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PAPER

Sensitivity to communicative relevance tells young children what to imitate

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Abstract

How do children decide which elements of an action demonstration are important to reproduce in the context of an imitation game? We tested whether selective imitation of a demonstrator's actions may be based on the same search for relevance that drives adult interpretation of ostensive communication. Three groups of 18-month-old infants were shown a toy animal either hopping or sliding (action style) into a toy house (action outcome), but the communicative relevance of the action style differed depending on the group. For the no prior information *group, all the information in the demonstration was new and so equally relevant. However, for infants in the* ostensive prior information *group, the potential action outcome was already communicated to the infant prior to the main demonstration, rendering the action style more relevant. Infants in the* ostensive prior information *group imitated the action style significantly more than infants in the* no prior information *group, suggesting that the relevance manipulation modulated their interpretation of the action demonstration. A further condition* (non-ostensive prior information) *confirmed that this sensitivity to new information is only present when the 'old' information had been communicated, and not when infants discovered this information for themselves. These results indicate that, like adults, human infants expect communication to contain relevant content, and imitate action elements that, relative to their current knowledge state or to the common ground with the demonstrator, is identified as most relevant.*

Introduction

The ubiquity of human imitation gives the impression of an ability that is a trivial feat. We inadvertently imitate one another during social interactions (Chartrand & Bargh, 1999), newborn infants imitate the facial expressions of their caregivers (Meltzoff & Moore, 1983), and, by about 9 months of age, human infants spontaneously begin to imitate the actions of others. Recent findings from social neuroscience have led to the suggestion that a dedicated neural mechanism, which maps observed behaviours directly onto the observer's own motor system, may exist to sub serve this ability (Iacoboni, Woods, Brass, Bekkering, Mazziotta & Rizzolatti, 1999).

However, as several authors have noted, imitation requires not only the ability to map observed behaviours onto one's own body, but also cognitive mechanisms to select which behaviours are necessary to be imitated (Gergely & Csibra, 2006; Brugger, Lariviere, Mumme & Bushnell, 2007; Csibra, 2007; Southgate & Hamilton, 2008). The capacity to identify relevant behaviours for reproduction is essential for imitation to have evolved as an efficient tool for cultural transmission (Boyd & Richerson, 1985; Galef, 1992; Tomasello, 1999). As a number of studies have shown, children do not blindly imitate every action that they observe. For example, 12- and 14-month-old infants take into account the action constraints of the demonstrator, and appear to modulate their imitation depending on whether their own situation is subject to the same constraints (Gergely, Bekkering & Kiraly, 2002; Schwier, van Maanen, Carpenter & Tomasello, 2006). In another study, infants at 18 months did not imitate what an experimenter actually did when she failed to achieve a goal – they imitated what she had intended to do (Meltzoff, 1995).

In a recent paper, Carpenter, Call and Tomasello (2005) argued that infants imitate actions in terms of what they think the demonstrator's goal is. In their study, when 12- and 18-month-olds were shown a toy mouse either hopping or sliding into a toy house, infants selectively imitated putting the animal in the house, but did not imitate the particular means (hopping or sliding) by which the animal went into the house. However, when there was no house present and they were shown the animal simply hopping or sliding around a mat, infants at both ages imitated the action style. Similar findings were reported in a different paradigm and in older children by Bekkering, Wohlschlager and Gattis (2000). The authors concluded that infants copied actions in

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terms of goals: when there was a clearly visible goal (e.g. a house), infants interpreted the outcome as the goal (putting the mouse into the house), but when there was no visible goal, infants interpreted the action style (e.g. hopping or sliding) as the goal. Thus, since one could reproduce behaviours at a number of different levels (Byrne & Russon, 1998; Csibra, 2007), one can isolate relevant from irrelevant actions by identifying the goal of a particular action, and imitating at the goal level, disregarding any lower-level components that do not appear to be causally related to the desired outcome. That infants as young as 14 months are capable of identifying causally relevant actions and imitating on this basis has been demonstrated by Brugger and colleagues (Brugger *et al.*, 2007).

However, some authors have argued that, unlike the many documented instances of other animal cultures (e.g. Laland & Hoppitt, 2003; Rendell & Whitehead, 2001; Whiten, Goodall, McGrew, Nishida, Reynolds, Sugiyama, Tutin, Wrangham & Boesch, 1999), the goals and the causal relations between performed actions and their outcomes are often not immediately obvious in human cultural practices (Gergely & Csibra, 2006). This *cognitive opacity* will often render selective imitation, on the basis of goal identification, impossible. For example, humans engage in tool making for which, to a naïve observer, there may appear no immediate and visible goal at the time of construction, and perform rituals that do not reveal how they are supposed to work. If much of human culture consists of such cognitively opaque practices, it would make little sense for infants' observational learning to be driven solely by the identification of goals.

To cope with this problem of cognitive opacity, Gergely & Csibra (2005, 2006) have proposed that, as part of a suite of evolved adaptations, imitation has been selected to be sensitive to the communicative intent of the demonstrator. By this account, infants' interpretation of action demonstrations directed to them is based on the same pragmatic assumptions that human adults employ when engaged in communicative interactions with others (Sperber & Wilson, 1986). One of these assumptions is that the communication is in some way relevant to the recipient, where relevance is determined in relation to the knowledge state of the individual. Thus, any information that is not already possessed by the recipient, or could not be inferred on the basis of her knowledge, will be identified as relevant, and as the intended content of the demonstration. That communication plays a role in imitation is suggested by a number of recent studies showing that selective imitation in the second year of life is influenced by the presence or absence of ostensive communication (Brugger *et al.*, 2007; Kiraly, Csibra & Gergely, 2004; Nielsen, 2006), findings that are inconsistent with the proposal that infants simply imitate observed actions in terms of perceived goals.

The present study aimed to test the hypothesis that the role played by communication in imitation is the expectation of relevance that it elicits in recipients. Specifically, we predicted that human infants seek relevance in others' communication and selectively imitate what they infer to be the communicatively most relevant part of action demonstrations. We modelled our task after the paradigm used by Carpenter and colleagues (2005), described above. However, in our version, we varied the communicative relevance of some aspects of the information that 18-month-old infants received in each of three groups. Infants in the first group received a demonstration in which all of the information demonstrated to them was new (no prior information condition). In this condition, infants watched as an experimenter either hopped or slid a toy animal into a toy house. In another condition (ostensive prior information), infants were first told and shown that the animal lives in the house, before seeing the same demonstration of the animal either hopping or sliding into the house. By showing infants that the animal lives in the house prior to the main demonstration, the placing of the animal into the house becomes 'old' information and should, if infants are sensitive to communicative relevance, receive less attention and processing resources than the 'new' information in the demonstration (the manner in which the animal moves). Our hypothesis was thus that infants who receive prior information would imitate the manner by which the experimenter moved the animal more than infants in the other condition in which all information is new. We expected that without prior information infants would perform as they did in Carpenter *et al.* (2005), and selectively imitate at the hierarchically highest level, putting the mouse into the house without reproducing movement style.

Our predictions here are based on the assumption that it is the communicative context that generates the expectation that the demonstrator is going to manifest some relevant information for them (Gergely & Csibra, 2006). However, the expectation that communication is relevant is proposed to derive from a more general *cognitive* principle of relevance (Sperber & Wilson, 1986), which describes the fact that human cognition is geared to the maximization of relevance (i.e. attend to information providing the most cognitive effects using the least processing resources). Thus, it is also possible that infants would simply attend more to the new information because of the greater cognitive effects it brings them, but that this relevance seeking is not related to the interpretation of the communicative intent of the demonstrator. To control for this possibility, we included a third condition (non-ostensive prior information), in which infants discovered for themselves that the animal could go in the house before the full demonstration. In this way, the action outcome component still constitutes cognitively 'old' information for the infant when it is subsequently ostensively demonstrated by the experimenter, but, crucially, it is not 'old' information in the communication. If infants' imitation is driven by a sensitivity to communicative (rather than just cognitive) relevance, then even if they already know that the animal

can go in the house, they should nonetheless treat this information as a relevant element of the experimenter's communication. As such, we predicted that infants in this condition would behave as they do without prior information, imitating predominantly the action outcome, and ignoring the action style.

Method

Participants

Thirty-nine infants aged 18 months (M = 18.1; range 17.5–18.5 months; 22 boys and 17 girls) were recruited from a database of infants volunteered by their parents for participation in studies. Thirteen infants were assigned to each of the three conditions. A further 10 infants were tested but excluded from the final sample because of parental interference (3), the child refused to participate (6) and experimenter error (1). Four of the excluded infants were from the ostensive prior information condition, two were from the no prior information condition, and four were from the non-ostensive prior information condition.

Materials

A table with a black mat measuring 60 cm × 42 cm and a small cardboard house measuring 6 cm × 6 cm × 12 cm were used to demonstrate the actions. Four small toy animals (a squirrel, a rabbit, a mouse, and a monkey) were used to demonstrate the actions.

Procedure

Infants sat on a caregiver's lap at a small table facing the experimenter. To familiarize the infant with the materials, the experimenter first showed the infant the four toy animals and allowed the infant to play with them for about 1 minute. The animals were then removed from the table and the experimenter uncovered the house and drew infant's attention to it, by pointing to it. Then, in the ostensive prior information condition, the experimenter brought out one of the four animals (randomly selected), showed it to the infant, and then from the back of the house, placed the animal inside the house saying '*Look, the (animal) lives in the house. This is where he lives*'. Following this, the experimenter took the animal out of the house again, said to the infant '*Look, I*'m going to show you what the (animal) does', placed it in front of the infant, and demonstrated the animal sliding or hopping into the house, saying '*Look, the (animal) went into the house*'. The experimenter then removed the animal from the house, placed it in front of the infant and said '*Now it*'s your turn!' In the no prior information condition, after engaging in the same warm-up, the experimenter brought out the first animal, showed it to the infant, but instead of placing the animal in the house, she simply talked for an equivalent amount of time about some aspect of the animal (e.g. '*Look, the squirrel has a big bushy tail*'). Following this, the experimenter followed the same script as in the ostensive prior information condition, placing the animal in front of the infant, saying '*Look, I*'m going to show you what the (animal) does', and modelling an action by which the animal moved into the house, commenting finally '*Look, the (animal) went into the house*'. Again the animal was then placed in front of the infant for their turn. In the non-ostensive prior information condition, after engaging in the same warm-up, the experimenter simply gave infants one of the animals and said, '*Here, do you want to play with the (animal)*?' At this point, infants were left to do what they wanted with the animal until the point where the infant placed the animal inside the house. If infants appeared fixated on the animal for more than about 30 seconds, the experimenter took the animal away, drew their attention to the house again, and then returned the animal to the infant. Crucially, the experimenter never instructed the infants, or suggested to them, to place the animal in the house, and so they acquired this information non-communicatively. All infants included in the sample placed the animal in the house on each trial within 90 seconds (mean = 16 seconds). As soon as the infant had placed the animal in the house, the experimenter took the animal out of the house and performed the same demonstration as in the other conditions, saying '*Look, I*'m going to show you what the (animal) does', demonstrating the action, and placing the animal in the house saying '*Look, the (animal) went into the house*'. The experimenter again then placed the animal in front of the infant for their turn.

Infants in all conditions received a total of four trials, each with a different animal, with a fixed order of actions demonstrated (slide, hop, hop, slide). This fixed order was chosen because pilot testing suggested that hopping was a more familiar and more easily executable action for 18-month-olds, and presenting hopping as the first action often led infants to continue to hop on subsequent trials, irrespective of what the experimenter had demonstrated. Each demonstration of hopping or sliding was accompanied by a sound (a 'shush' sound for each turn of the slide and 'boing' sound for each hop). If infants did not pick up the animal, or became distracted while holding the animal, the experimenter would prompt the infant by saying, 'What are you going to do with the (animal)?' The infants were judged to have finished responding when they had either placed the animal in the house and left it there, left the animal on the mat, or gave the animal to the experimenter. If they had not made a clear response after 60 seconds, the experimenter requested the animal from them. If the infants put the animal in the house at this point, their behaviour was coded as such, but if they gave it to the experimenter, they were coded as not putting the animal in the house.

Coding

Infants were scored on two measures; matching the style (hopping or sliding the animal) and matching the outcome (placing the animal in the house). The percentage of matches for each of the measures (number of trials on which infants matched the action/matched the outcome, divided by the total number of trials that they completed) was calculated for each infant. Eight infants' percentages were calculated based on only three trials, and three on two trials, because either a parent prompted them (3), the child did nothing on one of the trials (6), or refused to participate in a fourth trial (2).

In accord with Carpenter *et al.* (2005), we coded an action as 'sliding' when the animal moved continuously without breaking contact with the mat, and we coded it as 'hopping' when the animal broke contact and made contact at least once again with the mat. Infants were coded as having put the animal in the house if they placed the animal in the house at least once, even if they then removed it afterwards. Occasionally infants placed the animal into the house before removing it and performing the action. Nevertheless, when these actions matched the style of the experimenter on that particular trial, they were coded as matches. Infants' imitations of the sounds the experimenter made were not coded as they rarely imitated this component.

An independent coder re-coded half of the data to assess reliability. Video clips of the imitation phase of each trial of 21 infants were created that did not include the demonstration that the infant had received. These were presented in a random order (so that the coder could not use the fixed trial order to guess the trial type), and the secondary coder was asked to assess whether the infant either hopped, slid, or did neither action, and whether the infant placed the animal in the house. Perfect reliability (100% agreement) was achieved.

Results

The mean proportion of trials in which infants imitated the two aspects of the demonstration (the outcome and the style) is represented in Figure 1. Our main interest was in whether the novelty of the demonstrated information modulated the likelihood that infants would imitate that act. A repeated-measures ANOVA was carried out on these proportions with condition (no prior information, ostensive prior information, non-ostensive prior information) as a between-subjects factor and type of imitation (action style vs. action outcome) as a within-subjects factor. This analysis revealed a significant main effect of type of imitation [$F(1, 36) = 29.2$, $p = .0001$], indicating a stronger tendency to imitate the outcome than the action style, and a significant interaction between condition and type of imitation [$F(2, 72) = 7.84$, $p = .001$], indicating that what

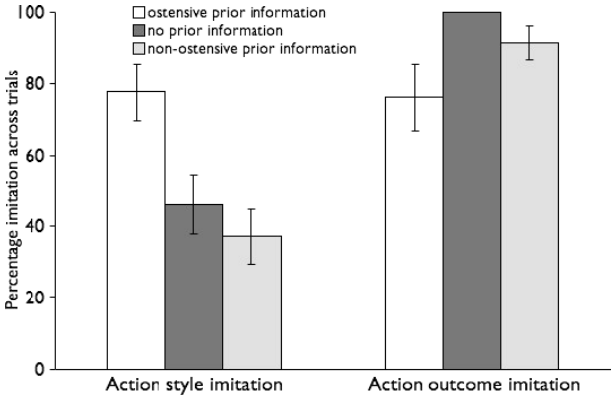

Figure 1 *The mean percentage of trials on which infants imitated the action style (hopping or sliding) and the outcome (putting the mouse in the house) in each condition.*

infants imitated depended on the condition that they were in. The absence of a condition main effect confirms that the overall amount of imitation did not differ across groups.

To investigate the interaction, planned independent samples *t*-tests, and equivalent non-parametric (Mann-Whitney) tests were carried out separately for each type of imitation (action matching and house matching). Infants in the ostensive prior information condition matched the style of the demonstrator significantly more (77.6%) than infants in the no prior information condition (46.2%), [$t(24) = 2.56$, $p = .017$; $Z = 2.34$, $p = .02$, two-tailed], or the non-ostensive prior information condition (37%), [$t(24) = 3.62$, $p = .001$; $Z = 3.00$, $p = .003$, two-tailed]. There was no difference between the amount of action style imitation in the no prior information and the non-ostensive prior information conditions [$t(24) = 0.74$, $p = .47$; $Z = .76$, $p = .45$, two-tailed], suggesting that infants in both conditions interpreted the demonstration similarly. Conversely, infants who received ostensive prior information about the potential action goal matched putting the animal in the house (action outcome) significantly less (76.3%) than infants who received no such information (100%), [$t(24) = 2.65$, $p = .01$; $Z = 2.71$, $p = .007$, two-tailed]. There was no significant difference between the amount of action outcome imitation in the no prior information (100%) and non-ostensive prior information (92%) groups [$t(24) = 1.8$, $p = .08$; $Z = 1.80$, $p = .07$, two-tailed]. Again, the amount of action outcome imitation suggests that infants in the non-ostensive prior information condition construed the demonstration as if they had not received any information.

We were also interested in whether either aspect of the demonstration was more likely to be imitated than the other. Although, as in Carpenter *et al.* (2005), infants for whom all information was new in the communication matched putting the animal into the house significantly more than matching the style of the action [$t(12) = 5.78$,

$p = .0001$]; infants in the ostensive prior information condition imitated action style and outcome equally [$t(12) = 0.093$, $p = .93$].

Discussion

Our results show that, by 18 months of age, infants can selectively imitate observed actions based on the perceived relevance of component actions. Infants who had already received communication about one component of a subsequent demonstration were more likely to imitate the new information than infants who had not received this prior communication. Infants for whom all information was novel imitated placing the animal in the house at the expense of imitating the style of the action, replicating the result of the 'house' condition in Carpenter *et al*. (2005). Importantly, the additional demonstration of the animal in the house received by infants in the ostensive prior information condition did not result in an advantage for imitating this aspect of the demonstration. Instead, receiving *more* demonstrations of this aspect resulted in children imitating it *less*.

The overall amount of imitation in each group was the same, indicating that the extra demonstration did not simply facilitate the amount of imitation, but rather modified the relative *kind* of information imitated in the ostensive prior information condition. It is interesting to note that although our manipulation modulated how much infants in each group imitated the action style and the action outcome, the pattern did not completely reverse upon receiving extra information from the demonstrator, suggesting that despite raising the relevance of the action style, infants in this group still found the action outcome worth imitating. This is likely because the house served as a visible reminder of the action outcome and so was relatively easy for infants to reproduce and/or difficult to inhibit reproducing (Durham, Cannon & Woodward, 2008). It is also unlikely that the presence of only one house in our study can explain our results. Bekkering *et al*. (2000) reported that when they reduced the 'goal complexity' by executing actions on only one ear (rather than both), 4- to 5-year-old children were better at using the correct hand demonstrated by the experimenter. However, although the level of action style imitation in the no prior information group was higher than in the Carpenter *et al*. (2005) study (46% as opposed to 15%), it was still significantly higher than in the ostensive prior information group. This suggests that although the presence of only one house may indeed result in higher levels of action imitation overall, this cannot explain the differences in imitation between the two groups.

Instead, these results support our hypothesis that, in humans, imitation is not solely driven by what the infant conceives to be the goal of the demonstrator. As many human cultural practices are cognitively opaque, it would often not be possible to identify important components to imitate based on the causal relationship between a means and an end, or to use outcomes to identify components that are irrelevant. As a result, we propose that human imitation of communicative demonstrations is guided by the same inferential process that accompanies any other instance of communication (Sperber & Wilson, 1986). The extent to which some aspect of the communication is conceived as relevant will depend on the knowledge state of the recipient as well as on the history of the interaction between the participants (Sperber & Wilson, 1986). If information in the communication is unknown to the recipient, it will be identified as most relevant. In the present study, the fact that infants in the ostensive prior information group had already been exposed to the outcome (the animal in the house) and therefore already had this knowledge, the new information (the action style) was highlighted as being more relevant to attend to and reproduced. In the no prior information group, there is nothing in the communication that would enable infants to evaluate the importance of various aspects of the demonstration. In such situations, when nothing in the communication tells the infant to do otherwise, infants do appear to interpret the action to be reproduced at its hierarchically highest level, in terms of the outcome.

As relevance seeking is hypothesized to be a general property of human cognition (Sperber & Wilson, 1986), one possible interpretation of infants' performance in the ostensive prior information condition is that it reflects not a sensitivity to communicative relevance, but a general sensitivity to new information, irrespective of whether or not it is communicated. However, infants' behaviour in the non-ostensive prior information condition strongly suggests that this is not the case. Here, infants discovered for themselves that the animal could go in the house. An explanation based on the general cognitive relevance principle would predict that, during the demonstration, infants will attend more to the information that will bring them greater cognitive effects. This would be the action style information, since through their own discovery, the action outcome information is now less novel for them. However, we found that infants in the non-ostensive prior information condition behaved in the same way as infants who did not receive any information before the demonstration. Thus, the expectation of relevance was generated only by the ostensive communicative demonstration, which made the repeated information about the home of the animal look superfluous, and consequently increased the perceived relevance of the novel movement style.

Our results add to a growing body of literature demonstrating the important role that ostensive communication plays in modulating imitation in infants (Brugger *et al*., 2007; Kiraly *et al*., 2004; Nielsen, 2006). For example, when a model performed a strange action (turning on a light box with her head) non-communicatively, infants were less likely to reproduce the strange head action than if the model had

demonstrated the action ostensively (Kiraly *et al*., 2004). Brugger and colleagues showed that while, in the absence of ostensive communication, infants' decisions on what to imitate depended largely on their knowledge of the causal relationship between means and outcomes, when the causally irrelevant components were ostensively cued, infants were more likely to imitate these causally irrelevant components (Brugger *et al*., 2007). These findings, together with the present result, suggest that it is a mistake to conceive the prototypical situation of imitation studies as an example of pure observational learning, where the selection of what to imitate would depend only on the child. Rather, communicative elements of the experimenter's demonstration addressed to the infant contribute to this selection process by raising their expectation of relevance. The expectation of relevance, which defines unknown or highly unexpected aspects of demonstrations as maximally relevant, may also explain the high degree of imitation of causally unnecessary or inefficient actions observed in a number of studies with older children (Horner & Whiten, 2005; Nagell, Olguin & Tomasello, 1993; Lyons, Young & Keil, 2007; Williamson & Markman, 2006). However, we note that this sensitivity to communicative relevance is only one way in which naïve observers can learn culturally relevant information and, as others have shown, in some cases, knowledge of desired outcomes can help infants to identify causally relevant components of action demonstrations (Carpenter, Call & Tomasello, 2002).

Our view of imitation in the current study portrays the infants' task as comprehension of the experimenter's communicative intent rather than interpretation of her behavioural intention. That infants expect communication to contain new and relevant information has been demonstrated previously in non-imitative contexts (e.g. Moll, Koring, Carpenter & Tomasello, 2006). The results of the current study suggest that this expectation of relevance extends to demonstrations of actions, and that infants use their interpretation of others' communicative intent in order to select important components worthy of imitation.

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