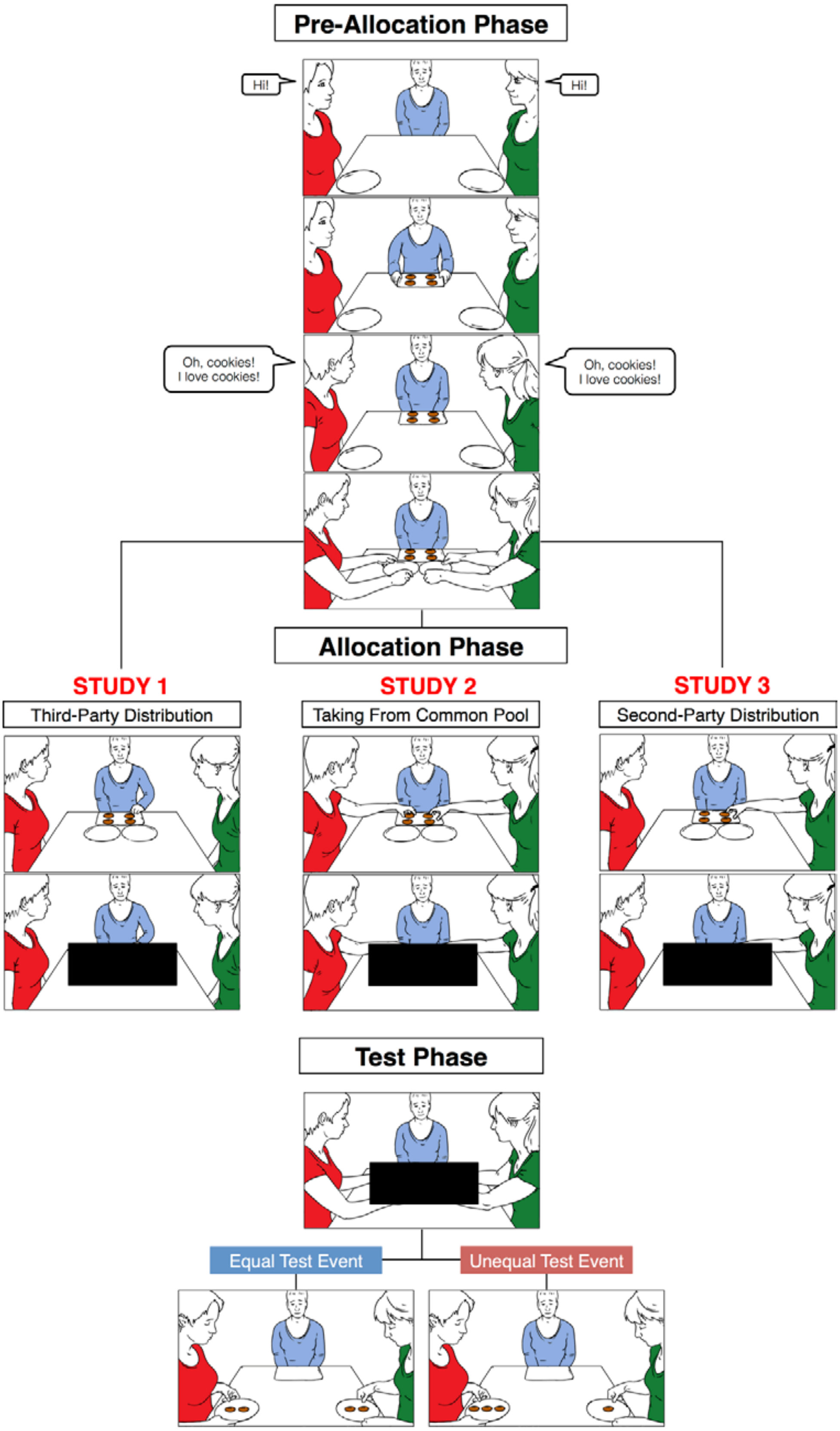

Figure 12. Schematic visualization of the events shown in Studies 1-3.

7.3.1.3 Coding and Data Analysis

We performed an off-line frame-by-frame analysis of looking behaviour. In order to be included in the final data analysis, infants were required to watch the pre-allocation phase for at least 50% of its duration (7.25 s), and continuously throughout the allocation and test phase. Infants who did not meet these requirements were labelled as “inattentive”. LTs at test were measured from when the actors took their plates back to when the infant looked away from more than 2 s or looked cumulatively more than 60 s. The same coding and rejection criteria were adopted in Studies 1-3.

No effect of test order was found in any of the studies reported.

7.3.2 Results and Discussion

15-month-old infants looked longer to the Unequal (M = 29.21; SD = 13.14) than to the Equal test event (M = 22.48; SD = 15.78), $t(15) = -2.617$; $p = .019$, $r^2 = .051$. In contrast, 12-month-olds did not (Unequal test event: M = 16.69; SD = 14.05; Unequal: M = 16.35; SD = 12.41), $t(15) = -.171$; $p = .867$ (Figure 13). There was no difference in how long the two age groups attended to the events before test (15-month-olds: M = 25.62, SD = 1.05; 12-month-olds: M = 25.12, SD = 1.45; $F(30) = 1.301$, $p = .263$.

The results closely replicated the age difference found by Schmidt & Sommerville (2011): 15-, but not 12-month-old infants, looked longer to the unequal allocation. As the familiarization LT data shows, the difference between age groups cannot be explained in terms of attentional differences to the distributive event.

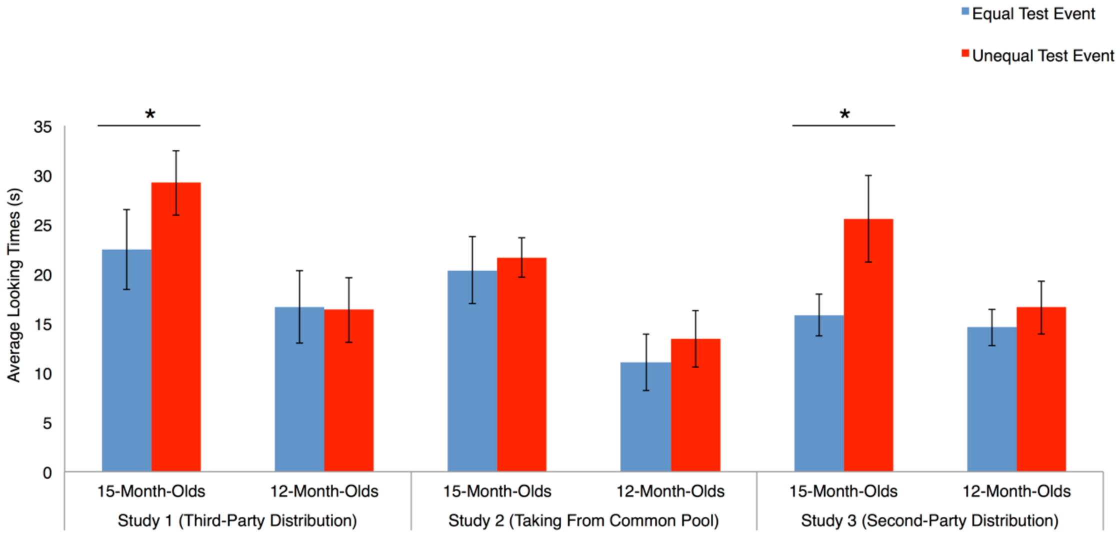

Figure 13. Average looking times during the test trials (by age groups) in Studies 1-3. Error bars indicate standard errors. Asterisks represent statistically significant differences (*p < .05).

7.4 Study 2. Taking from common pool

In Study 2 we sought to test whether infants would form similar expectations of equal resource division also for different allocation procedures, such as taking from a common pool (in this case, A's tray).

7.4.1 Methods

7.4.1.1 Participants

Two separate groups of sixteen 12-month-old (8 females; mean age = 362; age range = 344-373) and 15-month-old infants (8 females; mean age = 466; age range = 455-476) participated in the study. In the group of 12-month-olds, three additional infants were excluded from the analysis due to inattentiveness (n = 1), crying during test (n = 1), and maternal intervention (n = 1). In the group of 15-month-olds, three additional infants were excluded due to inattentiveness (n = 3).

7.4.1.2 Stimuli

The only difference from Study 1 consisted in the allocation phase: after B and C put the plates next to the tray, they started dividing the cookies themselves by putting them onto their plates. Infants could only see the arms of B and C moving (twice) from the location of the tray to that of the plate. At the end of the division, the two agents retreated their hands below the table, while still gazing at the black screen. As in Study 1, the movements of B and C were executed synchronously. The allocation phase lasted 5.5 s.

7.4.2 Results and Discussion

Differently from Study 1, 15-month-olds did not look longer to the Unequal (M = 21.70; SD = 11.71) than to the Equal test event (M = 20.37; SD = 13.46), $t(15) = -.520$; $p = .611$. The same looking pattern held for 12-month-olds (Equal: M = 11.07; SD = 10.98; Unequal: M = 13.43; SD = 11.07), $t(15) = -.903$; $p = .381$.

There was no difference in how long the two age groups attended to the events before test (15-month-olds: M = 24.89, SD = 1.35; 12-month-olds: M = 25.25, SD = 1.30; $F(30) = .569$, $p = .465$. Moreover, there was no difference in how long the two age groups attended to the familiarization events between Studies 1 and 2 (15-month-olds: $F(30) = 2.955$, $p = .296$; 12-month-olds: $F(30) = .077$, $p = .783$).

Unlike Study 1, infants of either age groups did not react to the unequal allocation outcome. These results cannot be accounted for by attentional differences to the familiarization, or by differences in the type of communicative interaction preceding the allocation phase. These findings also indirectly confirmed that infants, despite the presence of a large occluder, were able to distinguish which agents were involved in the distribution in Studies 1 and 2. Furthermore, they provided indirect evidence that infants' reaction to the test outcomes of Study 1 did not reflect a mere perceptual preference for symmetric displays, which should have otherwise emerged also in Study 2.

The difference between studies suggests that the type of allocation procedure adopted was crucial in influencing infants' expectations of equal division. However, given the presence of other differences between the two studies, it remains to be understood which characteristics of the two procedures were responsible for eliciting these expectations.

7.5 Study 3. Second-party distribution

In light of the findings of chapter V, it may be tempting to conclude that the difference between Studies 1 and 2 was ultimately due to the type of relational frame that the different modes of transfer (giving vs. taking) primed. However, several other dimensions distinguished the third-party distributive event from the allocation procedure used in Study 2 (Table 6). Two key characteristics unique to the distributive action displayed in Study 1 are the triadic nature of the interaction and A's role both as resource provider and distributor. To investigate whether infants' expectations of equal allocations were induced by the type of transfer means adopted (giving) or, specifically, by the two other features of the interaction above described, we assessed infants' sensitivity to unequal divisions in the context of distributive events which, despite involving giving, consisted in a *dyadic* interaction between B and C with no involvement of the resource provider (A) in the distribution.

	Type of Action	**Interaction**	**A's Role**
Study 1	Giving	Triadic	Provider and Distributor
Study 2	Taking	?	Provider
Study 3	Giving	Dyadic	Provider

Table 6. The table lists all the relevant factors of the distributive events varying between studies. The question mark indicates ambiguity concerning whether infants perceived the actions of the two Takers in Study 2 as part of a dyadic interaction (hence, mutually coordinated) or not.

7.5.1 Methods

7.5.1.1 Participants

Two separate groups of sixteen 12-month-old (10 females; mean age = 355; age range = 349-369) and 15-month-old infants (6 females; mean age = 462; age range = 450-476) participated in the study. In the group of 12-month-olds, three additional infants were excluded from the analysis due to inattentiveness (n = 2), and crying during test (n = 1). In the group of 15-month-olds, four additional infants were excluded due to inattentiveness (n = 2), experimenter's error (n = 1), and maternal intervention (n = 1).

7.5.1.2 Stimuli

In the allocation phase, after B and C put their plates next to the tray, B started dividing the cookies between herself and the other actor. The infants could only see B performing two arm movements, first from the tray to B's plate, then from the tray to C's plate. At the end of the division, B retreated her hand under the table. The allocation phase lasted 5.5 s. The agent performing the division (B vs. C) and the plate to which the distributor first moved her arm (B's vs. C's) were counterbalanced across infants.

7.5.2 Results and Discussion

Similar to Study 1, 15-month-olds looked reliably longer to the Unequal (M = 25.57; SD = 18.44) than to the Equal test event (M = 15.84; SD = 8.87), $t(15) = -2.731$; $p = .015$, $r^2 = .101$; $p = .026$ by Wilcoxon signed ranks test. On the other hand, 12-month-olds looked equally to the two test events (Equal: M =14.60; SD = 8.03; Unequal: M = 16.62; SD = 10.49), $t(15) = -.347$; $p = .734$). There was no difference in how long the two age groups attended to the events before test (15-month-olds: M = 25.32, SD = 1.50; 12-month-olds: M = 25.58, SD = 1.34; $F(30) = .249$, $p = .621$.

An ANOVA with test type (Equal vs. Unequal) as within-subject variable and Study (1 vs. 3) as between-subject factor in the 15-month age group revealed a main effect, but no interaction: $F(1,30) = 6.801$, $p = .014$, $\eta_p^2 = .185$

As in Study 1, 15-, but not 12-month-olds, reacted to occurrence of an unequal split. The similarity of reactions between Studies 1 and 3 suggests that neither (a) the triadic nature of the interaction nor (b) the role overlap of distributor and resource provider were critical to induce expectations of distributive fairness, thus strengthening the possibility that the difference found between Study 1 and 3 was due to the type of mode of transfer displayed.

Nevertheless, a note of caution is necessary. Studies 1 and 3 differed from Study 2 not only in the type of mode of transfer used but also the number of actors simultaneously involved in the allocation (one in Studies 1 and 3, two in Study 2). The null results of Study 2 may thus also suggest that infants had difficulties to monitor two actions being performed at the same time (regardless of their type). This would account for the results obtained without the need of postulating distinct relational models cued by different transferring actions. While the present data do not allow us to exclude such possibility, recent (unpublished) findings suggest that the particular mode of transfer used matters in inducing fairness expectations: 14-month-olds presented with an actor taking from two puppets – i.e., a third-party distributive event involving only one agent – did not look longer to unequal allocations (Baillargeon, personal communication; see also the null results of Studies 1-2 in the Appendix, which featured dyadic taking-based interactions where the resource-allocating actions took place *sequentially*, not simultaneously).

Caution must be exercised also concerning the comparison between Study 1 and 3. While the findings from these two studies show that infants expect equal allocations for giving-based distributions, regardless of whether these involve two or three agents, we do not know whether the presence of the resource provider mattered for supporting these expectations in Study 3. Despite not being directly involved in the distribution, A, by being present, may have nonetheless fulfilled an implicitly enforcing role, making infants expect that the allocating actor would comply to the equality norm upheld by the resource provider. Alternatively, the fact that actor A was the first possessor of the goods, and not the allocating agent, may have mitigated the perception of resource entitlement that possession induces. Directly bearing on this hypothesis, a well-known finding in the literature on dictator games is that designating the dictator as possessor of the endowment leads to a striking reduction of the dictators' tendency to produce even split (Cherry et al., 2002; Corrigan & Rousu, 2006). It is thus conceivable that highlighting that the allocating actor (B) was the possessor of the cookies could have reduced the expectations that she would have produced an equal division. It should be noted, however, that both accounts assume mental phenomena that have not been empirically described yet in infancy: the former, an understanding of tacit compliance; the latter, the ability to represent ownership, i.e., an agent-object relation that survives to local changes of possession (Friedman, Deyfeter, & Neary, 2013).

Lastly, it is worth emphasizing that infants in Study 3 were presented only with unequal divisions advantaging the allocating actor. The alternative scenario (disadvantageous inequality), despite representing also a deviation from the standard of even split, seems to constitute a case of supererogatory behavior (i.e., an action going beyond the call of duty: Chisholm, 1963), rather than a norm violation *sensu stricto*. If infants' expectations concerned normatively relevant standards of resource distribution rather than mere outcome regularities (e.g., Meristo & Surian, 2013), infants should react less, or not at all, to recipient-advantageous divisions. This issue will be explicitly explored in forthcoming studies.

7.6 General Discussion

Across three studies, we showed that infants' expectations of distributional fairness are critically influenced by the type of transferring action used: infants expected distributions to result in equal allocations t when realized via third- and second-party giving, but not via taking. Consistently with previous research (Schmidt & Sommerville, 2011; Sommerville et al., 2013), a developmental gap was observed, with such expectations being present in 15-month-olds, but not in younger infants.

Following the theoretical lead of chapter V, we interpret these results as evidence that different transferring actions may be a cue to social relations governed by different directive standards. The observation of giving (in Studies 1 and 3), we surmised, induced the adoption of an EM frame and consequently the expectation of equal allocation. The equality norm was however differently instantiated in the two studies. In Study 3 this norm governed the relation between the endowments of distributor and recipient: the benefits delivered to C should match those that B provided to herself. In Study 1, on the other hand, the equality norm applied to the relative amount of resources that the distributor provided to the two recipients (but not to the amount she kept for herself[30]). The findings that infants flexibly shifted the locus of welfare comparison to evaluate the equality of a distributive action suggests that expectations of distributive fairness cannot be reduced to rigid heuristics such as "resources should be equally divided among the interacting agents". Neither of the test events of Study 1, in fact, would have

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[30] It is not clear however how the directive standard of EM relations may apply to triadic arrangements. Had infants interpreted the third-party distribution as combining two EM relations having one individual in common (resource provider), they should have expected equality to occur not between the two recipients (B = C), which would not share any relation in this triadic arrangement, but between the resource provider and each of the recipients (A = B; A = C). Indeed, because of this interpretive difficulty, we first hypothesized that infants' longer LTs to the Unequal Test Event would not necessarily indicate the detection of a sociomoral violation (since there is no relational template which may feasibly capture this triadic arrangement), but rather the learning of previously unknown relationships. In other words, a biased distribution would reveal a privileged social bond (i.e., friendship) between the distributor and the favored agent, which infants did not know about (for evidence of partial resource sharing as cue to friendship in children, see: Lieberman & Shaw, 2017). However, this interpretation cannot be easily accommodated with either the literature on the sociomoral evaluation of distributors earlier reviewed (e.g., Geraci & Surian, 2011), since learning about particular relationships would not scaffold this type of evaluation (especially from the perspective of uninvolved third parties), or our own studies. Recall in fact that infants in Study 3 looked longer at the Unequal Test Event despite the structure of the interaction (i.e., second-party distribution) did not allow for any comparison between putative recipients, and thus could not have possibly "uncovered" previously unknown dyadic associations.

satisfied this rule of thumb, given that the distributor, differently from the recipients, was left with no resources as a consequence of her actions.

Concerning the interpretation of the taking event (Study 2), the null results are compatible with several competing readings. On one hand, infants may have represented the two taking actions as independently aimed at the goal of resource acquisition: in other words, infants may have not perceived any inter-dependency between the actors' behaviors. On the other, infants may have been prompted by the coordinated aspect of the two taking actions to assume that any of the outcomes produced by the resource division was the result of an agreed-upon negotiation. Lastly, infants may have represented the interaction as the instantiation of a CS relation. Under this interpretation, the lack of reactions to different allocation outcomes was not justified by the concerted aspect of the allocation, but by the adoption of a relational frame in which welfare imbalances have no sociomoral significance. The present results do not allow us to disentangle between these accounts. It would be relevant to explore under which conditions taking actions become represented as components of a social interaction – an issue that bears directly on the difference in infants' interpretation of taking events that we observed in the studies discussed in Chapter III and V.

Despite our emphasis on the allocation procedure, we do not intend to underplay the role of the interaction preceding it – in particular, the affiliative hand-waving and the expression of mutual interest in the revealed goods. The existing literature on this topic suggests that these cues of affiliation and desire are not necessary to induce expectations of equal allocation – at least in the context of third-party distributions (as in Study 1): infants presented with limbless geometrical agents distributing objects between two passive recipients spontaneously produce social evaluations of the distributors on the basis of their allocation decisions (Meristo & Surian, 2013; Geraci & Surian, 2011).

Whether the same argument can be applied to second-party distributions, it is early to say. The expression of mutual interest in Study 3, for example, could have been crucial to license the interpretation that the allocating actor should have divided the resources equally. The desire vocalized by the social partner may have constituted a demand influencing the distributive options of the actor who committed herself in the allocation. Under this reading, the equality assumption was thus supplied *exogenously* – that is, by factors external to the allocation, such as the similarity of needs of the involved parties. This hypothesis could be straightforwardly tested by assessing infants' reaction to unequal allocations (produced by second-party distributions) in absence of the above cues. If equality expectations would not be elicited in absence of these cues, such evidence would delimit the scope of our hypothesis that this mode of transfer is a sufficient cue to EM relations, thus cautioning generalizations across situations that differ in aspects other than the type of transfer means adopted.

Chapter VIII. Conclusions

The research presented in this dissertation was based on the general thesis that humans have a universal and early-developing tendency to infer the existence of relationships based on different relational models from different types of sharing-based interactions. A more circumscribed application of this thesis concerned the hypothesis that giving may represent a cue of EM relationships. This hypothesis was developed through two arguments. First, we showed with the help of the comparative literature that humans are the only primate species in which active sharing regularly occurs among nonkin individuals. Second, we argued that, compared to other evolutionary models of sharing, reciprocal altruism was the model best suited to explain all the design features of giving. On these premises, we put forth an evolutionary conjecture according to which giving has been pressed into service in the domain of nonkin interactions to initiate and maintain relationships based on asynchronous and reciprocal resource exchange. If such giving-based relationships represented a recurrent feature of our ancestral social ecology, we reasoned, the human cognitive system should bear signature of this functional relation between giving actions and reciprocally patterned (EM) relationships in the form of a diagnostic dependency between these two terms. In other words, natural selection should have equipped the human mind with an evolved prior to interpret the occurrence of a giving as the episodic manifestation of an EM relation.

To explore this conjecture, we proceeded in two steps, first exploring whether infants understand interactions based on active transfer, and later investigating whether the representation of the relationship they set up by observing these interactions is functionally suited to track socially meaningful features of EM-like relationships, such as welfare imbalances. In Chapter III we presented findings supporting the hypothesis that infants are equipped with a giving action schema, which allows them to readily integrate the event constituents of a giving episode (Giver, Givee, and object) in a coherent representational structure. We demonstrated that the activation of such schema relies on a minimal set of input conditions, which we maintained to be necessary and sufficient criteria for its deployment. To provide a direct and stringent test for this sufficiency thesis, in Chapter IV we showed that, provided that (a) an agent is causally responsible for the displacement of an object, and (b) a recipient becomes possessor of the displaced object, infants are compelled to ascribe to the Displacer the goal of giving, even when the displacement could be readily explained away as side effect of the agent's pursuit of a different goal (i.e., approaching of another previously sought object). Crucially, despite we predicted that the activation of the giving schema should have led infants to entertain both outcomes (i.e., the displacement of the first object and the approach of the second) as equally plausible goal states, infants systematically expected the first outcome to be produced. To explain these results, we suggested that infants may have privileged giving as goal hypothesis because of its inferred utility (providing higher net benefits for the agent). Given the immediate costliness of giving, however, these benefits necessarily consist in non-local gains, which we hypothesized to accrue to the Giver in the form of later reciprocation by the beneficiary.

This conjecture set the stage for the studies discussed in Chapters V and VI, where the hypothesis that giving may presuppose prime a reciprocally patterned relationship was (indirectly) explored by investigating which type of information infants registered in the representation of said relationship. If giving is a diagnostic cue of EM-like relationships, we reasoned, it should prompt infants to spontaneously encode information functional to the tracking of welfare imbalances, which are socially meaningful properties of a relationship (such as EM) based on even balance. The types of bookkeeping-relevant information we focused on here were: (a) the direction of transfer, and (b) the identity of the transferred object, which allow to keep track of who benefited whom and of what, respectively. Corroborating our hypothesis, we found that, even though infants were similarly prone to form representations of relationships based on giving and taking actions, only in the former case they spontaneously integrated bookkeeping-relevant information within these representations.

Finally, in Chapter VII we extended our main hypothesis to the domain of allocation decisions, suggesting that, just as the observation of giving prompts the tracking of welfare imbalances through time, it may similarly induce expectations of welfare-equalizing outcomes in distributive contexts. In line with our suggestion, infants expected distributions via giving, but not via taking, to result in equal shares, supporting the proposal that EM relationships can be constituted both locally (through "concrete matching operations", such as one-to-one sharing: Fiske, 1992) and diachronically (through reciprocal exchange).

8.1 Giving among competing cues

The studies above reviewed provide initial evidence in support of the hypothesis that infants are prepared to interpret giving as cue of EM relationships. This conclusion, however, should not be taken to imply that this interpretive tendency will be expressed whenever giving is observed, regardless of other competing cues. In our studies infants were presented with transfer events explicitly stripped away of any attributes which may have cued alternative RMs. Real-life interactions, on the other hand, may exhibit a number of (sometimes conflicting) cues associated to different models. We do not know how the diagnostic value of giving would be weighed relatively to other cues in such cases. For instance, presenting infants with a giving action between two agents exhibiting features known to prime mother-offspring interaction (e.g., size difference and distress-contingent helping: Johnson et al., 2010; Johnson, Dweck, & Chen, 2007; Spokes & Spelke, 2017) may lead them to represent the relationship in CS (which regulates kin interactions) rather than EM terms. Similarly, a resource provider distinguished by spatial location and bodily features may be considered higher in status to her beneficiaries (akin to a generous "Big Man": Henrich et al., 2015), priming AR instead of EM. Understanding how infants determine which RM a sharing episode is governed by requires investigating how cues are ranked in terms of their diagnostic strength, which is supplied by in-born or learned priors. The breadth of such comparison will necessarily depend on how wide is the repertoire of RM-diagnostic cues that infants are sensitive to at any age point.

Though our research did not address the issue of how RMs are ontogenetically acquired and modified, it seems reasonable to suggest that infants may start with a basic database of cues, each tokening (more or less rigidly) a particular RM, and progressively acquire more fine-tuned diagnostic associations by enriching and refining through experience the RMS' input conditions (for a similar argument in the domain of chasing: Frankenhuis & Barrett, 2013). Notwithstanding these caveats, the multiple lines of evidence presented here convergently support the claim that, by the first year of age, infants spontaneously produce specific relational inferences upon observing giving in otherwise relationally underdetermined interactions[31].

8.2 Tolerated taking as cue to CS relationships

With the exception of Chapter IV, in our studies we always compared infants' representation of giving with that of taking. The primary rationale for such comparison was to ascertain if the encoding strategies adopted to represent giving were specific to giving, or more generally used for superficially similar transferring actions. This comparison yielded a series of intriguing findings about infants' understanding of taking. In the same conditions in which giving was represented as social interaction, taking was instead represented as an object-directed action, with no information encoded about the Takee (Chapter III). On a similar note, while the

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[31] We cannot exclude however that, beyond giving, other features of the social interactions that infants were exposed to did not contribute to prime an EM model. Note however that several features that may have intuitively suggested the interactions to occur among peers of equal status (as in EM) seemed not sufficient *by themselves* to cue the corresponding model. For instance, observing two agents of similar size, positioned at the same height with respect to each other, and engaging in positive communicative exchanges (and bouts of synchronized behavior: see Chapter VII) were not sufficient per se to support expectations of equal distribution. Similarly, cues of "transfer acknowledgment" (Chapter V, Studies 3 and 5) were not sufficient to prompt the encoding of bookkeeping relevant information for taking-based interactions.

representation of giving included information about the transferred object, no such information was registered in the representation of taking (Chapter VI). Furthermore, moving to the sociomoral domain, giving induced expectations of equal allocation in a distributive event, whereas no such sensitivity was found for taking-based distributions (Chapter, VII).

In sum, across different studies we found that a host of information that could be readily queried in the giving case (i.e., what is transferred, and by whom) seemed compressed or discarded in the case of taking. Yet, under certain conditions, infants can represent taking as a relationship-establishing action. As we showed in Chapter V, when provided with contrastive evidence of distinct interactions and/or cues of "transfer acknowledgement", infants were able to set up a representation of the taking-based interactions as a relationship, to be re-identified across its occurrences, despite (differently from giving) they did not show sensitivity to within-relationship changes in the resource flow.

Previously we argued that the informational content of this representation, which allows infants to distinguish a relationship from others but not to keep track of its exchange history, meets the representational demands of a CS-like model. This model characterizes relationships solely as equivalence classes, thus requiring observers only to segregate the terms of these relations from others (A = B, but not A = C), without keeping track of their permutations (since A = B entails that B = A). The different types of information that infants encoded in the representation of giving and taking actions can thus be explained in terms of the different RMs (CS and EM) respectively primed by these two actions, defining in turn which aspects of the corresponding relationships are socially meaningful, and thereby worth tracking.

As Fiske (1992) wrote, "the use of the models imposes an increasing burden of information collection, storage, and processing, along with greater specificity of the terms that must be agreed upon in order to coordinate. Likewise, the determinacy of the interaction increases step by step, while flexibility decreases". A CS relationship, in which social actors are considered equivalent to each other and undifferentiated, is the simplest model in terms of its structural implications, for it only requires representing the boundary conditions of the relationship (i.e., who belongs to it and who doesn't), whereas an EM relationship, which is based on a standard of even balance, additionally entails bookkeeping the direction and magnitude of any eventual imbalance between its participants. As earlier suggested (Chapter V), the hypothesis that giving and taking may respectively prime EM and CS can be further tested by investigating if the corresponding action representations exhibit other formal properties (e.g., transitivity), which can be directly derived by the normative orientations underlying the two models. This hypothesis, if supported, would provide strong empirical footing to our original contention that, beyond giving, different transfer-related behaviors may map onto distinct RMs.

Under this respect, it is worth noting that, despite having suggested that "taking" may be a cue of CS relationships, our claim should be in fact restricted to a very specific type of tolerated (or unresisted) taking, as rendered in our animations, in which the Takee peacefully consents to the Taker's goal of acquiring her object (Brosnan & de Waal, 2002). There are good reasons to expect that, despite the surface similarities, differences in the choreography of resource expropriation may lead to radically different relational inferences. Wrestling out of the possessor's hands, for instance, may be interpreted as a form of dominance on the part of the Taker, formidable enough to seize the Takee's possession to her own benefits. Consistently with this idea, infants presented with two linearly ordered interactions based on forceful taking produced transitive inferences characteristic of AR relationships (Gazes et al., 2015; for AR-priming interactions involving the monopolization of non-transferable resources, see: Mascaro & Csibra, 2012). More subtly, relinquishing an object contingently to another agent approaching may also be interpreted in AR terms, as indicating appeasement on the possessor's part (for evidence in primates: Mazur, 2009).

Moreover, contextual or historical factors (such as the object's ownership status) may influence the interpretation of taking actions as "antisocial" even when none of its action features suggests any predatory or aggressive dispositions. For instance, infants exposed to an agent taking a ball "accidentally" dropped by another agent seem to negatively evaluate the Taker, as evinced by their systematic avoidance of this character in a manual-choice paradigm (compared to another character who gave back the ball: Hamlin & Wynn, 2011). Similarly, when exposed to an agent taking a ball in a similar fashion from a Hinderer (i.e., an agent previously shown to block the completion of a third party's goal), infants preferred this character to the one giving back the ball, suggesting that they evaluated the taking action as an appropriate punishment for the Hinderer's behavior (Hamlin, Wynn, Bloom, & Mahajan, 2011; for similar evidence in the domain of preference sharing: Hamlin, Mahajan, Liberman, & Wynn, 2013). Even more intriguingly, 10-month-olds exposed to animations strikingly similar to the ones used in Chapters III and V looked longer to a hand taking an apple from an unfair distributor over a fair one (Meristo & Surian, 2014), a finding which the authors interpreted as suggesting that infants interpreted the taking action as a form of third-party punishment. While these studies did not directly investigate what type of relational inferences infants drew upon witnessing these interactions, they nonetheless demonstrate that, depending on an agent's morally relevant conduit or implicit normative stipulations (e.g., about who owns an object changing possession: Friedman et al., 2013), vastly different interpretations of the same taking action can be produced, thereby suggesting that infants are able to integrate a host of contextual factors in the process of action evaluation.

8.3 Representing relationships or ascribing traits?

Beyond differences in how taking was interpreted in our studies compared to the ones above reviewed, there is a more fundamental divergence worth making explicit in the working assumptions of these two research endeavors. A paradigm that has attracted a great deal of attention in the domain of early sociomoral evaluation is the manual-choice paradigm[32] (MCP; for an in-depth description, see: Hamlin, 2013a). In its standard version, infants are exposed to a “morality play” involving a character (the Protagonist) trying to achieve a goal, and (on alternating trials) being helped by a second character (the Helper) or hindered by a third (the Hinderer). Once habituated or familiarized to these interactions, infants are then presented with the Helper and the Hinderer and encouraged to choose between them. Part of the appeal and success of the MCP rests in its straightforward logic: if infants are capable of differentiating between the two actions in terms of their moral valence (on the basis of how they contributed to the realization of the Protagonist’s goal), and differently evaluate each character on the basis of these actions, they should develop character-specific preferences, which would be revealed at test in their selective reaching.

Crucially, infants could only form and act on these preferences if they attributed to these characters a sociomoral disposition that can be generalized to new individuals, such as infants themselves (Kuhlmeier, 2013a; 2013b; Wynn, 2009). Compared to the attention that the MCP garnered as a measure for charting out infants’ sociomoral evaluations (Hamlin, 2015), the fact that it rests on the assumption of trait-like generalizations has received much less scrutiny. As in indirect-reciprocity models of partner choice (e.g., Nowak & Sigmund, 1998), infants here seem to operate under the assumption that the behavioral policy adopted by an agent towards another is predictive of the type of behavior that the same agent would exhibit towards third parties – be them the infants themselves (as in the MCP) or other previously unrelated agents (as in looking-time variants of the same paradigm: e.g., Meristo & Surian, 2013; Geraci & Surian, 2011). In a way, such propensity to conceive of interactions as diagnostic of distinctive and consistent individual traits (as in: Boseowski & Lee, 2006: i.e., generalizable across recipients and stable over time) is

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[32] Besides the MCP, other paradigms have been recently developed to investigate infants’ trait ascription. In a study by Repacholi, Meltzoff, Henning, & Ruba (2016), for instance, trait ascription was measured by assessing the infants’ hesitation to manipulate an object in the presence of an adult who previously emoted angrily against another individual performing a different action on a different object. According to the authors, behavioral inhibition in such condition can be taken as evidence that infants produced a predictive generalization about the adult’s reaction that included the infants’ object-directed action as candidate trigger (i.e., “she gets angry whenever someone plays with objects).

reminiscent of the interpretive bias underlying the "fundamental attribution error" (FAE: Ross, 1977; Jones & Harris, 1967): the tendency to privilege explanations based on internal factors, such as dispositions, over situational ones.

Needless to say, we do not know the extent to which infants would resort to trait-based inferences in real-life situations. The same caveats previously used to circumscribe our claim that giving may prime EM apply here: in real life trait evaluation tend to occur on the basis of multiple sources of behavioral information that vary in credibility and derive much of their meaning from the social context they are embedded in. In fact, new research on the FAE showed that, outside of forced-inference situations, observers seem use trait explanations quite reluctantly, preferring instead to resort to conventional explanation based on contextual knowledge or (assumed) previous history to explain an agent's behavior (Malle, 2004). This seems to be especially the case when participants are asked to explain an agent's sociomorally relevant behavior: instead of adopting broad personality judgments (e.g., "Mary is helpful"), adults were found to consistently privilege inferences based on reason explanations and motive ascriptions across a number of studies (Gawronski, 2004; Kammrath et al., 2003; Reeder 2009; Reeder, Vonk, Ronk, Ham, & Lawrence, 2004; Sabini, Siepmann, & Stein, 2001). Similarly, it may then be that the scope of trait attribution in infancy is limited to the context-free and dichotomous evaluations scaffolded in the MCP. Regardless of whether this is the case (cf. Dahl, Schuck, & Campos, 2013; Salvadori et al., 2015), the infants' behavior in the MCP cannot be accounted for without positing a form of "inductive bet" about the character's disposition (i.e., expecting that character A will behave in a certain way with C in virtue of having acted previously in the same way with B).

Such inferential leap from behavior to dispositions seems prima facie at odds with our own findings[33], where the test of trait attribution was not based on infants' affiliative responses (reaching) but on their expectations of consistent behavior towards new partners. Recall in fact that infants did not expect a Giver to give to new recipients (Chapter III, Study 2). Similarly, infants did not expect an agent A dominating over B also to dominate over C, which A never interacted with before (Csibra & Mascaro, 2012). The representations that infants formed in these cases clearly restricted the agents' behavior to the targeted patient. Such lack of generalization is

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[33] Infants' propensity to ascribe trait-like sociomoral dispositions ('goodness' or 'badness') seems also at odd with the toddlers' rare and reluctant adoption of trait- vs. norm-based explanations to account for other people's interpersonal behavior (using vignette tasks: e.g., Kalish & Shiverick, 2004). Moreover, such readiness seems somewhat difficult to reconcile with recent evidence according to which a *single* episode of behavioral inconsistency (e.g., A hinders B despite having helped her twice before) is sufficient to erase any preference for (mostly) altruistic characters in a standard MC task (Steckler, Woo, & Hamlin, 2017). Interestingly, the same results obtained when the inconsistent action occurred in an interaction with a new agent, which should have provided infants with a reason to bracket away the deviation from the previous behavioral policy as specific to the interaction observed.

consistent with our proposal according to which infants are primarily concerned with determining the types of relationships organizing their social surroundings, but less so with the claim that they would spontaneously infer trait-like dispositions for partner-choice use from interactions between unfamiliar agents. While these two accounts are not mutually exclusive (representing relationships serves ultimately the purpose of intervening on them), it remains to be understood in which circumstances and to what extent infants adopt the stance of naïve personality or social psychologists.

Complementarily, evolutionary accounts specifying which selective pressures may have led to the evolution of either prior (to posit the existence of long-term relationships in one case, and to expect the observed behavioral conduit to be generalizable to third parties in the other) need to be articulated. In this respect, the adaptive significance of defaulting on the assumption that interactions have a higher-than-zero probability to be repeated has been already defended on the backdrop of the observation that humans evolved in spatially clustered and temporally stable groups where "meeting now suggests we will meet again" (Krasnow, Delton, Tooby, & Cosmides, 2013; Delton, Krasnow, Cosmides, & Tooby, 2012; Yamagishi, Terai, Kiyonari, Mifune, & Kanazawa, 2007). Similar attempts to identify the socioecological conditions in which a FAE-like "personality judgment instinct" (Haselton & Funder, 2006) could have produced positive fitness effects are on the other hand still becoming (but see: Andrews, 2001).

8.4 Moving beyond the representation of social groups

Beyond the research on sociomoral evaluation, a second strand of developmental inquiry that is worth comparing our framework to concerns how infants reason about coalitions and tag-based groups (*sensu* Cohen, 2012). This growing literature has revealed in recent years that infants can exploit a host of information, such as shared food preferences (Liberman, Woodward, Sullivan, & Kinzler, 2016; Liberman, Kinzler, & Woodward, 2014), language (Liberman, Woodward, & Kinzler, 2016), surface features (He et al., 2013), or imitation (Powell & Spelke, 2016; 2013) to form expectations about patterns of positive interactions (ranging from affiliation to conformism and favoritism: reviewed in Baillargeon, Scott, & Bian, 2016), between agents with similar attributes and, *vice versa*, negative interactions between agents with different attributes. Importantly, these homophily-based expectations have been found also to modulate the affiliative decisions of the infants themselves across several domains (food preferences: Hamlin et al. 2013b; language: Kinzler et al., 2007; surface features: Mahajan & Wynn, 2012), thus demonstrating that they are also factored in from a first-person perspective for partner-choice purposes (cf. Wynn, 2016). Despite the potentially contentious implications of this research, which reveals a disposition to base (or to expect others to base) cooperative decisions onto seemingly trivial similarities[34], the studies cited above emphatically show that infants' reasoning about coalitional dynamics requires only minimal inputs (i.e., weak proxies of shared intentional stances) to prompt in-group affiliation (Wynn, 2016; reviewed in Liberman, Woodward, & Kinzler, 2017).

There is no doubt that tracking coalitions, attending to group-wide moral obligations (Rhodes, 2013), and anticipating how individuals may react towards unrelated others on the basis of their membership in (or outside of) said coalitions (Pietraszewski & German, 2013; Rhodes, Heretington, Brink, & Wellman, 2015) are core components of infants' naïve sociology. However, it is important to note that these mechanisms operate at a fundamentally different level from the ones we posited. If the task of coalition-tracking mechanisms is to parse social collectives into meaningful sub-groups and determine the quality of the ongoing relations between these units (Tooby & Cosmides, 2010), representing interactions as modelled onto specific RMs additionally requires a conceptual database of social schemata that supply coordination rules for the maintenance of relationships over time. Under the RM framework, groups cease to be homogeneous entities whose behavior can be exhaustively described in terms of cooperation/competition, to become aggregates of social actors who, even if orchestrating their actions towards the same coalitional goal, may stand in qualitatively different relationships with respect to each other. Beyond the commitments that derive from being a group member (Chalik & Rhodes, 2014), the types of entailments that the RMT posits requires finer-grained differentiations of social roles (such as being a mother, a friend, or a leader). Our account therefore orthogonally interfaces the research on coalitional psychology and N-person conflicts to suggest that infants, beyond mapping the social space into distinct groups, are simultaneously engaged in representing relationships defined by their own internal logic of diachronic development (cf. Thomsen & Carey, 2013).

8.5 Revisiting two tenets of RMT

Having discussed how our research relates to the current literature on early social psychology, we should also examine what our studies contributed to the RMT itself. Instead of reviewing findings that support its main theoretical tenets (for the interested readers: Haslam, 2004; chapter II), here we intend to focus on two results which may call for a revision of other

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[34] Differently from the literature on adults' group formation which underwent a major re-assessment of the diagnosticity of different attributes (e.g., race) in predicting coalitionary patterns (Pietraszewski, Cosmides, & Tooby, 2014; Cosmides, Tooby, & Kurzban, 2013), the ecological validity of infants' seemingly promiscuous receptivity to a broad range of group-marking features has yet to receive critical evaluation (for a few notable exceptions, see: Baron, Dunham, Banaji, & Carey, 2014; Cohen & Haun, 2013).

ancillary aspects of RMT: specifically, the so-called conformation theory and the developmental timeline of RM acquisition (Fiske, 2004; Fiske et al. 2009).

Conformation theory posits that each of the three RMs is constituted and communicated in a distinct medium. In CS, the equivalence of social persons is indexically made manifest through the transmission of body substances, physical contact, and synchrony of movements. In AR, on the other hand, the dominant-subordinate asymmetry is rendered iconically in by positioning bodies along dimensions of physical (or metaphorical space: above vs. below), magnitude, time (preceding vs. following), and force (stronger vs. weaker). Finally, the medium of EM consists of concrete operations that are ostensive procedures of even balancing, such as taking turns, flipping a coin, lining up on a starting line, or matching shares in a one-to-one correspondence. Yet, if our conjecture is correct, the studies presented in Chapter V suggest that two distinct RMs (CS and EM) can be primed by different modes of transfer (unresisted taking and giving, respectively) which, given their similarity, would certainly belong to the same medium concerning concrete actions that involve object manipulation (Fiske et al., 2009). This minimally suggests that, even if RMs are constituted into and expressed through distinct mediums, differentiation between these models is also possible within the same class of actions (in this case, sharing behaviors).

A related observation concerns the EM-cueing procedures described by Fiske (1992). As the list above shows, all of these consist of local instantiations of equality (i.e., operations that immediately produce a levelled playing field of resource access or use, and welfare distributions). Yet, as Fiske also extensively argued (1992; Fiske & Fiske, 2007), the directive standard of EM (even balance) also applies to how relationships unfold through time. In this case, even balance cannot be achieved through the momentary application of an equalizing procedure, but by patterning the exchange in a reciprocal fashion. When we consider the normative orientation of EM as dictating a long-term coordination rule, equality becomes a property of how altruistic acts are diachronically organized with respect to each other. Because of this, however, reciprocity is a poor candidate as predictive cue, since by the time the observer could recognize the exchange as reciprocal (which requires a series of chained interactions to be monitored), she would have already accumulated enough evidence to safely identify the underlying relationship as EM-based.

This brings us to a paradox, which seem to have escaped Fiske's theorizing: if we wish to endow a cognitive system with inferential productivity about the long-term shape of an EM relationship, then we must assume some sensitivity to a spatiotemporally discrete cue which, by definition, cannot consist itself in an equalizing procedure. Giving, we argued, is such a cue. In this case however the EM standard cannot be "read off" from the action effects of this cue (as in the case of one-to-one distribution: Chapter VII), but is primed via an inbuilt diagnostic dependency – which, as we said, is itself the outcome of selective pressures that led to engrain in the human cognitive system covariation information between a particular mode of transfer and a corresponding type of long-term exchange. If our hypothesis about giving will stand further empirical scrutiny, it should lead to revisiting the idea that EM cues should be restricted to locally equalizing procedures.

Finally, our research (complementing recent studies on infants' representation of dominance-based relations: Mascaro & Csibra, 2012; 2014; Thomsen et al., 2011; Pun et al., 2016) provided initial evidence that, by the first year of age, infants already possess, and can effectively put to use, the representational machinery required to track relationships modelled onto the first three RMS. This precocious capability seems to conflict with Fiske's developmental timeline, according to which CS emerges first during the first months of life (given that prototypical instances of consubstantial assimilation, such as intimate physical contact and the transmission of bodily substances, take place in the first nurturing interactions between infant and mother), followed by AR in the second and third year (when young toddlers start to be subjected to siblings rivalry and aggressive confrontations over object possession, conformingly to observational data: Hawley, 2014), and finally by EM in the fourth and fifth year of age (when children begin to master simple divisions and are increasingly confronted with coordination dilemmas involving the use of commons). While the proposed timeline may accurately track the children's ability to *perform* actions constitutive of different RM, it does not speak of their competence in identifying such models, which, as our studies suggest, may be already in place (at least within the domain of possession-related behaviors) in the first year of life.

8.6 Implications of RMT for developmental science

As a concluding note, we shall briefly discuss the far-reaching implications that a developmental theory of RM acquisition has for social cognition at large. Firstly, it provides cross-cultural psychology with a cognitively sound theory of cultural variation: just as cultural transmission requires pre-existing relationships to operate onto, conversely these relationships require culturally transmitted paradigms (preos) to become group-specific coordination devices (Fiske, 2000; Fiske & Haslam, 1996). Infants' proclivity to systematize relationships in different schemata and their sensitivity to RM-specific cues are necessary to bootstrap the process of cultural complementation through which humans learn how each RM is expressed and negotiated within their social groups. The study of early naïve sociology, which may shed light on how infants become proficient and motivated participants of the social network they inhabit, should not therefore be divorced from investigating the ontogeny of cultural learning, through which socially stipulated rules about RMs become progressively fine-tuned (cf. Legare & Harris, 2016).

The proposal that infants may privilege the stance of naïve sociologists when entering the social world has arguably even more relevant consequences for the study of moral psychology, which we believe excessively focused on the evaluation of social acts occurring in interactions (assumed to be) unconstrained by previous relations and common history. This issue has been already raised in the Relationship Regulation Theory developed by Fiske & Rai (2011; 2014; Rai & Fiske, 2012), which, against other influential accounts (Hauser, 2006; Turiel, 1983), posits that the moral status of an action cannot be automatically assessed from its effects (e.g., whether it is detrimental or beneficial to somebody's welfare), but chiefly depends on the motive employed with reference to a prescriptive RM (Simpson, Laham, & Fiske, 2016). In a similar fashion, while discussing the drawbacks of attempting to understand adult moral judgment by focusing on artificial cases of moral calculus involving unrelated strangers (such as standard trolley problems), Bloom (2011) lamented of a "crisis in moral psychology" caused by the departure of our theories of moral decision-making from sociologically thick categories of interpersonal conduit, such as those pertaining to interactions with kin and friends. Translated in a developmental perspective, these considerations make it untenable to expect early moral evaluation to first emerge in a relational vacuum and later be modulated by the deontic expectations supplied by specific RMs. Taking seriously the idea that only relationships can provide prescriptive models of behavioral conduit (e.g., Curry, 2016; Graham, 2013) therefore requires to ultimately abandon the proposal that moral evaluation can precede sociological reasoning. This is a perspective that is still to be embraced in our field. We hope that our research may have represented a first, albeit small, step in this direction.

Chapter IX. Appendix

9.1 Introduction

Here we will briefly present four studies conceived and conducted before we begun to lay down the foundations of our account about the naïve sociology of transfer-based relations. Despite none of these studies produced positive findings, their motivating hypotheses are nevertheless worth describing because relevant to some of the questions previously explored – in particular, those concerning which allocation procedures may induce equality expectations (cf. Chapter VII) and which object-related inferences can be drawn from representing giving as a fundamentally prosocial action (cf. Chapter VI).

In details, Studies 1-2 explored the situational breadth of equality expectations by investigating infants' sensitivity to unequal outcomes produced via allocation procedures different from third-party distributions. Relatedly, Study 3 tested whether such expectations would extend also to situations of asymmetric endowments involving windfall-like resources. Finally, Study 4 tested whether the observation of giving spontaneously induces expectations about the value of the transferred object: if the goal of giving is to increase a recipient's welfare by transferring the possession of a resource on the recipient's behalf, it should follow that infants would infer said resource to be "valuable" (i.e., benefit-bearing) enough for the recipient to justify the Giver's action.

9.2 Study 1. Equality expectations (without turn taking)

In this study, we sought to test whether infants expect individuals to have equal entitlements over unclaimed resources. As discussed in Chapter VII, the existing studies on infants' sensitivity to resource distribution are all based on the same allocation procedure, i.e., third-party distribution (e.g., Schmidt & Sommerville, 2011). Due to this commonality, the current literature cannot adjudicate whether infants' equality expectations reflect the application of a general heuristic according to which individuals are perceived as equally entitled over acquirable resources (as in: Messick, 1993) or are specifically induce by distributions carried out by third parties. Under the first account, infants should exhibit sensitivity to equal allocations whenever two or more individuals have an equal interest in an amount of rival goods (amenable to be divided evenly). The assumption of equal interest here should be conceived of as an interpretive default which infants apply when no difference in need, dominance, or deservingness (attributes known to influence the allocation predictions of older children: e.g., Charafeddine et al., 2016; Baumard, Mascaro, & Chevallier, 2012) can be inferred (for evidence of such default in adults, see: Weber, Kopelman, & Messick, 2004). This assumption should be applied whenever individuals without a previous history of interactions or any of such distinguishing attributes face a resource-allocation dilemma, regardless of whether this is modelled as a third-party distribution (i.e., how much A should give to B and C?) or a common-pool scenario (i.e., how much shall A take for herself and leave to B?). Under the second account, on the other hand, infants' expectations of equality should be chiefly limited to third-party distributions[35].

In order to test the first account, we first familiarized infants with two actors (one at the time) equally motivated to acquire resources, and later tested which actor they expected to take the last resource in a situation of asymmetric endowments (3:1).

9.2.1 Methods

9.2.1.1 Participants

Sixteen 12-month-old (7 females; mean age = 362; age range = 343-371) participated in the study. Four additional infants were excluded from the analyses due to inattentiveness (*n* = 2) and experimenter's error (*n* = 2).

9.2.1.2 Procedure

Unlike the previous studies, Study 1 adopted a double-familiarization design[36] (cf. Mascaro & Csibra, 2012). Infants were shown 4 identical familiarization trials involving an actor (A) taking an apple, followed by 4 trials involving a second actor (B) performing the very same action. The purpose of this familiarization was to provide evidence that both agents within each pair had equal interest in the apples. At test, infants were shown the two actors in possession of a different number of apples (2 vs. 1), with one apple left unclaimed. The apple could be taken by either the advantaged or disadvantaged actor, producing respectively a 2:2 (Equal Test Event) or a 3:1 (Unequal Test Event) resource distribution. After either of the two test events, infants were

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[35] No explanation for this signature limit has been suggested in the literature thus far. In Chapter VII, we attempted to remedy to this gap by proposing that giving specifically primes a RM that makes welfare-balancing acts expected (EM). According to our hypothesis, infants should be sensitive to unequal outcomes not only when facing situations involving an individual determining the endowment of have-nots by actively dividing a resource pool, but more broadly whenever resource sharing occurs via giving. Alternatively, infants may be more likely to expect equality when allocation dilemmas require the intervention of a single individual (a resource provider) than the coordination of multiple ones (cf. Paulus, Gillis, Li, & Moore, 2013).

[36] The rationale of such design is to avoid the possibility that, when presenting expectation-violating (inconsistent) test events first, their occurrence might lead the infants to revise their expectations about the typical outcome of the events observed, making the looking behavior to the subsequent (consistent) test of difficult interpretation.

presented with another familiarization (8 trials) featuring a new pair of actors, followed by the second test event.

9.2.1.3 Stimuli

Familiarization events. The familiarization events (4 s total running time) started with a female actor (A or B in pair 1, respectively wearing a red and a light-brown sweater; C or D in pair 2, respectively wearing a grey and a pink t-shirt) sitting at the left end of a table and gazing at a fruit (apple for pair 1, orange for pair 2) placed at its centre, with both her hands resting palm-down on the table. After a 1-s pause, the actor reached for the fruit, placed it next to herself, and put her hand back onto the table, while gazing at the fruit. After 4 identical trials, the same action was performed by the other actor in the pair (B or D), sitting on the opposite side of the table. A short sound (0.5 s) was produced whenever the actors put the fruit down.

The order of the pairs (pair 1 first vs. pair 2 first) and the order of the actors within each pair (A and C first vs. B and D first) were counterbalanced across infants.

Test events. The test events (6 s total running time) started with the two actors of pair 1 (or 2) sitting in front of and gazing at each other (the actors occupied the same side of the table they sit by during familiarization). On the table, there were 4 fruits: 2 were placed on the opposite corners of the side occupied by actor A (or B), 1 on the farthest corner (from the observer) of the side occupied by the other actor, and 1 at the centre. After 2 s, the actors looked simultaneously at the fruit at the centre of the table, and one of the two reached for the fruit, took it, and put it close to her side. Depending on who was the actor performing the action (the one with 1 or 2 fruits), the resulting distribution was either equal or unequal. When the fruit was taken by the disadvantaged actor, it was placed by the closer (to the observer) corner of her side of the table; when taken by the advantaged actor, it was placed in front of her, equidistantly between the two other fruits on her side of the table. Both actors always gaze-followed the taken fruit as it changed location. As in familiarization, a sound was produced when the fruit was finally put down.

The order of test events (Equal first vs. Unequal first), the identity of the actor producing the unequal distribution (A or C vs. B or D), and the side of the table with more fruits in the Unequal Test Event (left vs. right) were counterbalanced across infants.

At the end of each trial, a short attention-getting animation (1 s) was played.

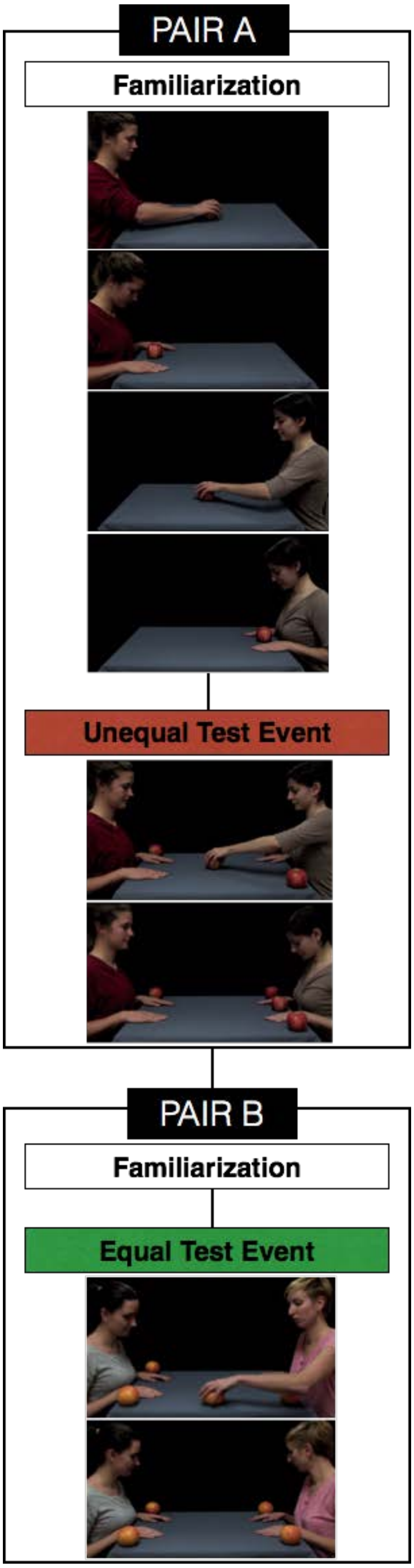

Figure 14. Schematic visualization of the design structure and stimuli material used in Study 1. For ease of visualization, screenshots of the second familiarization (featuring pair B) have been omitted.

9.2.1.4 Coding and Data Analysis

In order to be included in the final data analysis, infants were required to (1) watch continuously the reaching action (3 s) in at least 2/4 familiarization trials for each of the two pairs, and (2) attend to the two test events from when one of the two agents started reaching for the fruit to the completion of the action (4 s). LTs at test were measured from when the actor put her hand back on the table to when the infant looked away from more than 2 s or looked cumulatively more than 60 s.

9.2.2 Results and Discussion

Infants did not look longer to the Unequal (M = 14.42; SD = 10.22) compared to the Equal Test Event (M = 14.91; SD = 15.89), $t(15) = .144$, $p = .887$, suggesting that they did not form expectations about which of the two actors should have taken the last fruit on the basis of their endowments.

This may be due to a number of reasons: (1) a failure to represent the fruits placed on the two sides of the table as possessed by the two actors (either because of their scattered arrangement, which we resorted to in a – perhaps misguided – attempt to facilitate the comparison of the two amounts of fruit via spatial alignment, or because infants may not represent possession on the basis of proximity alone if the objects have not been previously acted upon[37]), or (2) a failure to relate the actors' endowments to the remaining resource. Under this interpretation, infants did not represent the fruits possessed by the actors as belonging to the same resource pool of the fruit left unclaimed, and consequently did not use the initial 3:1 division as basis for assessing who should be the actor entitled to the last resource[38].

9.3 Study 2. Equality expectations (with turn-taking)

In Study 2 we sought to determine whether the 12-month-olds' lack of sensitivity to unequal outcomes revealed in the previous study was due to the inability to form expectations about resource entitlement on the basis of pre-existing endowments. To do so, we exposed infants to two actors taking resources from a common pool in a turn-taking fashion, until reaching the same 3:1 distribution (with one fruit left unclaimed) used as test event in Study 1. In this way, we could provide evidence that the actors' endowments derived from the same common pool, making

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[37] We thank Gyuri Gergely for this suggestion.

[38] Alternatively, the initial endowment asymmetry may have been interpreted as a cue of power differential (as in: Gulgoz & Gelman, 2016), supporting the representation of the advantaged actor as dominant (because she was able to seize more resources against the other actor's will), and consequently benefiting from priority-of-access privileges over the last fruit. If this were the case, however, infants should have looked longer at the Equal Test Event rather than similarly to both test trials.

manifest that the remaining fruit was part of the same sharing event that brought to the 3:1 distribution, while also discouraging the interpretation of this asymmetric allocation as cue to power differentials (cf. Pietraszewski & Shaw, 2015). Most importantly, we adopted an allocation procedure (i.e., taking turns in apportioning shares from a common pool) which Fiske (1992) notably included among the "concrete operations" through which EM is prototypically instantiated, which may plausibly make the expectation of equality more salient. Finally, by showing infants two actors successfully interlocking their actions to produce a turn-taking sequence, we provided behavioral evidence of tacit coordination over a jointly represented outcome (of equal division; for a similar argument, see Schelling, 1960).

Besides testing whether infants would expect equality in a scenario with redundant cues of equal resource entitlement, we also sought to explore if they would differently evaluate actors on the basis of their allocation decisions, since such evaluations have been shown to influence infants' partner choice (Geraci & Surian, 2011; Deschamps et al., 2015) and their expectations about the affiliative or punitive behavior of third parties (Meristo & Surian, 2014; 2013) in the domain of third-party distribution. To this end, we presented infants with the two actors who took the last fruit in the two test trials (actor A, who produced equal allocations by abiding to the turn-taking rule vs. actor C, who produced advantageous inequality by violating such rule), each offering an identical object, and tested which actor infants would take the object from. Similarly to other studies on early sociomoral evaluation using the MC paradigm (e.g., Hamlin & Wynn, 2011), we predicted that infants should selectively reach for the object offered by actor A. Crucially, we expected this preference to be driven not by a positive evaluation of actor A per se, given that she merely conformed to the turn-taking rule, but rather by an aversion against B, who on the other hand violated both the procedural and distributive rule to maximize her gains. In this respect, the choice that infants were confronted with could be deemed similar to the one they faced in the Neutral vs. Hinderer comparison of Hamlin et al. (2011).

9.3.1 Methods

9.3.1.1 Participants

Sixteen 12-month-old (9 females; mean age = 364; age range = 345-373) participated in the study. Three additional infants were excluded due to inattentiveness (*n* = 2), and crying during familiarization (*n* = 1). Seven infants who met the inclusion criteria were nonetheless replaced due to not having produced any data in the manual choice test for the following reasons: not reaching for either object (*n* = 3), improper positioning of the infant by the mother (*n* = 2), maternal intervention (*n* = 1), experimenter's error (*n* = 1).

9.3.1.2 Procedure

The same procedure and design of Study 1 was used here. The only difference here was that infants at test were not presented with the two actors having already asymmetric endowments, but with a pool of fruits from which they asynchronously took fruits in a turn-taking fashion, until the same 2:1 distribution as shown at the beginning of the test events of Study 1 was obtained. At the end of the second test event, a MC test followed, in which infants were presented with two agents who took the last fruit in the two events offering an identical object (i.e., a toy sandwich) to them.

9.3.1.3 Stimuli

Familiarization events. The familiarization phase was identical to Study 1.

Test events. The test events (24 s total running time) started by showing the two actors of pair 1 (or 2) sitting in front of and gazing at each other (the actors occupied the same side of the table they were sitting by during familiarization), but with no fruits in their possession. Four fruits were placed along the table midline, equidistantly from the two actors. After 2 s (during which the actors looked at each other without moving), A reached for the fruit farthest from the observer, took it, and placed it to corner closer to the observer on her side of the table. Subsequently B took the second farthest fruit and put it on her side (also on the corner closer to the observer). Finally, actor A took the fruit at the centre of the table and put it on the corner farther from the observer. At the end of each taking action, 2 s elapsed during which both agents remained motionless, gazing upon the last displaced fruit. After the third taking action, the two actors looked synchronously to the remaining fruit (on the edge close to the observer) for 2 s. This three-action sequence (Turn-taking Allocation, see Figure 15) lasted 20 s. At this point, either the advantaged actor reached for and took the fruit, placing it between the two she already possessed, or the other actor did, putting it on her side, on the corner closer farther from the observer. The same factors of Study 1 were also counterbalanced in Study 2.

As in the previous study, a short sound was produced whenever a fruit was placed down. Each trial was followed by a short attention-getting animation (1 s).

Manual choice. After infants have been presented with the second familiarization and test event, the MC phase started (modelled after Kinzler et al., 2007). Infants were shown the actors who within each pair took the last fruit in the two test events (A and C or B and D). The actors stood next to each other, frontally facing the infants and smiling, each holding high an identical toy sandwich (see Figure 15). After 1 s, they greeted the infants together ("Hi baby, hi!"; in Hungarian: "Szia, baba, szia!"), and turned their head towards their respective objects, while maintaining a smiling expression (for 2 s). Afterwards, they turned their head back to a frontally facing position and lowered the objects down (as if they were offering them to infant). As soon as the objects disappeared from the screen, E1 removed a black cloth placed under the screen (by pulling a thread attached to it from behind the curtains), revealing two replicas of the toy sandwiches spatially aligned along the trajectory of the arms of the two actors. At this point, as instructed before the study, the caregivers (while still keeping their eyes closed) moved the infants close to the objects, by pushing the wheeled chairs they were sitting on in a straight line (for about 40 cm), until reaching a plastic peg (put on the floor to ensure that infants would be at an appropriate distance from the objects). Infants were given 30 s to choose one of the objects. A second camera mounted over the screen was used to monitor the infants' behaviour, to ensure that infants produced visually guided reaches (as in Hamlin & Wynn, 2011). The still image of the two actors, smiling with their arm stretched down, was left on the screen until a choice was made or 30 s elapsed.

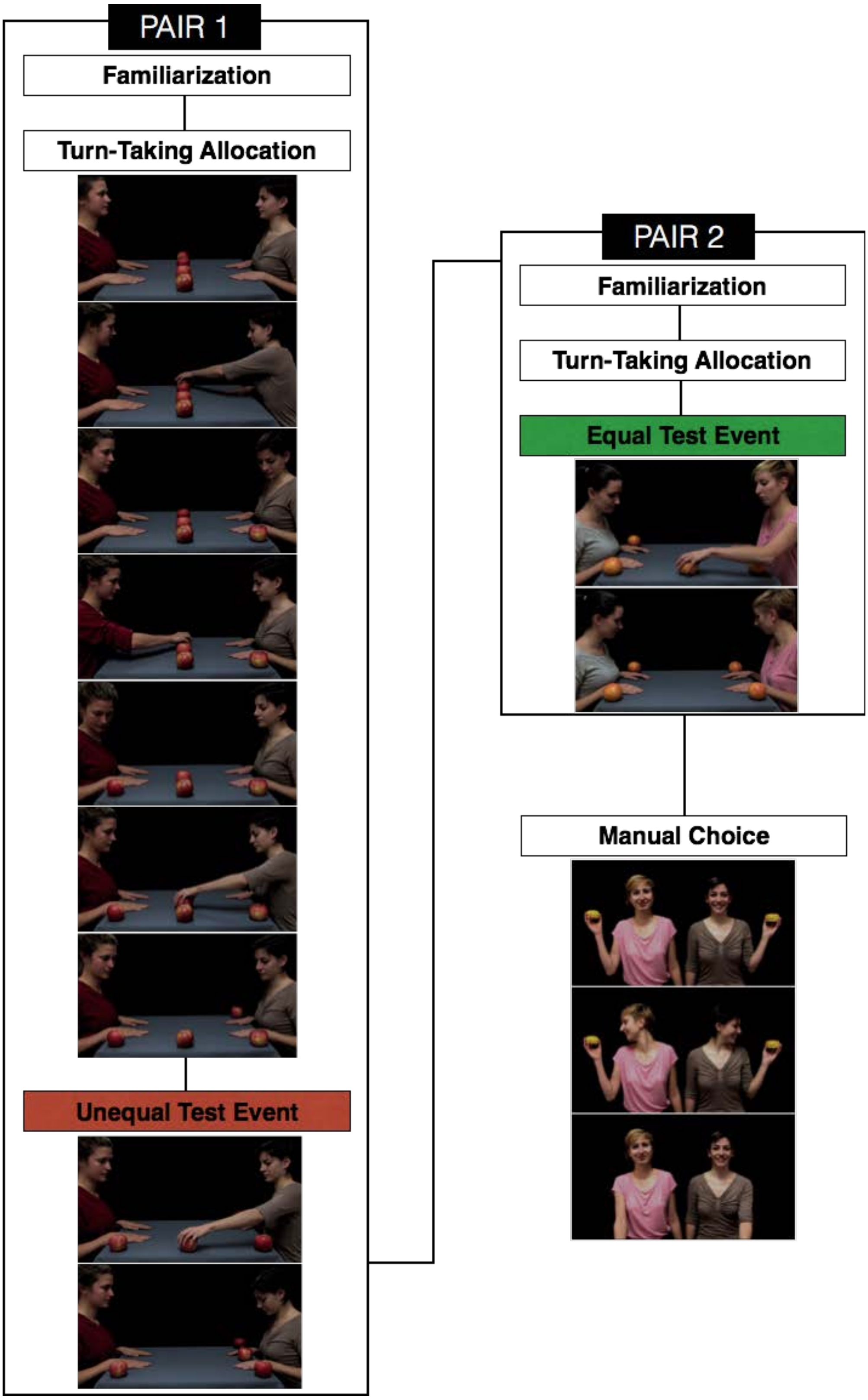

Figure 15. Schematic visualization of the design structure and stimuli material used in Study 2. For ease of visualization, screenshots of the second familiarization and turn-taking allocation (featuring Pair B) have been omitted.

9.3.1.4 Coding and Data Analysis

In order to be included in the final data analysis, infants were required to (1) watch continuously the reaching action (3 s) in at least 2/4 familiarization trials (3 s) for each of the two pairs, (2) watch the four taking actions preluding and completing the test event for at least 50% of their duration (9 s), (3) watch the video preceding the MC phase from when the actors greeted the infants to when the objects disappeared from the screen (7 s). Infants who did not meet these criteria were considered "inattentive". LTs in the familiarization and test trials were measured in the same way as in Study 1. Moreover, for the object choice to be considered valid, infants were required to make visually guided reaches.

LT data was first analysed upon sample completion, despite 7 infants did not produce any valid manual-choice data. The findings discussed in the Results refer to a new sample obtained after having replaced said infants. No difference was found in the looking behaviour of the two samples.

9.3.2 Results and Discussion

As in the previous study, infants did not look longer to the Unequal (M = 9.49; SD = 8.40) than to the Equal Test Event (M = 9.32; SD = 8.28), *t*(15) = -.085, *p* = .933. Furthermore, no evidence of social evaluation was found, since only 7/16 infants reached for the object offered by the actor who took the last fruit in the Equal Test Event (*p* = .803). There was no difference in how long infants attended to the turn-taking allocation preceding the two test events: *t*(15) = -.698, *p* = .496. As the null results suggested, even providing infants with a prototypical EM procedure, which made manifest that the actorsreceding the two test events: e last cussed in the Results refer to a new sample obtainue raised in Study 1), was not sufficient to induce expectations of equal allocation. Moreover, given that violation of the procedural and distributive rule always co-occurred, these findings also suggest that infants did not produce expectations about the structure of the turn-taking interaction, irrespectively of the allocations obtained. Consistently with this failure, infants showed no evidence of selectivity in the MC phase, suggesting that the violation of either rule did not induce infants to differentially evaluate the two actors. These results stand in contrast with the ability of older children to solve coordination dilemmas concerning the division of finite goods by spontaneously taking turns (Gruneisen & Tomasello, 2016; Melis, Grocke, Kalbitz, & Tomasello, 2016; Zeider, Herrmann, Haun, & Tomasello, 2016).

9.4 Study 3. Equalization via giving

While in Studies 1-2 we explored whether infants can form expectations about which of two actors is entitled to an unclaimed resource on the basis of their respective possessions, in Study 3 we addressed the question whether infants would expect actors to rectify a state of unequal endowments. Similarly to Study 1, we presented infants with two actors with different amounts of goods (3:1), and tested whether they would expect the advantaged actor to give one of her resources (thereby producing an equal split) or the disadvantaged actor to do the same (further increasing the relative inequality). We used cues of behavioural synchronicity to induce the representation of the two actors as equal peers engaged in an affiliative interaction (Choi & Luo, 2015), and tried to discourage the interpretation of the unequal possessions as evidence of pre-existing power differentials by making the actors emote with surprise upon discovering their respective endowments. Furthermore, differently from Studies 1-2, where we used actions (taking from a common pool) that influenced the partner's welfare only indirectly (by constraining her acquisitive options), in Study 3 we adopted transferring actions (giving) that directly targeted the actors' possessions – hence compelling infants to represent them as instances of social interactions (as argued in Chapter III). Lastly, given the previous null results with one-year-olds and the evidence that infants' equality expectations (in third-party distributions) may not reliably emerge before 15 months (Ziv & Sommerville, 2016; Schmidt & Sommerville, 2011; see also Studies 1-3, Chapter VII), we decided to test two different age groups (12- and 15-month-olds) to assess whether such developmental gap would be found also in a different distributive context, such as the inequality-rectifying scenario here used.

9.4.1 Methods

9.4.1.1 Participants

Sixteen 12-month-old (7 females; mean age = 366 days; range = 352–377 days) and sixteen 15-month-olds (9 females; mean age = 468 days; range: 453-478 days). In the group of 12-month-olds, two additional infants were excluded from the analysis due to inattentiveness (n = *1*), and crying during familiarization (*n* = 1), whereas in the group of 15-month-olds, three infants were excluded due to inattentiveness (n = *1*), experimenter's error (n = *1*), and maternal intervention (n = *1*).

9.4.1.2 Procedure

Infants were presented with one video showing two actors (A and B) with different resource amounts (1 vs. 3 cookies). After the actors inspected their own and their partner's respective endowments, two types of redistributions occurred: either the advantaged actor gave one of her cookies to the other actor, producing a 2:2 split (Equal Test Event), or the disadvantaged actor did, resulting in a 0:4 distribution (Unequal Test Event).

9.4.1.3 Stimuli

Infants were presented with a video (25 s total running time) showing two female actors (A and B, respectively wearing a blue and a red sweater) sitting at the two opposite sides of a table (sideways to the infants) covered with a checked cloth. A plate (white or blue) with an upside-down breakfast bowl on top (beige or blue) was placed in front of each actor (Figure 16).

Pre-allocation phase. The video started by showing actor A waving to and greeting B ("Hi!"; in Hungarian: "Szia!"), to which the other actor immediately replied in a similar fashion. The two actors then synchronously looked down on their respective bowls, grasped them, and put them away on the farthest side of the table (from the infants). Upon revealing the content of their plates (1 cookie in one plate, 3 in the other), the two actors simultaneously emoted with surprise ("Ooh!"), and then, one at the time, peeked into each other's plate. The whole sequence of events preceding the allocation lasted 20 s. A sound was produced when the two actors placed the bowl on the table (0.5 s).

The side of the actors, the identity of the advantaged actor, and the identity of the agent who peeked first were counterbalanced across infants.

Allocation phase. In the Equal Test Event, the advantaged actor took one of her cookies, placed it into the partner's plate, and put her hand back on the table, producing a 2:2 distribution. In the Unequal Test Event, the same giving action was performed by the disadvantaged actor, who put her only cookie in the partner's plate, thus producing a 0:4 distribution. During the two events, both actors continuously gaze-followed the displaced cookie. Both action sequences lasted 5 s. A short beeping sound was produced when the cookies were put onto the other actor's plate (0.5 s).

The order of test events was counterbalanced across infants.

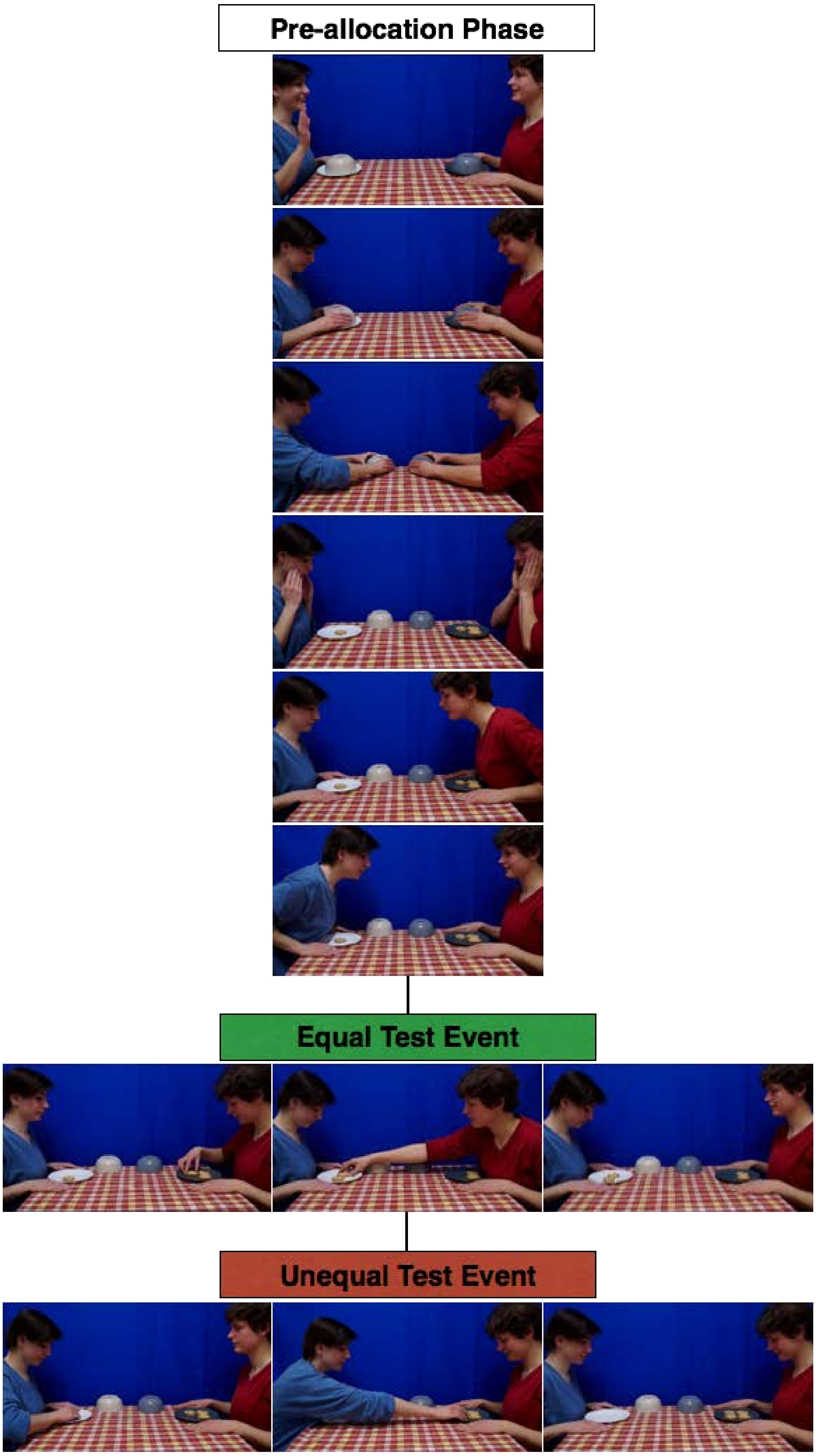

Figure 16. Schematic visualization of the design structure and stimuli material used in Study 3.

9.4.1.4 Coding and Data Analysis

To be included in the analysis, infants were required to watch (1) at least 50% of the pre-allocation event from the point when the cookies were revealed (7 s), and (2) the two test trials for the whole duration of the giving action (5 s). Infants who did not meet these requirements were labelled as "inattentive". LTs at test were measured from the moment when the actor put her hand back on the table to when infants looked away for more than 2 s or 60 s elapsed.

9.4.2 Results and Discussion

Twelve-month-olds did not look longer to the Unequal (M = 21.59; SD = 11.32) than to the Equal Test Event (M = 18.43, SD = 12.60), $t(15) = -.708$, $p = .490$. Similar results obtained for the 15-month-olds (Unequal: M = 24.64; SD = 14.25; Equal: M = 28.42, SD = 16.38; $t(15) = .883$, $p = .391$). No test order effect was found in either age group. A one-way ANOVA with familiarization LT revealed no difference between age groups in how long infants looked at the events preceding the distribution: $F(1, 30) = 1.489$, $p = .232$.

Infants showed no expectations of equality-rectifying actions in either age groups. We briefly consider two reasons for such results. Firstly, the events preceding the test (where the two actors reacted with surprise to the 'discovery' of the cookies under the bowls) may have not been sufficient to invite the inference that the actors did not know about the presence and relative amount of these resources (and hence did not possess them) before the content of their plates had been revealed. Such interpretation, as we said earlier, should have discourage representing the 3:1 distribution in terms of asymmetric possessions acquired in different amounts because of differences in actor-specific attributes (e.g., dominance or deservingness), which would have inhibited the expectation that inequalities should be rectified.

Secondly, infants may have formed this expectation, but nevertheless failed to perceive the Unequal Test Event as violating an equality norm. Notice in fact that in this test event it is the disadvantaged actor herself who voluntarily gives away her only resource. Strictly speaking, this does not constitute a violation of the equality norm, since such norm (like many others) treats deviations asymmetrically: those who have more should give, whereas those who have less are not pressed nor expected to demand for more (despite they should be entitled to do so) – in other words, recognizing a right does not compel its use (Darwall, 2006). On these premises, a more adequate test comparison should have instead involved the same advantaged actor rectifying the inequality (by giving) in one case and increasing it (by taking) in the other. Such a contrast would have more clearly pitted an instance of norm abidance vs. one of norm violation.

9.5 Study 4. Giving-induced value attribution

Here we explored the hypothesis that, upon observing a giving action, infants would spontaneously infer that the transferred object must be valuable (for the recipient). This hypothesis follows straightforwardly from the claim that infants represent giving as a fundamentally prosocial action, as argued at length in Chapter III. If giving is designed to produce benefits for an individual by means of resource transfer, the resource which the recipient becomes possessor of must necessarily represent the source of said benefits. We tested this hypothesis by exploring if infants would prefer an object transferred to an animate recipient over another transferred to an inanimate one.

As discussed earlier (Chapter III, 3.1.1.), the presence of a beneficiary is a necessary input condition for the activation of the giving schema. Absent such cue, the evidence that an agent is causally responsible of an object transfer is not sufficient to induce the representation of giving, as we showed in Chapter IV. Hence, even if presented with two transferring actions with obvious surface and kinematic similarities, targeting respectively an animate and inanimate recipient (motionless and unreactive: Figure 17), only in the former case infants should represent the action as giving, and consequently apprehend the transferred object as valuable.

To control for the possibility that infants may prefer the object transferred to the animate recipient not because given, but simply because involved in an exchange between two human actors, we compared the infants' object choice in a specular condition featuring two new objects taken from the two recipients. In relinquishing a resource, the costs paid by the agent can only be rationalized in the giving case by appealing to the benefits that the object brings to the recipient, whereas in acquiring a resource, the action costs can be interpreted as functional to generate material benefits for the agent herself, regardless of whether the object acquired was previously possessed by someone or not. It thus follows that both instances of taking should license inferences about the value of the acquired object (sufficient to motivate the agent to perform the action). On these bases, we predicted that infants should prefer the object involved in a transfer between two human actors selectively in the giving condition, while choosing at random between the two objects in the taking condition.

9.5.1 Methods

9.5.1.1 Participants

Sixteen 12-month-old (6 females; mean age = 363; age range = 342-373) participated in the study. Ten additional infants were excluded from the analyses due to inattentiveness (*n* = 2), not reaching for either object in one of the two test trials (*n* = 5), and maternal intervention (*n* = 3).

9.5.1.2 Procedure

Infants were presented with a familiarization phase (4 trials) featuring an actor placing an object (X) next to a second actor (animate patient) and a different object (Y) next to a big object (inanimate patient). Afterwards, a MC phase followed, during which infants were invited to chose one of the two objects previously acted upon. After the choice, infants were presented with a second familiarization phase (4 trials) featuring the same two actors and inanimate patient. This time, however, the actor was shown taking a new pair of objects (W and Z), each placed in the proximity of the animate and inanimate patient. At the end of the familiarization, a second MC featuring the WZ object pair followed.

9.5.1.3 Stimuli

Familiarization events. Infants were presented with two female actors (A and B), sitting around a table covered with a grey cloth. Actor A, sitting in front of the infant, wore a red sweater and a green hat. Actor B, sitting sideways, wore a grey t-shirt and a beige hat. The hats served to cover eyes and face so to avoid that facial expressions might contribute to the infants' interpretation of the events. Placed on the side opposite of B, a large pink paper lamp with a green ribbon on top acted as inanimate patient. In front of A there were two unfamiliar wooden objects different in colour and shape (X and Y).

The Giving Familiarization (12 s total running time) started with A placing her left hand onto X and pushing it towards the left corner until reaching the table edge close to the infant, in proximity to the inanimate patient (see Fig. 4), and then bringing her hand back to its initial position (palm-down on the table, next to her chest). After 2 s, a spatially specular action was performed with the right hand against object Y, pushed towards the right corner of the table, a few centimetres away from agent B. As in previous studies (see Chapter VI), we exclusively relied on physical proximity as cue of possession, which allowed us to match the "receipt" behaviour (or lack thereof) of inanimate and animate patient.

The Taking Familiarization was identical in length, timing, number of actions and spatial arrangements to the previous familiarization, with the only difference that now actor A was shown taking a new pair of objects (W and Z, also different in shape and colour) from the two patients and pulling them close to her chest. The objects were presented in the same location occupied after the displacement in the Giving Familiarization (each standing a few centimetres away from a patient).

In all familiarization events, actor A visually followed the objects that she was acting upon until the displacement was complete, and at the end of each familiarization, she always resumed her initial position, looking down in front of her. A pulsating sound (1 s) was produced whenever the displacement of an object was complete.

The patient's side (B on the left vs. on the right), the identity of the first patient to be targeted (B first vs. B second), the type of object pair used in each familiarization (XY vs. WZ), and the order of familiarizations (giving first vs. giving second) were counterbalanced across infants.

The two object pairs were selected from a total of 8 objects on the basis of a pilot study with 12 infants of similar age (recruited for another study) in which no preference for either object was found using an unstructured MC task.

Manual Choice phase. At the end of each familiarization, the MC phase started. E2 came out of the curtains, keeping a grey tray behind her back onto which two objects (X and Y or W and Z) were provisionally attached. She kneeled in front of the infant, greeted her, and only then held the tray in front of the infant. Infants had 30 s to perform a visually guided reach. If no choice was produced after 10 s, E1 produced a sound to tell E2 to repeat again the hiding-and-showing sequence. During the MC, E2 always kept gazing at the infant with a positive expression, breaking momentarily eye contact only when she had to hide the tray behind her back again.

Half of the infants were presented with the two objects on the tray in the same relative locations as those occupied on the table during familiarization. For the other half, the locations were swapped.

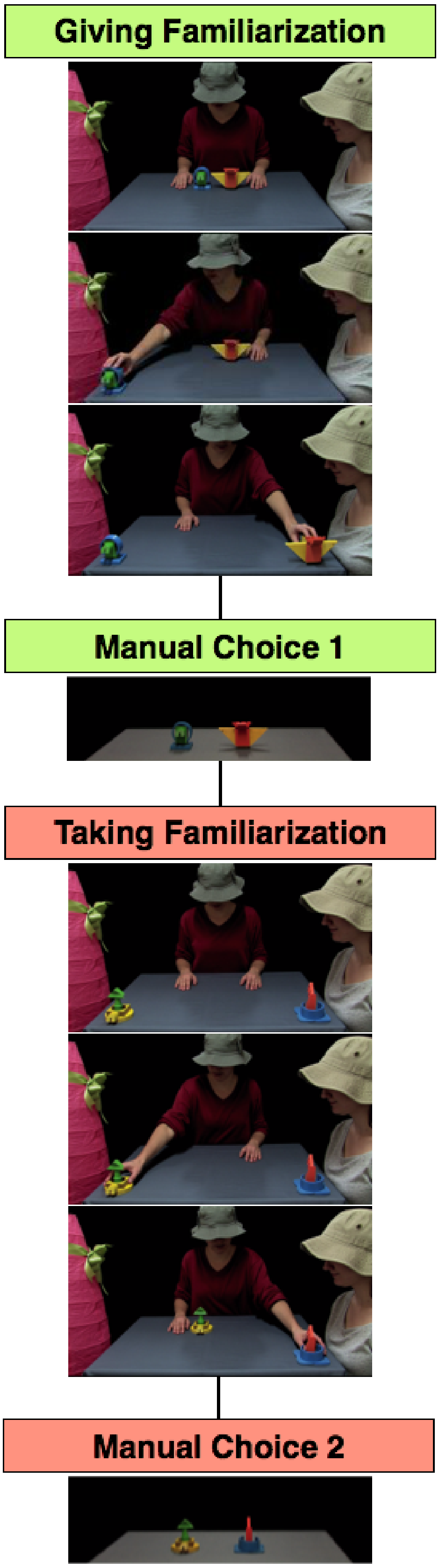

Figure 17. Schematic visualization of the design structure and stimuli material used in Study 4.

9.5.1.4 Coding and Data Analysis

To be included in the final analysis, infants were required to (1) watch each of the actions in all familiarization trials for at least 50% of their duration (5 s) or attend to two full trials for each familiarization type, and (2) produce visually guided reaches in both MC tests. LTs during familiarization were recorded from when the actor started to move her hand to when she put her back on the table.

9.5.2 Results and Discussion

The MC data did not reveal any preference for the object given to an animate recipient: 10/16 infants selected the object given to the animate patient (p = .454), while 9/16 selected the object taken from the same patient (p = .803). Infants who received the Giving familiarization first were no more likely to choose the object transferred to the animate recipient than infants who received the Giving familiarization second. Collapsing the data of the two tests together, we found neither a preference for objects transferred between humans (p = .371), nor a side bias (p = .139). Finally, a one-way ANOVA with averaged LT data across the four trials revealed no difference in how long infants attended to the two familiarization events: $F(1, 30) = 1.052$, p = .313.

The findings did not support the hypothesis that the observation of giving would automatically trigger an inference about the value of the transferred resource, in virtue of the fact that the goal of giving consists in producing benefits for a recipient via resource transfer. Such failure, we believe, may reflect an unwarranted inferential step assumed by our design: namely, that the object should be considered valuable not only for the recipient, but for the infant herself. Such generalization does not follow from our hypothesis and may have not been produced in our study. Indeed, infants presented with an actor emoting positively or negatively towards two objects do not interpreted these reactions as indicating value assessment generalizable to new actors (unless these referential emotions are preceded by ostensive signals: Egyed, Király, & Gergely, 2013). Moreover, the use of unfamiliar objects (of which infants presumably never formed a value assessment before) may have further inhibited such generalization. To obviate to this issue, future studies should either opt for paradigms not requiring generalizations or feature objects familiar to the infants and comparable in value (e.g., two types of food[39]).

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[39] Indeed, the hypothesis tested here was first developed on the backdrop of studies (e.g., Shutts, Condry, Santos, & Spelke, 2009) showing that human infants, unlike rhesus monkeys, failed to privilege edibility-diagnostic information (substance) over feature information when categorizing novel food. The authors interpreted such failure as indicating that core knowledge of food emerges only later in development, since human infants are not actively engaged in food selection. This conjecture gave traction to our conviction that, precisely because of their reliance of adult provisioning, infants may have been particularly prone to imbue of value objects that were actively handed over (by adults).

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