Preverbal infants' ability to encode the outcome of distributive actions

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Abstract

The present research examined whether10-month-old infants expect the agents perform equal or unequal distributions of resources. In Experiment 1, infants saw a donor performing either an equal distribution where one strawberry was given to each of two recipients, or an unequal distribution that favored one of the recipients. Infants looked longer at the unequal outcome test event, suggesting that they expected the strawberries to be distributed equally. In Experiment 2, the potential recipients were replaced with inanimate objects and infants’ looking times did not reveal a preference for one of the two outcomes of the test events. Experiment 3 controlled for the donors’ role as distributing agent – no preference was observed when the donor only revealed an equal or unequal initial allocation of resources. Experiment 4 (*N* = 16; *M* = 307 days) controlled for possible affiliative information provided by the agent’s movement. The donor made the same movements as in Experiment 1, but without strawberries, and no difference in looking times were observed. These findings support the view that preverbal infants are surprised when resources are distributed unequally among recipients. We discuss the possible links between such reactions and the emergence of an early sense of fairness.

Keywords

morality, infant cognition, social reasoning

Humans are very sensitive to being treated unfairly and typically react strongly when desirable resources are distributed inequitably. For instance, in bargaining games used by experimental economists, adult participants apparently behave irrationally in rejecting offers of cost-free money. From the "respondent's" perspective however, small offers might be conceived as unfair when the "proposer" retains a much larger amount, especially if the "proposer" was given the money by the experimenter without a corresponding effort (Nowak & Sigmund, 2000). Without any instructions of fair play, results like those obtained in economic games are typically explained in terms of a deeply rooted inherent sense of fairness. A crucial question for cognitive science is to what extent this sense of fairness stems from implicit socio-moral principles rather than from explicit verbal reasoning or even legally enforceable contracts (Fehr & Rockenbach, 2003).

Recent research suggests that a basic sense of fairness might be present even in infants and toddlers (Geraci & Surian, 2011; Meristo & Surian, 2013; Schmidt & Sommerville, 2011; Sloane, Baillargeon & Premack, 2012; Sommerville, Schmidt, Yun & Burns, 2013). Geraci and Surian (2011) showed infants simple animations in which one animal (e.g. a bear) distributed resources equally between two recipients, and another animal (e.g. a lion) performed an unequal distribution instead. During the distributive actions, a fourth animal (a chicken) just observed. In the test trials infants first saw the observer approaching either the fair or the unfair animal, and after that they where given the possibility to manually choose one of the two distributors. Results provided evidence for an emerging sense of fairness by showing that 16-month-olds, but not 11-month-olds, looked longer at the test trials showing the chicken approaching the fair agent. Additionally, 16-month-olds preferred to reach for the fair agent who had distributed resources equally between the two possible recipients, rather than the unfair agent who had given everything to one of the two recipients. In Sloane et al.´s

(2012) study, 19- to 21-month-old toddlers' watched test scenarios in which an experimenter distributed some objects to two identical puppets. In one trial the experimenter made an equal distribution giving one object to each puppet, whereas in the second trial, in the unequal scenario, one of the puppets received two objects. The toddlers looked reliably longer at the test scene after witnessing the unequal distribution of objects, suggesting that they expected the experimenter to divide the objects equally between two identical agents. Similar results in response to equal and unequal distribution events have been found with infants as young as 15 months by Schmidt and Sommerville (2011) who found that infants were surprised, as revealed by their longer looking times, when actors performed unequal rather than equal distributions.

Thus, a few recent experimental studies have found evidence suggesting an incipient sensitivity to inequity in infants during their second year of life in various contexts with natural agents and cartoon characters, different number of resources across categorical and continuous quantities, and measuring infants' responses through their looking times as well as preferential manual choices. However, in most previous studies have failed to find positive results in the first year of life, suggesting that the incipient sense of fairness may not emerge before the second year.

In two recent studies Meristo and Surian (2013, 2014) reported positive results even in 10-month- old infants. Infants' reactions to the rewarding (Meristo and Surian, 2013) and punishment (Meristo and Surian, 2014) of distributors were found to be related to the fairness of the distributions they performed. These results suggested that not only infants assign a positive/negative value to fair/unfair distributions, but also expect third parties to act in accordance to the principle of indirect reciprocity. This was particularly clear in the experiments on rewards that manipulated also the informational state of the reciprocator. If this agent had seen the distributors' actions, infants were surprised to see that he would reward the unfair agent rather than the fair one. If the agent was was not informed about the distributors' behavior, infants showed no specific expectations. These results provide the first evidence that an incipient sense of fairness may be emerge even in the first year of life. However, no previous published study has so far demonstrated that in the first year infants expect agents to perform equal distributions.

The origins of the sense of fairness however remain elusive and the question of how the ability to detect inequalities develops requires further detailed research. One prominent suggestion has long been that the socio-moral norms of how resources should be distributed are explicitly taught through verbal instructions and parent socialization, or are acquired via the interaction with peers, as such interaction forces the child to consider others' perspectives and take them into account in order to construct norms that can be widely accepted by social partners (Piaget, 1932). In line with these perspectives, previous studies have repeatedly found that preschoolers' distributions are typically guided by self-interest, but they tend to follow an egalitarian principle after reaching 6 or 7 years of age (see reviews, Smetana and Killen, 2014). For instance, when asked to distribute resources between themselves and others in several predetermined ways, the majority of 3 – 4-year-olds act selfishly, whereas most children at 7 – 8 years of age prefer an egalitarian distribution (Fehr, Bernhardt, & Rockenbach, 2008; see Shaw (2013) for a discussion of recent findings). Similarly, in bargaining games adapted for children, 3- to 5-year-olds keep most of the stickers or candies, while 9-year-olds show more egalitarian tendencies (Benenson, Pascoe, & Radmore, 2007; Rochat et al., 2009). The possible role of experience with observed distributions has been emphasized also by Sommerville et al. (2013) in discussing their findings and those reported by Geraci and Surian (2011), showing that before 15 months of age infants do not seem to show any evidence of surprise when looking at unequal (or equal) distributions.

Another perspective on the foundations of moral judgments emphasizes its evolutionary and biological roots, while not contradicting a gradual development of moral behavior. Within this perspective infants' early reasoning about fairness is proposed to be guided by innate principles that generate expectations about agents' behavior (Alexander, 1987; Boehm, 2012; de Waal, 2006; Fehr & Fischbacher, 2003; Gintis, Henrich, Bowles, Boyd & Fehr, 2008; Joyce, 2007; Nowak & Sigmund, 2005; Sober & Wilson, 1998). A sense of fairness and reciprocity have been suggested as fundamental preconditions for the development of cooperative behavior through human ontogeny and, possibly, phylogeny (Fehr & Fischbacher, 2003; Meristo & Surian, 2013; Tomasello, Melis, Tennie, Wyman, & Herrmann, 2012). Several studies have also demonstrated inequity aversion in non-human species such as chimpanzees (Brosnan, Schiff & de Waal, 2005) and capuchin monkeys (Brosnan & de Waal, 2003). For instance, capuchin monkeys are likely to reject a reward (a bit of cucumber) if their social partner is given a more valuable payment (a grape) for trials in which they performed equally. These findings support the view that emerging abilities to detect inequity and expect reciprocity do not depend on explicit teaching or verbal reasoning. Preverbal infants' ability to evaluate distributive actions would therefore make a stronger case for the inherent evolutionary predisposition to acquire a moral competence in humans.

Findings from several previous studies raise the possibility that infants might form expectations about simple distributive actions at even earlier ages than reported in the experiments described above (Geraci & Surian, 2011; Schmidt & Sommerville, 2011; Sloane et al., 2012). Recent research suggests that infants as young as 3 to 12 months of age are able to evaluate helping and hindering actions (Premack & Premack, 1997; Hamlin, Wynn &

Bloom, 2007; 2010). In a series of experiments Hamlin and colleagues have found that 10-month olds reach for the prosocial agent who previously helped another individual climb the hill, rather than the anti-social agent who instead hindered the climbing (Hamlin et al., 2007). Looking times further suggest that infants expected the climber to approach the helper, since they looked longer when the climber instead approached the hinderer. Similar findings are reported even with 3-month-olds, who preferentially look longer at the helper, compared to the hinderer, after witnessing their pro- vs. anti-social actions (Hamlin et al., 2010). Furthermore, young infants seem to be able to make even more nuanced social judgments of agents' actions that also consider the overall context in which the actions are performed (Hamlin et al., 2011). In particular, infants at 8 months of age showed evidence of incipient reasoning about indirect reciprocity when they preferred characters who acted pro-socially towards helping agents and punished hindering agents, as opposed to characters who rewarded hindererers and punished helpers. This early competence in evaluating helping and hidering actions suggest that young infants' ability to evaluate agents may also rely on other types of actions. Here we focused on agents' distributive actions.

Two further considerations led us to hypothesize that even infants during their first year of life might be able to form expectations concerning the distributions of resources that agents will perform. First, most previous studies on fairness reasoning in infants and toddlers have been carried out in the context of live events where research assistants distribute resources to puppets or real life adult experimenters (Sloane et al., 2012; Schmidt & Sommerville, 2011; Sommerville, Schmidt, Yun & Burns, 2012). Designing measures that instead include cartoon animations with characters based on simple geometric shapes might considerably simplify the test situation for very young infants (e.g. Csibra, 2008; Hamlin et al., 2007, 2010; Luo & Baillargeon, 2005; Mascaro & Csibra, 2012; Schlottmann, Surian & Ray, 2009; Thomsen, Frankenhuis, Ingold-Smith & Carey, 2011). The only previous study that has used schematic cartoons, rather than real life scenes in the context of fairness, is Geraci and Surian (2011), which also found evidence of a sense of fairness in 16-month-olds, but not in the younger 11-month-old group. In order to facilitate the performance of young infants on a test scenario of distributive events, it might be fruitful to try to keep the agents involved in such events to the minimum required. That is, a possible reason for why 11-month-olds failed to distinguish between the equal and unequal distribution events in Geraci and Surian (2011) might have been the total number of characters involved, which included two donors, two different recipients as well as a bystander. Thus, infants might be able to demonstrate an incipient ability to detect unfair outcome of distributive events even during their first year of life, in a test scenario involving only a few cartoon characters, which consists of very simple interacting geometrical shapes.

The present experiments therefore explored 10-month-old infants’ ability to form expectations about the outcome of distribution of resources. They were shown short animations where fair or unfair donors made equal or unequal distribution of two strawberries to two identical recipients. Given the lack of any information about the recipients’ relative needs or merits, such as working effort (as in Sloane et al., 2012), we hypothesized that infants would expect each recipient to receive one strawberry, rather than one receiving both strawberries and the other none.

Experiment 1

Method

Participants

Sixteen XXX 10-month-old healthy full-term infants (*M* = 306 days; *SD* = 6 days; 9 girls) were included. An additional four infants were tested but excluded because of a looking time of more than 7 *SD* from the mean (1), parental interference (1), or because they did not look at both test events (2).

Materials and procedure

Participating families were randomly chosen from the database of XXX Tax Agency among families who were living in the XXX area (XXX). Parents were informed about the purpose and procedure of the study and gave signed consent. Infants were tested at the Department of Psychology, University of XXX. The Regional XXX Ethical Review Board approved the study.

During the test session infants were seated on a caretaker’s lap in a dimly lit and quiet booth 50–70 cm from a 17-inch-monitor used to display the stimuli. The caretakers were asked to turn their head away from the screen and not to communicate with the infants during the testing. Infants’ looking behavior was recorded an analyzed using a Tobii T120 (Tobii Technology, Sweden) corneal reflection near infrared eye tracker. Each testing session began with a 5-points infant calibration procedure.

All infants saw three types of events: four in the *Donor Familiarization Phase*, two *in the Recipients’ Familiarization Phase* and two in the *Test phase*.

Donor Familiarization Phase. Infants saw an agent, a simple orange circle with eyes and mouth, moving from one side of the screen to the other, and back where it started. The rationale for this event was to familiarize infants with the donor who would later perform the distributive actions. The donor entered the screen from the right of the screen in two events and from the left side of the screen in the other two events of this phase.

Recipients Familiarization Phase. Infants were then shown two new events in which two yellow triangles, with eyes and mouth, entered the screen, one from the right side and the other from the left side, one at a time. An occluder was lowered after that, hiding the recipients (i.e. the yellow triangles) for one second. This was to familiarize infants with the agents who later played the role of recipients of strawberries and show that they remained still during the brief occlusion phase.

Test phase. Two test events followed, each starting with the two recipients in place on the upper part of the screen, and below them a Y-shaped path leading to each of them (see Figure 1). Next, the donor entered the scene bearing two strawberries and the occluder was lowered so that the recipients and the two-arms part of the Y-shaped path became hidden behind it. The donor entered the path from below twice, each time bearing one strawberry, and came out without the strawberry. In this phase of the event, infants only saw the donor entering the path, but they could not see where the strawberry was left. When the donor ended both distributions, the occluder moved out of the screen, revealing one strawberry in front of each recipient in the Equal test event, or both strawberries in front of only one of the two recipients in the Unequal test event. The whole sequence lasted for 15 seconds, after which the animation froze.

The following variables were fully counterbalanced across participants resulting in 16 different testing sessions: (i) order of the donor's motion direction of the four events in the Donor Familiarization Phase (Left Right Right Left vs. Right Left Left Right), (ii) side of the Recipients' entrance in the two events of the Recipient Familiarization Phase (Left first vs. Right first), (iii) order of the two test events (Equal Distribution – Unequal Distribution vs. Unequal Distribution – Equal Distribution) and (iv) side of the 'lucky Recipient' in the Unequal Distribution test event.

All infants followed the key sequences of all events in both familiarization phases, and were attentive throughout the whole procedure; they looked on average for 10.6 of the 12 seconds in the events of the Donor Familiarization Phase, and 13.5 of the 16 seconds in the events of the Recipient Familiarization Phase. We measured infants' looking times from the moment when the strawberries became visible from behind the occluder and infants could witness the final (Equal or Unequal) outcome of the distribution until they looked away from the screen for more than 2.5 consecutive seconds.

Results

Infants looking times at the end of the test events were analyzed using a two-way ANOVA with type of test event (Equal vs. Unequal) as within-subject factor and presentation order (Equal first vs. Unequal first) as between-subject factor. There was a significant main effect for type of test event, with infants looking longer at the unequal distribution of the strawberries (M = 11.0 sec, SD = 6.6 sec) than at the equal distribution (M = 6.9 sec, SD = 4.7 sec), $F_{(1, 14)} = 8.12$, $p = .013$, $\eta_p^2 = .37$ (Figure 2). There was no main effect for presentation order, $F_{(1, 14)} = 1.12$, $p = .307$, $\eta_p^2 = .07$, but there was also a significant order x event interaction effect, $F_{(1, 14)} = 11.24$, $p = .005$, $\eta_p^2 = .45$. Infants who saw the equal distribution test event first looked equally long at the following unequal distribution test event (M_{Equal} = 8.18 sec, SD = 5.30 sec; $M_{Unequal}$ = 7.46 sec, SD = 4.61 sec; $t(7) = 0.37$, $p = .723$). By contrast, infants who received the reversed order looked longer at unequal than equal distributions ($M_{Unequal}$ = 14.58 sec, SD = 6.64 sec, M_{Equal} = 5.64 sec, SD = 3.81 sec; $t(7)$ 4.23, $p < .004$). Therefore, the present findings of a within-subject design suggest that infants' looking behavior was affected both by their expectations of an equal distribution, and by a habituation process due to seeing more than one distributive test event in a row (see Mascaro & Csibra, 2010 for similar order effect).

The examination of the individual responses revealed that 13 out of 16 infants looked longer at the unequal event compared to the equal event (cumulative binomial probability, $p = .011$). We also conducted two additional two x two mixed ANOVAs with type of test event (Equal vs. Unequal) as within-subject factor and the counterbalanced factors as the between-subject factor, i.e. order of motion direction in the events of Donor Familiarization phase, and side of the recipients' entrance in the events of Recipients Familiarization phase 2. There were no main effects of the two counterbalanced factors or significant interaction effects (*p*'s > .59).

Thus, these results indicate that 10-month-old infants expect the outcome of distributive actions between two identical recipients to be equal, and are surprised as suggested by their longer looking times when the recipients end up with an unequal amount of strawberries.

However, it is possible that infants' looking times were influences by some lower-level visual-perceptual factors such as a preference for symmetrical outcome in the equal distribution test events. To test the possibility that the pattern of results in Experiment 1 was due to such visual factor, we carried out Experiment 2, where we replaced the self-moving animate recipients of strawberries with two inanimate objects (two bottles), and left everything else identical to Experiment 1.

Experiment 2

Method

Participants

A new group of 16 XXX healthy full-term 10-month-olds (*M* = 303 days; *SD* = 5 days; 6 girls) participated in Experiment 2. An additional 5 infants were tested but excluded from the sample because they did not watch both test events (2), or the looking time was more than 7

SD from the group mean (1), because of fuzziness (i.e. the infant moved too close to the screen where the stimuli was presented and thus out of the eye tracking range in the final test event) (1), or experimenter error (i.e. the final test event was accidentally ended before the look-away-criterion was met) (1).

Materials and procedure

The procedure in Experiment 2 was identical to Experiment 1, except that the two self-moving agents that played the role of recipients in Experiment 1 were replaced with two identical bottles. We chose bottles as inanimate object because previous experiments have shown that infants do not categorize artifacts, such as cups and bottles, as agents in the absence of any dynamic feature that is typical of agents such as autonomous and semi-rigid motion (Surian & Caldi, 2010). Similar artifacts have been also used with older infants in a previous control study by Geraci and Surian (2011).

Donor and Recipients Familiarization Phases. All infants began with the same four familiarization events used in Experiment 1 where an agent was moving on a path from one side of the screen to the other, and then back again where it started. *In the Recipients Familiarization Phase*, two bottles were pushed into the scene from the left and right side by a brown wooden stick. This was followed by a short occlusion event in which the bottles were hidden behind an occluder for one second.

Test phase. All infants were shown two test events (see Figure 3). In the equal event the donor placed one strawberry in front of each bottle, while in the second event, the unequal event, both strawberries were being placed in front of only one of the two bottles. Like in Experiment 1, the donor’s movements in the test events were largely invisible to the infants because an occluder was lowered over the upper part of the scene. At the end of the test event the occluder was removed, revealing either a symmetrical (‘equal distribution’) or an asymmetrical (‘unequal distribution’) displacement of the two strawberries.

(i) The order of the donor’s motion direction in the four events in Donor Familiarization Phase 1 (Right Left Left Right vs. Left Right Right Left) and (ii) side of entry of bottles in Recipients Familiarization Phase (Left Right vs. Right Left), as well as (iii) the order of the test events (Equal – Unequal vs. Unequal – Equal) and (iv) the side of the strawberries in the unequal test event (Left vs. Right) were fully counterbalanced across participants resulting in 16 different testing sessions.

All infants followed the key sequences of all events in both familiarization phases and were thus attentive throughout the whole procedure; they looked on average for 11.1 of the 12 seconds in the events of the first familiarization phase, and 11.5 of the 13 seconds in the events of second familiarization phase. Looking times in the test trials were coded from the moment at which the strawberries became visible, following the removal of the occluder.

Results

A two-way ANOVA was carried out with the type of test event (Equal vs. Unequal) as the within-subject factor and the order of presentation (Equal first vs. Unequal first) as the between subjects factor. There was no significant main effect for type of test event, $F_{(1, 14)} = 1.11$, $p = .311$, $\eta_p^2 = .07$, showing that the infants found both kinds of test events equally interesting (equal event: $M = 9.4$ sec, $SD = 5.3$ sec; unequal event: $M = 8.0$ sec; $SD = 5.0$ sec) (Figure 2). The main effect for order was also not significant, $F_{(1, 14)} = 1.51$, $p = .240$, $\eta_p^2 = .10$. Similarly, there was no significant interaction effect between type and order of test events, $F_{(1, 14)} = 2.23$, $p = .157$, $\eta_p^2 = .14$; infants looked at the two types of test events for approximately the same time both when they saw the equal event first ($M_{Equal} = 9.72$ sec, $SD = 4.96$ sec; $M_{Unequal} = 10.30$ sec, $SD = 5.80$ sec), and when they saw the unequal test event first

($M_{Unequal}$ = 5.69 sec, *SD* = 2.77 sec; M_{Equal} = 9.04 sec, *SD* = 6.03 sec). 8 out of 16 infants looked longer at the equal compared to the unequal test event (cumulative binomial probability, *p* = .598). We also ran two ANOVAs with type of test event (equal vs. unequal) as the within-subject and the counterbalanced factors as the between subject factor, i.e. the order of events in Donor Familiarization Phase in the first ANOVA, and the order of events in 'Recipients' Familiarization Phase in the second ANOVA, that did no yield any significant main or interaction effects (*p*'s > .19).

Important to our hypothesis, a 2 (Experiment: 1 vs. 2) x 2 (test event: equal vs. unequal) ANOVA showed a significant interaction effect, $F(1,30) = 5.62$, $p = .024$, $\eta_p^2 = .16$, but did not yield any main effects (*p*'s > .24). Therefore, the combined results of Experiments 1 and 2 suggest that 10-month-old infants expect identical self-moving agents to receive an equal amount of resources in a distributive event, and rule out an alternative lower level perceptual interpretation of the data based on the role of symmetry (i.e. a surprise for asymmetrical motions or displacement of objects).

Experiment 3

Method

Participants

A new group of 16 XXX healthy full-term 10-month-olds (*M* = 305 days; *SD* = 7 days; 8 girls) participated in Experiment 3. An additional 5 infants were tested but excluded from the sample because the child moved out of the eye tracking range in one or both test events.

Materials and procedure

The procedure in Experiment 3 was identical to the previous experiments. The difference was that in the test phase, the donor did not distribute the strawberries, but only showed that they were equally or unequally allocated from the beginning.

Donor and Recipients Familiarization Phases. All infants saw the same four Donor Familiarization Phases used in Experiment 1. The Recipients Familiarization Phases differed only in that the infants did not see an occluder hide the triangles in the end.

Test phase. All infants were shown two test events. The donor first entered the scene where the Y-shaped path was visible but the area below the two recipients was covered with two squares (see Figure 4). Instead of distributing the strawberries the donor moved to each recipient and removed the square below. In the equal event the donor revealed that there were one strawberry in front of each recipient, while in the unequal event, the donor revealed that both strawberries were being placed in front of only one of the two recipients. Unlike Experiment 1 and 2, the donors’ movements in the test events were visible to the infant during the test phase. Like in previous experiments all variables in all three phases were fully counterbalanced.

All infants followed the key sequences of all events in both familiarization phases and were thus attentive throughout the whole procedure; they looked on average for ??? of the 12 seconds in the events of the first familiarization phase, and ??? of the 13 seconds in the events of second familiarization phase. Looking times in the test trials were coded from the moment at which the donor returned to the bottom of the screen after removing both occluders until the infants looked away from the screen for more than 2.5 consecutive seconds.

Results

A two-way ANOVA was carried out with the type of test event (Equal vs. Unequal) as the within-subject factor and the order of presentation (Equal first vs. Unequal first) as the between subjects factor. There was no significant main effect for type of test event, $F_{(1, 14)} = 0.03$, $p = .860$, $\eta_p^2 = .01$, showing that the infants found both kinds of test events equally interesting (equal event: $M = 11.96$ sec, $SD = 11.32$ sec; unequal event: $M = 12.35$ sec; $SD =$

12.96 sec). There was no main effect for order $F_{(1, 14)} = 0.50$, $p = .49$, $\eta_p^2 = .04$, but an interaction effect between type and order of test events, $F_{(1, 14)} = 18.58$, $p = .001$, $\eta_p^2 = .57$. Infants looked longer at the unequal event when this was presented first compare to last ($M_{Unequal\ first} = 17.03$ sec, $SD = 16.62$ sec; $M_{Unequal\ last} = 7.67$ sec, $SD = 5.80$. A t-test for the groups who saw unequal first and last revealed no significant difference in looking times ($t_{(14)} = -1.50$, $p = .15$).

Experiment 4

Infants as young as 16 months can encode social partnership information from simple cooperative interactions (Rodhes, Hetherington, Brink and Wellman, in press). So, one possible explanation for the positive results in Experiment 1 is that infants formed expectations about affiliation behavior (i.e., the expected an agents to affiliate with both possible partners) trather than expections about their distributive hebaviors. We investigated this hypothesis in Experiment 4 by having agents approaching either both partners or just one possible partner, but without any distribution performed. If the presence of distrbutive behavior was critical in Experiment 1, than no difference should be found in looking times at the test events of Experiment 4.

Method

Participants

A new group of 16 XXX healthy full-term 10-month-olds (*M* = 307 days; *SD* = 8 days; 9 girls) participated in Experiment 4. An additional 5 infants were tested but excluded from the sample because the child moved out of the eye tracking range in one or both test events.

Materials and procedure

The procedure in Experiment 4 was identical to Experiment 1, except that donor had no strawberries to distribute but only made similar movements.

Donor and Recipient Familiarization Phases. These phases were identical to Experiment 3.

Test phase. All infants were shown two test events (see Figure 5). In the equal event the donor first moved to the first recipient and then moved to the second recipient. In the unequal event, the donor moved twice to one of the recipients. Unlike Experiment 1, the donor had no strawberries to distribute. Like in Experiment 3, the donors' movements in the test events were visible to the infant during the test phase. Like in previous experiments all variables in all three phases were fully counterbalanced.

All infants followed the key sequences of all events in both familiarization phases and were thus attentive throughout the whole procedure; they looked on average for ??? of the 12 seconds in the events of the first familiarization phase, and ??? of the 13 seconds in the events of second familiarization phase. Looking times in the test trials were coded from the moment at which the donor returned to the bottom of the screen after removing both occluders until the infants looked away from the screen for more than 2.5 consecutive seconds.

Results

A two-way ANOVA was carried out with the type of test event (Equal vs. Unequal) as the within-subject factor and the order of presentation (Equal first vs. Unequal first) as the between subjects factor. There was no significant main effect for type of test event, $F_{(1, 14)} = .01$, $p = .934$, $\eta_p^2 = .01$, showing that the infants found both kinds of test events equally interesting (equal event: $M = 15.1$ sec, $SD = 10.4$ sec; unequal event: $M = 14.8$ sec; $SD = 15.5$ sec) (Figure 5). There was no main effect for order $F_{(1, 14)} = 0.70$, $p = .42$, $\eta_p^2 = .05$, but an interaction effect between type and order of test events, $F_{(1, 14)} = 30.38$, $p = .001$, $\eta_p^2 = .69$. Infants looked longer at the unequal event when this was presented first compare to last

($M_{Unequal\ first}$ = 21.57 sec, *SD* = 19.92 sec; $M_{Unequal\ last}$ = 8.06 sec, *SD* = 3.93 sec). A t-test for the groups who saw unequal first and last revealed no significant difference in looking times ($t_{(14)}$ = -1.88, p = .08).

General Discussion

The present study investigated whether infants at 10 month of age expect that agents will distribute resources among identical recipients. Consistent with a positive answer to this question, in Experiment 1 infants looked reliably longer at the outcome of the unequal distributive events than at the outcome of the equal distributions where strawberries were given to two identical animate recipients. The results of Experiments 2-4 help to rule out three deflationary explanations. In Experiment 2 there were no differences in infants' looking times between the equal and the unequal displacement of strawberries in front of two bottles, a result that rules out the effect of perceptual factors, such as symmetry. In Experiment 3, infants where shown equal or unequal initial endowments of resources and did not look longer to one of the two test events, suggesting that what produced the longer looks in the unequal distributions test events of Experiment 1 were indeed due to the distributive actions, rather than simply the different final allocation of resources, which was similar in Experiments 1 and 3. Finally, Experiment 4 provides evidence against an alternative explanation based on infants' sensitivity to affiliation behavior. We have assumed so far that the main factor driving infants' reactions to different distributions was the differential outcome of objects distributed. However, such outcomes are typically associated with approaching motions that may be encoded by infants as manifesting agents' affiliations with the other agents present in the scenario. In Experiment 4, the approaching behavior was manipulated, but no resources were distributed, and infants did not look longer at events shown evenly distributed approaches as opposed to biased approaches favoring one of the two possible other agents that were present on the context, while ignoring the other one. This suggests that the results reported in previous experiments involving distributions were not simply due to a reactions to differences in the affiliation behaviors shown by the agents, since clear differences in such behaviors were also presented in Experiment 4, but did not yielded any difference in infants looks at the test events. Together these four experiments reported here suggest the presence of an expectation about the distributive behavior of agents in very young infants, which may constitute an important building block in the development of a sense of fairness

These findings are thus consistent with the view that infants' interpretations of the outcome of distributive events might be guided by an innate psychological-reasoning system that was selected for encoding agents' behavior and evaluate basic aspects of fairness (Geraci & Surian, 2011; Meristo & Surian, 2013; Schmidt & Sommerville, 2011). The result of this study provides strong evidence for the claim that the failure of those previous studies in finding expectations of fair distributions in infants in the first year of life was due to factors pertaining to the experimental procedure, not to infants' complete inability to generate such expectations. Future studies are needed to investigate systematically the effect of factors that are likely to increase the cognitive load required in these situations, such as total duration of the test procedure and the presence of some introduction to the characters prior to test. Such introduction was provided in Meristo and Surian (2013) and in Experiment 1 of the present study, though not in Geraci and Surian (2011).

. By at least 10 months of age infants seem to be able to distinguish between equal and unequal allocation of resources when observing others' actions, and expect their behavior to comply with an abstract egalitarian principle of conduct.

The present findings suggest that infants encode the outcome of distributive actions and are surprised when such outcomes present a departure from equal distributions. It will be important for future studies to determine the role and nature of donors in events involving distributive events. For example, do young infants expect agents to have equal amounts of resources only as a result of a distributive event, or even in test scenarios where agents end up with equal amount of resources as a result of accidental events? Experiment 2 demonstrates that it is critical for infants' fairness reasoning that the recipients of strawberries are agents as determined by the presence of agent-like dynamical features

It is possible that at this early age infants may not yet have the ability to detect the violation of basic fairness norms, but instead base their evaluation of the test events on an observed regularity in social interactions about how resources typically are divided between individuals (Sommerville et al., 2013; Turiel, 2002). However, goods might not be systematically distributed equally in everyday life and thus it is unlikely that such regularity can be easily learned through statistical regularities in daily interactions with others, not the least at that very early age. Also, experiments with 16-month-olds show that infants preferentially choose to interact with a fair donor, which supports the claim that they evaluated that agent positively, rather than representing the actions as more typical compared to the unequal event (Geraci & Surian, 2011). Another important piece of relevant evidence was reported by Schmidt and Sommerville (2011) who found a significant association in 15-month-olds between individual differences in preferential looking at the unequal test event, and altruistic sharing of a preferred toy. Infants, who were more attentive to the fairness of distributing cookies, were more likely to share toys with a research assistant. This is an important finding because it shows that infants' ability to detect inequalities in distributions is positively associated with their propensity in engaging in altruistic actions.

Another central topic for future investigations concerns whether and how infants’ social evaluation skills interact with their theory of mind competence. A rich body of recent literature indicates that preverbal or barely verbal infants are able to reason about agents’ true and false beliefs and predict agents’ actions by relying on such attributions (e.g., Kovacs, Teglas & Endress, 2010; Meristo, Morgan, Geraci, Iozzi, Hjelmquist, Surian & Siegal, 2012; Onishi & Baillargeon, 2005; Song, Onishi, Baillargeon & Fisher, 2008; Surian, Caldi, & Sperber, 2007; Trauble, Marinovic & Pauen, 2010; see Baillargeon, Scott & He, 2010 for a review). Since mental state reasoning interacts with moral evaluation processes in young children (e.g., Leslie, Knobe & Cohen, 2006; Pellizzoni, Siegal & Surian, 2009), as well as in adults (e.g., Young, Cushman, Hauser & Saxe, 2007), it would be crucial to investigate the emergence of such interaction in infants. A first step in this direction has been reported in Meristo and Surian (2013) where 10-month-olds infants appeared to generate different expectations of reciprocity among agents who did or did not witness previous distributive actions. Additionally, future studies focusing on motivational states of donors in distribution scenarios will be of great value to examine infants’ ability to evaluate the fairness of different types of distributions. That is, crucial comparisons would involve distinguishing distributors with prosocial and antisocial intentions whose actions bring unfair outcomes for the recipients (Dunfield & Kuhlmeier, 2010).

Finally, developmental research will need to explain the gap between the incipient competence about fairness principles found in infants and the poor performance of young children when themselves are asked to perform distributions. In situations in which young children are themselves recipients of the distributions, concern for fairness typically succumb to selfish interests. However, by the age of 4 years, children are also constrained by need to appear fair, which may be a prerequisite to be chosen as social partner in cooperative activities. Self-interest may not be sole factor necessary to explain the knowledge-behavior gap. Other possible factors appear to be the relative personal advantage, as revealed by children's choices in ultimatum game like test situations, and the processes by which rewards are acquired, as claimed by Blake, McAuliffe and Warneken (2014). As for the timing of the development in children 's ability to follow their knowledge of fairness principles when performing distributions, a recent theoretical proposal is that the onset of such ability may be explained by life-history analysis, an evolutionary perspective that was originally developed to explain the timing of appearance of morphological and physiological features, such as sexual maturation, but that has been recently extended to psychological traits, including fairness in distributive actions (Shewskin, Chevalier, Lambert & Baumard, 2014). The need to rely on cooperation with peers for gaining access to vital resources is at the center of these explanation, as it was in the classic Piagetian proposal, but unlike in Piaget (1932), the developmental timing in life-history analyses is derived by cost-benefits trade-off that shaped the optimal time for developmental onset of specific traits.

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Figure 1. Schematic illustration of the test phase in Experiment 1. A donor distributed two strawberries either equally or unequally between two identical recipients.

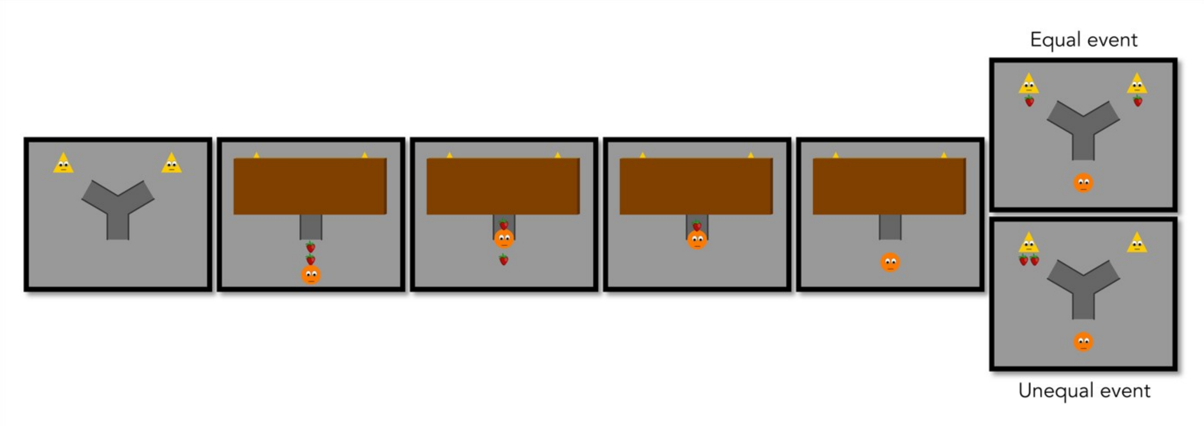

Figure 2. Average looking times (± 1 SE) in Experiments 1 and 2 at the two test conditions: the equal and the unequal distribution of strawberries.

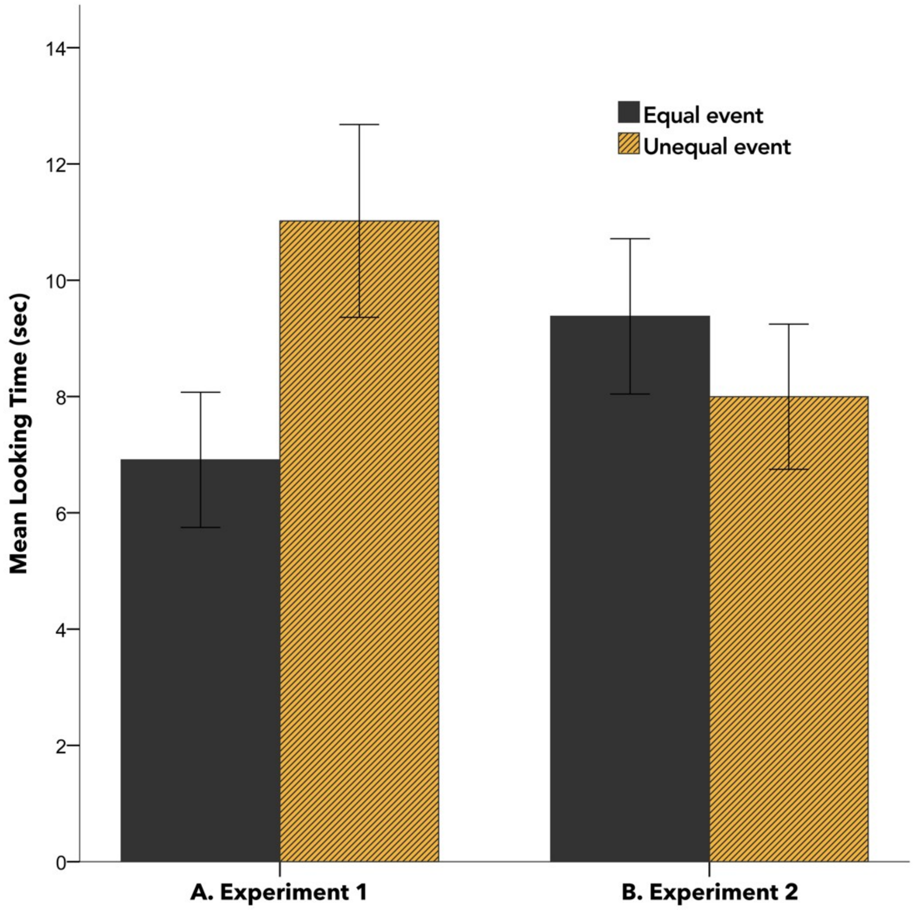

Figure 3. Schematic illustration of the test phase in Experiment 2. A donor placed two strawberries either equally or unequally in front of two identical bottles.