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Preschoolers' behavioural reenactment of "failed attempts": The roles of intention-reading, emulation and mimicry

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Abstract

To clarify the nature of the social cognitive skills involved in preschoolers' reenactment of actions on objects, we studied 31- and 41-month-old children's reenactment of intended acts ("failed attempts") in Meltzoff's (Meltzoff, A. N. (1995). Understanding the intentions of others: Reenactment of intended acts by 18-month-old children. *Developmental Psychology*, *31*, 838–850) behavioural reenactment paradigm. Measuring children's first action, performance of target acts was similar in a novel Emulation Learning condition to that seen in the Failed Attempt condition. In the Emulation Learning condition, children did not see the adult's manipulation and their response was likely to have been based on the end state specifying the object's key affordances. Both 31- and 41-month-old children also copied the control acts they had observed in the Adult Manipulation condition. However, 41-month-old but not 31-month-old children reproduced the failed attempt actions in the Failed Attempt condition. This pattern of findings suggests that, whilst 2- to 3-year-olds mimic adults' actions when these actions do not trigger alternative object affordances, only in the third year of life will children mimic adults' actions when these actions simultaneously trigger such affordances. Reenactment of actions on objects involves a number of social cognitive processes and exceptional care in the design of experiments is required to determine the roles played by intention-reading, emulation, and mimicry.

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A growing consensus suggests that infants' imitation of actions on objects depends on inferences about the adult model's intentions (Bellagamba & Tomasello, 1999; Carpenter, Akhtar, &

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Tomasello, 1998; Carpenter, Nagell, & Tomasello, 1998; Johnson, Booth, & O'Hearn, 2001; Meltzoff, 1995; Sanefuji, Hashiya, Itakura, & Ohgami, 2004). Results from Meltzoff's (1995) innovative behavioural reenactment procedure have been influential in generating this consensus. In the behavioural reenactment procedure, infants observe an adult model (1) performing a target act (Full Demonstration, e.g. putting a loop over a prong); (2) apparently trying but failing to perform the target act (Failed Attempt, e.g. dropping a loop before it reaches a prong); or (3) manipulating objects without an apparent goal (Adult Manipulation, e.g. moving a loop near, but not toward, a prong). Meltzoff found that 18-month-old infants produced a similar proportion of target acts following the Failed Attempt and Full Demonstration models, and that in each of these conditions they were more likely to produce the target act than in the Adult Manipulation or Baseline conditions. Meltzoff interpreted the equivalent effects of observing target acts and failed attempts as indicating that infants' responses in both conditions are based on reading the model's intended acts.

A range of social learning processes recently discussed in the comparative literature may provide alternatives to the intentional interpretation of behavioural reenactment data (Heyes, 1998, 2001; Heyes & Ray, 2002; Tomasello, 1990, 1996; Want & Harris, 2002; Whiten & Ham, 1992; Whiten, Horner, Litchfield, & Marshall-Pescini, 2004). These include: (1) local or stimulus enhancement: the model's action draws an observer's attention to particular environmental locations or relevant parts of objects; (2) emulation learning: an observer learns about stimulus consequences of the demonstration (i.e. affordances between objects) but not the model's behavioural strategy; and (3) mimicking: an observer reproduces the body movements of the model performing the manipulations without explicitly encoding the goals of the model.

In a previous study, we examined whether performance of the target act in the behavioural reenactment procedure could be due to learning about the affordances of objects (Huang, Heyes, & Charman, 2002). Three conditions in Meltzoff's (1995) study were replicated: Full Demonstration, Failed Attempt and Adult Manipulation. Additionally, in two novel conditions infants were exposed to stimulus displays that highlighted object affordances but did not indicate clear intentions to complete the target action on the part of the model. In the Emulation Learning condition (Experiment 1), infants were exposed to the initial state and target state of the object set without seeing the manipulatory acts (which were occluded by a screen). In the Spatial Contiguity condition (Experiment 2), infants saw the model move the target-relevant parts of the object close to one another but no attempt was made (successfully or unsuccessfully) to complete the target act. We also adopted a more conservative scoring criterion by focusing on the first action the infants produced. Infants produced several actions within the 20-s response period used by Meltzoff (1995) and others. Although infants in the Full Demonstration condition produced the most target acts, infants in the Emulation Learning and Spatial Contiguity conditions produced as many target acts as infants in the Failed Attempt condition. Huang et al. concluded that detection of object affordances was sufficient to induce the infants to produce the target act in the Emulation Learning and Spatial Contiguity conditions. Therefore, target act production after observing failed attempts may also have been based on affordance learning alone, or have represented the combined influences of affordance learning and intention-reading.

Huang et al. also noted, in line with previous studies, that infants rarely reproduced the actions they observed the model demonstrate in the Failed Attempt and Adult Manipulation conditions. This is in spite of the fact that these acts were intended, and no more complex than those observed in the Full Demonstration condition. We suggested therefore that the capacity for mimicking a model's behavioural strategy is not well developed in infancy, and may be readily diverted by object affordances.

The purposes of the present study was both theoretical and methodological: we hoped that assessing the response of preschool children to Meltzoff's behavioural reenactment paradigm would further illuminate the roles played by intention-reading, emulation learning, and mimicry. Therefore, we repeated Experiment 1 of Huang et al.'s (2002) study with older preschool children. The results of studies using a variety of paradigms demonstrate that children of this age are capable of intention-reading (Moses, 1993; Shultz, Wells, & Sarda, 1980; Yuill, 1984). Moreover, a theory-like understanding of the mind has been claimed to emerge between 2½ and 3 years of age (Wellman, 1990; Wellman & Woolley, 1990).

If, as Meltzoff suggests, performance of target acts after observation of failed attempts depends on intention-reading, the 2- to 3-year-olds—unlike the infants in the Huang et al. (2002) study—ought to produce as many target acts in the Failed Attempt condition as in the Full Demonstration condition, and a greater number of target acts in the Failed Attempt condition than in the Emulation Learning condition. However, if target performance in the absence of full demonstration is sensitive to both intention-reading and affordance detection, the 2- to 3-year-olds ought to produce more target acts in the Full Demonstration condition than in the Failed Attempted condition, and as many target acts in the Emulation Learning condition as in the Failed Attempt condition. If any differences among preschoolers in exact reproduction of failed attempts versus adult manipulation acts, this would help further to delineate the roles of mimicry and affordance detection (emulation) in the behavioural reenactment procedure.

1. Method

1.1. Participants

Two groups of forty 31- and 41-month-old children were recruited. The mean ages (and standard deviations), respectively, for the Full Demonstration, Failed Attempt, Emulation Learning, and Adult Manipulation conditions were as follows: 30.6 (1.5), 41.4 (3.3); 32.3 (1.8), 41.2 (4.2); 30.5 (2.1), 38.8 (3.8); and 30.8 (1.9), 42.2 (3.3). The 31-month-old group included 22 boys and 18 girls and were 70% White, 15% Asian, 7.5% African, and 7.5% mixed ethnicity. The 41-month-old group included 28 boys and 12 girls and were 77.5% White, 7.5% Asian, 7.5% African, and 7.5% mixed ethnicity. They all were recruited from a number of playgroups and nurseries in London, UK.

1.2. Test situation

The test session took place at a quiet corner in the playgroup or nursery where disturbances from other children and workers were reduced to the minimum. Children were seen at home if such an arrangement was favoured by parents or at the laboratory of a university psychology department. In the 31-month-old group, 12 of the participants were tested at home, 22 at the playgroup, 5 at the nursery and 1 at the laboratory. In the 41-month-old group, 2 were tested at home, 31 at the playgroup, and 7 at the nursery. A camcorder fixed on a tripod stood behind and to the left of the experimenter, focusing on the head, hands, and torso of the child and the surface of the table. The test started with joint play with rubber animals or a picture book, and when the child felt comfortable with the setting and the experimenter, the toys were withdrawn and the first object set was presented.

1.3. Test materials

The materials were replicas of the five object sets designed by Meltzoff (1995). The object sets were: (1) a dumbbell-shaped toy that could be pulled apart and put together again; (2) a box with an underlying buzzer that could be activated with a wooden stick going into a recessed button on the top of the box; (3) a loop that could be draped over a prong, which horizontally protruded from a vertical rectangular board; (4) a chain of beads that could be placed into a cup-like cylinder; and (5) a plastic square with a round hole in the center that could be put over a vertical dowel set in a wooden base plate.

1.4. Experimental design

As in our previous study (Huang et al., 2002, Experiment 1), the present study consisted of four conditions: the Full Demonstration, Failed Attempt, Emulation Learning, and Adult Manipulation conditions. These conditions followed those of Meltzoff (1995), except that the Emulation Learning condition replaced the baseline control. Full details of the procedure are given in Huang et al. (2002, pp. 843–844). The prong and loop object set will be used as an example for each condition.

In the Full Demonstration condition, the experimenter produced a specific target act with each of the five objects. The object was set in the initial state. The experimenter demonstrated the target act. As a consequence, two distinct parts of the object were related to one another in a specific end configuration. The target act was repeated three times in approximately 20 s. Then, the object was restored to the initial state and presented on the table in front of the child. For example, the experimenter raised the loop up to the prong and draped it over so that the loop rested on the prong.

In the Failed Attempt condition, the experimenter demonstrated the unfulfilled target acts. The object was set in the initial state. The experimenter was seen by the child as trying but failing to bring about a specific target act. The end state of the target act was thus not observed. This failed attempt was modeled three times in approximately 20 s. Then, the object was restored to the initial state and presented on the table in front of the child. For example, the experimenter raised the loop but, as he approached the prong, he inappropriately released it and the loop dropped to the table. First, the loop was released to the left of the prong, next to the right, and finally below the prong.

In the Emulation Learning condition, the child observed only the initial and end states of the object set. As in the other conditions, the initial state of the object was first introduced on the table. Then, a cardboard barrier was placed between the child and the object. The experimenter performed the target act unseen by the child behind the barrier. After the target act was completed, the experimenter removed the cardboard showing the end state to the child. The barrier was placed between the child and the object again and the object was restored to the initial state. Lastly, the barrier was withdrawn and the object was seen in the initial state. The procedure was repeated three times within a 20-s modeling period. For example, the initial state of the loop and prong was the loop lying on the table next to the board with the prong; the end state was the loop resting on the prong. It is important to note that this condition differs from the three other conditions in that no action on the object was seen by the child and thus tests whether the child could learn about the target act based on information about the end state.

In the Adult Manipulation condition, the experimenter demonstrated target-irrelevant acts by manipulating the same part of the object as in the Full Demonstration and Failed Attempt conditions. The object was set in the initial state. The experimenter manipulated the object, but produced neither the target act nor the failed attempt. The target-irrelevant control act was repeated three times in the 20 s modeling period. The object was then placed in front of the child. For example, the experimenter raised the loop up to the level of the prong, then slid it along the upper edge of the board past the prong and released it when it reached the end. First, the loop started from the left end of the upper edge, next from the right end, and third it was moved along the base supporting the board under the prong before being released.

Children were randomly assigned to one of the four conditions resulting in 10 children per condition. Sequences for the five objects were counter-balanced within each condition. The maximum number of target acts a child could produce was five.

1.5. Scoring

As the first action produced in the 20-s response period is maximally indicative of 19-month-old infants' imitative tendency (Huang et al., 2002), we scored the first action that 31- and 41-month-old children produced with each of the five objects. The first action was coded into one of four mutually exclusive categories, each with strict behavioural definitions (see Huang et al., 2002, p. 854 for detailed scoring criteria): (1) target act: a 'yes' was recorded if the child produced the modeled target act on the object; (2) failed attempt: a 'yes' was recorded if the child produced the modeled failed attempt on the object; (3) adult manipulation: a 'yes' was recorded if the child produced the modeled manipulation control act on the object; and (4) other response (including a range of manipulatory acts, lack of response, and activation of the buzzer in the object set of box and stick through the use of a finger to push the button).

1.6. Inter-rater reliability

Children's responses to each of the five objects were coded from videotape by the first author. Inter-rater reliability was assessed for 30% of the data (three children per condition at each age) independently coded by a colleague who was familiarized with the scoring system. Reliability was calculated for the coding of children's first acts as falling into one of the above mutually exclusive scoring categories. Agreement was $\kappa = .86$ for the 31-month-old group, and $\kappa = .94$ for the 41-month-old group.

2. Results

Four participants in the 31-month-old group did not have a complete record of five response periods due to a camcorder fault during the testing. Therefore, proportions rather than frequencies were used in the analyses. The missing data points included two children's responses to the dumbbell in the Adult Manipulation condition, one child's response to the dumbbell in the Emulation Learning condition, and one child's response to the beads and cylinder in the Failed Attempt condition.

Table 1 shows the mean proportion of children's first acts across the five object sets coded as producing target actions, failed attempts, adult manipulation acts and other actions as a function of condition and age. The data for each response category were subjected to a 2×4 (age $\times$ condition) analysis of variance (ANOVA).

Table 1
Mean proportions of 31- and 41-month-old children producing Target Acts, Failed Attempts, and Adult Manipulation Acts and Other Actions at the first action across the four conditions

Condition	Full Demonstration		Failed Attempt		Emulation Learning		Adult Manipulation	
Action	*M*	S.D.	*M*	S.D.	*M*	S.D.	*M*	S.D.
Target Act								
31-month-old	.78	.18	.65	.34	.44	.24	.20	.16
41-month-old	.84	.18	.52	.30	.58	.15	.18	.20
Failed Attempt								
31-month-old	.04	.08	.10	.17	.06	.10	.06	.10
41-month-old	.00	.00	.34	.31	.04	.08	.06	.10
Adult Manipulation Act								
31-month-old	.02	.06	.00	.00	.02	.06	.22	.18
41-month-old	.00	.00	.00	.00	.00	.00	.54	.30
Other Actions								
31-month-old	.16	.21	.25	.27	.49	.28	.53	.26
41-month-old	.16	.18	.14	.19	.38	.15	.22	.11

2.1. Target acts

There was a main effect of condition, $F(3, 72) = 25.17$, $p < .001$, with no reliable effect of age, $F(1, 72) < 1$, or age × condition interaction, $F(3, 72) = 1.31$, $p = .277$. Follow-up Bonferroni tests showed that the children in the Full Demonstration condition produced more target actions than did children in the Failed Attempt, Emulation Learning, and Adult Manipulation conditions ($p = .016$, $p < .001$, and $p < .001$, respectively). No difference was found between children in the Failed Attempt and Emulation Learning conditions, and each produced more target actions than did children in the Adult Manipulation condition (both, $p < .001$).

2.2. Failed attempts

There was a main effect of condition, $F(3, 72) = 7.65$, $p < .001$, no reliable effect of age, $F(1, 72) = 1.91$, $p = .171$, and a significant age × condition interaction, $F(3, 72) = 4.06$, $p = .01$. Simple effects analysis exploring the interaction showed that the effect of condition was significant in the 41-month-old group, $F(3, 36) = 8.42$, $p < .001$, but not in the 31-month-old group, $F(3, 36) < 1$. Follow-up Bonferroni tests within the 41-month-old group revealed that the children in the Failed Attempt condition reproduced the failed attempts more frequently than did children in the Full Demonstration, Emulation Learning, and Adult Manipulation conditions ($p < .001$, $p = .002$, and $p = .004$, respectively). No difference was found among the latter three conditions. Tests of simple main effects for age revealed a significant difference only in the Failed Attempt condition, $F(1, 18) = 4.53$, $p = .047$, where the children in the 41-month-old group reproduced the failed attempts more often than the children in the 31-month-old group. To determine whether the relatively infrequent occurrence of failed attempts might bias our conclusions, the data were also assessed using non-parametric procedures (Kruskal–Wallis and Mann–Whitney tests). These non-parametric analyses yielded identical results, except that the difference between the two age groups was marginally significant in the Failed Attempt condition ($Z = 1.91$, $p = .056$).

2.3. Adult manipulation control acts

There were main effects of condition, $F(3, 72) = 42.48$, $p < .001$, and age, $F(1, 72) = 6.27$, $p = .015$, with a significant age × condition interaction, $F(3, 72) = 8.86$, $p < .001$. Simple effects analysis revealed a reliable effect of condition in the 31-month-old group, $F(3, 36) = 10.19$, $p < .001$, and in the 41-month-old group, $F(3, 36) = 32.64$, $p < .001$. Follow-up Bonferroni tests in each of the 31- and 41-month-old groups showed that the children in the Adult Manipulation condition reproduced the adult manipulation control acts more often than the children in the Full Demonstration ($p = .001$ and $p < .001$, respectively), Failed Attempt (both, $p < .001$), and Emulation Learning ($p = .001$ and $p < .001$, respectively) conditions. No difference was found among the latter three conditions. Simple effects analysis of age revealed a significant difference only in the Adult Manipulation condition, $F(1, 18) = 8.69$, $p = .009$, where the 41-month-olds copied the adult manipulation control acts more often than did the 31-month-olds. Note that no children in the 41-month-old group reproduced such acts in the other three conditions. As before, the data were assessed using non-parametric procedures (Kruskal–Wallis and Mann–Whitney tests) to determine whether violation of assumptions for the use of ANOVA biased the analyses. These non-parametric analyses yielded identical results.

2.4. Other acts

There was a main effect of age, $F(1, 72) = 6.80$, $p = .011$. Overall, the 31-month-old group produced a range of other actions more often than the 41-month-old group. There also was a main effect of condition, $F(3, 72) = 6.47$, $p = .001$. Follow-up Bonferroni tests showed that overall, the children in the Emulation Learning and Adult Manipulation conditions were more likely to produce other actions as their first act than the children in the Full Demonstration ($p = .006$ and $p = .015$, respectively) and Failed Attempt ($p = .019$ and $p = .043$, respectively) conditions. No difference was found between the Emulation Learning and Adult Manipulation conditions or between the Full Demonstration and Failed Attempt conditions.

3. Discussion

3.1. Production of target acts

The present study found the same pattern of target act performance in 2- to 3-year-old children, who are capable of intention reading, as was shown by Huang et al. (2002) in 19-month-old infants. Across both age groups, children in the Full Demonstration condition produced more target acts than children in the other three conditions, including the Failed Attempt condition, and those in the Emulation Learning condition produced the target action as often as those in the Failed Attempt condition. This pattern of results suggests that emulation learning in the form of affordance detection provides an alternative interpretation of children's responses in the behavioural reenactment paradigm.

When a child observes the Full Demonstration model they see both the action and its end result, and it is plausible that under these conditions production of the target act occurs most frequently. Observing the end result provides information about the affordance which characterizes the object's end configuration (e.g. the loop over the peg; beads inside the cylinder). Thus, production of the target act in the Emulation Learning condition, where the end result is observed, is likely to be influenced by the detection of object affordances. Emulation in this form may also influence a child's response in the Failed Attempt condition where manipulation of the target-relevant parts of the object allows them to explore visually the dynamic affordances of the object.

Some readers may doubt that our data show that 2- to 3-year-olds in the Emulation Learning condition merely learn by observation about object affordances. After all, the Emulation Learning condition allows the child to see both the starting state and the end state of the objects, and it is conceivable that such experience supports inferences about the model's intentions (Whiten et al., 2004). Preschoolers are also different from infants in many ways. Indeed, the age groups in this study were selected for that very reason. However, these differences raise a fundamental question about the intentionality-based interpretation served by the behavioural reenactment paradigm: do infants depend mainly on the information about the model's body movements to anticipate the target act? If so, and given that the end state in the Emulation Learning condition does not specify the terminal position of the model's hands, it is unlikely that the child's experience in this condition supports or promotes inferences about the model's intentions. However, we cannot rule out that seeing the initial and end states of the object might also induce a causal inference based on the model's intention change. An interesting area for future studies would be to clarify the roles of object understanding and intentional attribution in the Emulation Learning condition. This could be achieved by comparing this condition to two novel conditions: in one condition, children are exposed to the end state only, but not to the initial state (see Bellagamba & Tomasello, 1999, for an example); in the other condition, children are exposed to the initial and end states, both of which include the relative positions of the model's hands to the object.

3.2. Production of failed attempts and adult manipulation actions

In earlier studies with younger infants (Bellagamba & Tomasello, 1999; Huang et al., 2002; Meltzoff, 1995), reproduction of acts in the failed attempt and adult manipulation conditions rarely occurred. In the present study, both 31- and 41-month-old children produced a significant number of adult manipulation actions. However, 41-month-olds but not 31-month-olds reproduced the Failed Attempt model they had observed.

Why do the older children show a stronger tendency to reproduce observed acts following the failed attempt model? One possibility is that older children are better able to attend to and remember the physical details of the model's actions, given the age effect for both reproduction of failed attempts and reproduction of adult manipulation acts. However, this does not explain why 2-year-old children differentially reproduce the adult manipulation but not failed attempt acts they had seen demonstrated. Based on this observation, we can also rule out that older children are more likely to infer that, strange as it seems, the model intends them to reproduce the failed attempt. After all, failed attempt and adult manipulation acts presumably do not differ in visuomotor complexity from an intentional perspective. A more likely explanation is perhaps that 3-year-olds are better able to inhibit performance of the action triggered by the dynamic affordances of the object. Note that the manner in which the object set is manipulated in the Failed Attempt condition more closely resembles the target act than does the manipulation observed in the Adult Manipulation condition. By design, the Failed Attempt model provides more information about the object affordances relevant to the target act. For example, moving a loop to prong and then dropping it (Failed Attempt) is more suggestive than moving a loop past a prong (Adult Manipulation) of the loop-on-prong affordance. Therefore, it is plausible that 2-year-olds provided less evidence of copying failed attempts than adult manipulation acts because in the former condition their detection of the affordances produced a conflicting tendency to perform the target act (i.e. the act implementing the affordance). This is likely to account for the initially counter-intuitive findings that the 3-year-olds produced fewer (albeit non-significantly) target acts but considerably more failed attempts in response to the failed attempt model than the 2-year-olds. It is also in line with the findings of work comparing children with non-human primates. This shows that copying an observed action is the favoured strategy of children between the ages of 3 and 4 years old, even when they have sufficient causal information about the task to support the use of alternative behavioural strategies (Call & Tomasello, 1995; Horner & Whiten, 2005; Whiten, Custance, Gomez, Teixidor, & Bard, 1996).

In conclusion, the findings of the present study provide an important caution for researchers in their interpretation of children's responses in imitation situations. Undoubtedly at some age, in some situations, preschoolers, and most probably infants, are beginning to read other people's intentions (Carpenter, Call, & Tomasello, 2002, 2005; Want & Harris, 2001). However, there are other social and non-social learning processes that influence how an infant or child responds when they observe an adult model an action (Carpenter & Call, 2002; Want & Harris, 2002). Across the different conditions and different age groups included in the present study and in our previous work (Huang et al., 2002), it is clear that intentional imitation, emulation, and mimicry all play a role in determining the child's response. While it may not be possible in any particular paradigm to identify exactly how much each of these processes is influencing children's responses, it is important to consider them all when interpreting the child's behaviour (see Huang & Charman, 2005, for a recent example).

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