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The role of 'action-effects' and agency in toddlers' imitation☆

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Abstract

We report an experiment on imitation by children between 14 and 26 months in which the presence or absence of an outcome of the procedure to be imitated was varied against whether the procedure was one performed by the experimenter or by a descending arrow. The presence of an outcome did not affect performance positively when the procedure was performed by the experimenter, but it did when it was performed by the descending arrow. When there was an outcome, performance on the experimenter-perform and the arrow-perform conditions did not differ. We argue that this result puts pressure on theories like 'the theory of common coding' (W. Prinz) which view the presence of an outcome as being crucial to imitation.

Keywords: Action-effects; Emulation; Imitation; Stimulus enhancement

We know that babies and toddlers are very good at learning from observation. However, even if we confine ourselves to their immediate performance of a modelled means–end action, as contrasted with their ability to engage in deferred means–end imitation (on which see Meltzoff, 1988), we confront a number of essentially reductive accounts of their successful performance. It is possible – one argument runs – that when very young children see a means–act demonstrated to them by another agent all that is happening is that the agent's action draws their attention to the relevant part of the apparatus or object (see Huang, Heyes, & Charman, 2002) thereby encouraging its manipulation. This is generally called 'stimulus enhancement'.

In a somewhat similar vein, instead of infants actually drawing a parallel between their own body and the modelling agent's body and perhaps assimilating his or her intentions in relation to a goal, what Tomasello (1999) has dubbed 'emulation' may be taking place. This means that the child may be doing no more than trying to bring about the same outcome that the model has brought about

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simply by virtue of understanding the mechanically effective operation bringing it about, with no necessary regard to the model's actions. To take an illustrative example from Tomasello, imagine that a young chimpanzee learns from watching his mother how to roll logs over in order to get access to the grubs underneath it. In this case it is possible that, through emulation, "the youngster would have learned the same thing if the wind, rather than the mother, had caused the log to roll over" (p. 29). In fact, inspired by this kind of possibility, Thompson and Russell (2004) were able to show that the imitation of a counterintuitive means action is at least as likely when the apparatus moved of its own free will; (a 'ghost condition') as when an experimenter manipulated it. In contrast to this result, however, Nagell, Olguin, and Tomasello (1993) conclude from a comparative study that emulation characterises the imitative strategies of chimpanzees, whereas children tend to reproduce the actual actions modelled by the agent, even if these are relatively ineffective.

In this paper, we investigate how emulation[1] effects of the kind demonstrated in Thompson and Russell's ghost condition interact with whether or not a basic action (a hand-press) or an inanimate event (a descending arrow) has an outcome. We examine toddlers' imitation, therefore, in terms of the relation between whether an outcome is caused by a human action or by something mechanical and whether either of these two events has an outcome. Before describing our task, however, it is necessary to set out why action outcome is such a crucial variable.

Since James (1890) articulated the 'ideomotor' theory that what potentiates the selection of an action is a representation of the action's outcome, a number of theorists have elaborated on this claim. The most notable of them is Prinz (Hommel, Müsseler, Aschersleben, & Prinz, 2001; Prinz, 2002), who argues in his 'theory of common coding' (TCC) that perceived outcomes, dubbed by Prinz *action effects*, potentiate the action that caused them because execution and perception share a common representational code.

TCC is taken to be supported by studies of both adults and infants. In the former case, Elsner and Hommel (2001) and Flach, Osman, Dickinson, and Heyes (in press) report that adults participants' responses to an imperative stimulus are speeded when this is the same stimulus that was previously the outcome of the action when done voluntarily. They also report that their responses are relatively retarded when the imperative stimulus was one that was the consequence of a *different* action. (See Eenshuistra, Weidema, & Hommel, 2004, for similar data from 4- to 7-year-old children.) These Stroop-like compatibility effects are also found when basic actions like hand-spreading and fist-making have to be imitated (Stürmer, Aschersleben, & Prinz, 2000), suggesting that action is speeded when a representation of the congruent action is called up. With regard to very young children, a typical result is that children of 12 and 18 months are more likely to imitate the actions of shaking a cylinder and placing it in front of a teddy when one of the actions makes a sound (Hauf, Elsner, & Aschersleben, 2004). The sound is taken to be 'the action effect'. Also see Hauf and Prinz (2005), Elsner, Hauf, and Aschersleben (in preparation) and Klein, Hauf, and Aschersleben (in preparation).

In the present study we asked whether seeing an outcome which was produced by a mechanical event is *sufficient* to encourage production of the action-equivalent of that event. Specifically, will an arrow event plus an outcome be as likely to encourage imitation as witnessing the experimenter's hand-press plus an outcome. There were five conditions in our study:

(1) hand event plus outcome;
(2) hand event without outcome;

[1] Some might prefer to call this manipulation one of 'stimulus enhancement'; but if so this would not affect the rationale or significance of the study.

(3) arrow event plus outcome;
(4) arrow event without outcome;
(5) baseline.

TCC will predict that there should be more imitation in (1) than in (2). But additionally, if an essential claim of TCC is that it is only outcomes caused by the acts of *agents* whose witnessing potentiates their action selection, and not outcomes caused by mechanical events, then condition (3) should result in less imitation than condition (1). By the same token, TCC should predict no difference between (3) and (4) because, while one of these contains an outcome, neither contains an agent.

1. Method

1.1. Participants

Participants were 125 children (61 males and 64 females). Four children had been discarded from the original sample of 129 due to fussiness or interference by the mother. They ranged in age from 14.8 to 26.8 months (mean = 20.51). They were recruited from a 10-mile radius from the city of Cambridge, UK. Recruitment was carried out through approaching mothers at local mother–toddler groups, by word-of-mouth, or through leaflet drops at local nurseries. English was typically the child's first language.

1.2. Design

The 'Woody Woodpecker Task' had two between-subjects variables. The first was kind of observation, which had three levels (hand/arrow/baseline) and the second was the outcome, which was either present or absent. Assignment of children to these groups was done on a random basis. (See Table 1 for the composition of the groups.)

1.3. Materials

A touch-screen specifically designed for heavy use was employed. This was a 19 in. ELO Touchsystems colour touch-screen equipped with infrared LED touch-sensitive hardware. A small portable computer (Toshiba Tecra) was connected to the screen to automatically record each child's data including the location, latency and accuracy of each touch. The software program

Table 1
Composition of the experimental groups

Condition		Age (months)		Gender		Total
Observation	Outcome	Range	Mean	Male	Female	
Hand	Present	14.9–26.8	19.2	13	12	25
	Absent	15.9–25.6	20.1	12	13	25
Arrow	Present	15.3–26.6	21.6	12	13	25
	Absent	16.7–26.0	20.3	13	12	25
Baseline	Absent	14.8–26.7	21.1	11	14	25

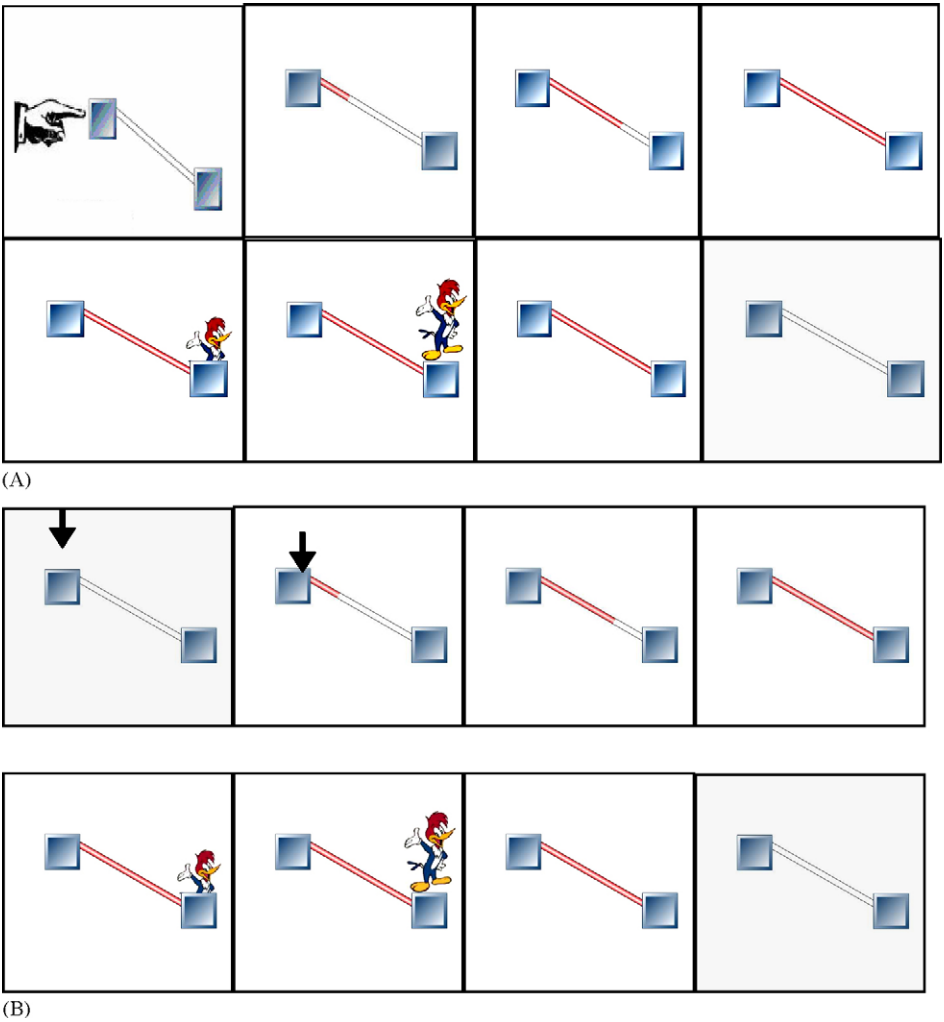

Fig. 1. Diagram of the test conditions, with time left to right: (A) for the hand conditions and (B) for the arrow conditions.

was designed using Microsoft's VisualBasic, and the Woody Woodpecker animations were created using the Macromedia's Flash animation package.

On the screen, two identical 'pads' were presented. See Fig. 1 for an illustration. The pads were connected through a tube-like conduit. Note that for all conditions the location of the pads was counterbalanced, so that the top and bottom pads either appeared on the right or left side of the screen.

Pressing on the top pad activated the following sequence of events (see Fig. 1A):

1. The top pad seemed to be depressed.
2. The connecting tube seemed to fill up with a reddish colour starting from the top. The time it took for tube-filling effect to be completed was 2.41 s.

3. Once the red line reached the bottom pad, the pad changed its colour three times. Woody Woodpecker then came out of the bottom pad and danced around the screen giving his famous laugh.
4. Woody Woodpecker re-entered the bottom pad and the screen went back to how it started.

A further animation supported the arrow condition, in which the same sequence of events took place, though with this time an arrow descending onto the top pad. See Fig. 1B.

1.4. Procedure

The testing environment was a quiet area in the nursery or mother–toddler group. Each child was seen individually. While the child's caretaker was being briefed about the experiment, the child accustomed him/herself to the testing environment. The caretaker was instructed not to assist the child in any way during the procedure. During the entire experiment the child was seated on his or her caretaker's lap. Testing was conducted by the first author.

The experiment was divided into three phases:

Warm-up phase: This phase took about 3 min. The child was seated on his/her caretaker's lap facing the touch-screen. A smiley face appeared on the touch-screen and the child was encouraged to press on the face. When the face was pressed, it produced a chime and moved to a different location on the screen. Again, the child was encouraged to press it. This was repeated ten times.

Demonstration phase: The demonstration phase lasted for about a minute. The experimenter said "Look" to draw the child's attention to the test equipment. The demonstration phase depended on the condition (as explained below). This would be: hand-with-outcome, hand-without-outcome; arrow-with-outcome; arrow-without-outcome; baseline event.

Test phase: The test phase followed the demonstration phase without intermission. The experimenter simply said "Look" to the child, when the test configuration appeared. There was no encouragement from her to act. The test phase was the same for both 'outcome' conditions: the child's depressing the top pad activated the screen and created the sequence of events previously described. However, for the 'no outcome' conditions, the screen remained inactive if the top pad was pressed.

The five demonstrations:

Hand-with-outcome: The experimenter pressed the top pad. The 'Woody' sequence of events was presented. This was done three times.

Hand-without-outcome: The experimenter pressed the top pad. The screen remained inactive. This was done three times.

Arrow-with-outcome: The experimenter did not touch any part of the screen. Instead, an arrow descended onto the top pad of the screen. As soon as the arrow touched the top pad, the 'Woody' sequence of events was presented. This was done three times.

Arrow-without-outcome: The experimenter did not touch any part of the screen. Instead, an arrow descended onto the top pad of the screen. The screen remained inactive. This done three times.

Baseline-demonstration: Instead of a demonstration the child was presented with a short unrelated video clip, called The Flying Snail. (In the test phase, if a child in this condition did happen to press the top pad this caused the Woody event to take place with a probability of 0.5.)

Table 2
Numbers of children who performed the target action within 20 s and the mean latencies to success in seconds

Condition	Pressed within 20 s		Total
	Yes [mean latency in seconds]	No	
Hand-with-outcome	17 [6.44]	8	25
Hand-no-outcome	16 [7.97]	9	25
Arrow-with-outcome	15 [10.64]	10	25
Arrow-no-outcome	5 [9.88]	20	25
Baseline	1 [10.39]	24	25
Total	54	71	125

2. Results

A tally was made of the children who performed the target action within the 20 s of the test screen appearing in each condition. The latencies were also calculated in milliseconds for every touch, timed from the appearance of the screen in the test phase. Every touch was classified as one of the following:

- *Target*: The touch occurred on the top pad.
- *Non-target*: The touch occurred on the bottom pad.
- *Other*: The touch occurred anywhere else on the screen other than the target and non-target pads.[2]

Table 2 shows the number of children who pressed the target pad within the first 20 s and the mean latencies to success in seconds. It is evident from the table that only in the case of the arrow-without-outcome condition did a substantial number of children not perform the correct action, while the other three demonstration conditions differed little from one another. These impressions were checked with statistical tests.

Overall, children's performance varied depending on whether they saw an outcome or did not. A loglinear analysis on the five conditions showed this variable to be significant: outcome × performance: $G^2(1) = 5.272$ ($p = 0.02$). Also, children's performance varied depending on which condition (hand, arrow, baseline) they were placed in regardless of whether they saw an outcome: condition × performance, $G^2(2) = 21.578$ ($p = 0.0001$), on loglinear. Moreover, the presence or absence of an outcome interacted with condition: condition × outcome $G^2(2) = 20.036$ ($p = 0.0001$) on a loglinear analysis.

Turning to the individual analyses, the arrow-without-outcome condition was the only one of the four test conditions in which performance did not significantly exceed that of the baseline: χ^2 $(1) = 3.03$, $p > 0.05$.

We asked whether children in the hand condition were more likely to press the top pad when there was an outcome. They were not: $\chi^2(1) = 0.09$, $p > 0.05$. By contrast, the existence of an outcome was crucial in the arrow condition, as an outcome lead to significantly more correct responses: $\chi^2(1) = 8.33$, $p < 0.01$.

[2] Data arising from these will not be reported here, but are available from the first author on request.

We asked whether performance differed between the two conditions in which there was an outcome. In fact, performance was not better in the hand-with-outcome condition than in the arrow-with-outcome condition: $\chi^2(1) = 0.35$, $p > 0.05$. Finally, performance was superior in the hand-without-outcome condition than in the arrow-without-outcome condition: $\chi^2(1) = 9.93$, $p < 0.01$.

A one-way analysis of variance on the latencies to correct response in the four experimental groups revealed a marginally significant difference: $F(52) = 2.76$, $p = 0.052$. Post hoc tests (Tukey HSD) revealed only one significant difference between the groups however: hand-with-outcome took significantly less time to complete than arrow-with-outcome ($p = 0.042$).

3. Discussion

The first question to ask is why the presence of an outcome failed to improve performance in the hand condition. Such an effect would be predicted by Prinz's theory of common coding (TCC) and was one found in infant studies such as that by Hauf et al. (2004), and in other similar studies with infants. There are many differences between our study and those by Hauf et al. and others, but perhaps the most obvious is that, while in the Hauf et al. study the 'action effect' (sound) was an immediate consequence of the action on the object, in our case the 'Woody' event took place 2.41 s after the pad was pressed. It should be noted here that in studies of animal learning (Mackintosh, 1974) and in studies of human causal learning (Shanks, Pearson, & Dickinson, 1989) delaying the outcome reduces learning. The fact is, however, that the causal process, in the sense of the connecting tube filling up, began immediately the top pad was pressed. Moreover, the outcome *did* have an effect in the arrow condition, so at some level the outcome must have been registered as such despite the relative delay in its being completed.

In reply, it could be said by supporters of the 'action-effect' research program that either the seeming depression of the top pad or the hand movement itself was the 'action effect'. But, in the first place, it would be surprising indeed if the slight depression of the top pad could be as efficacious as Woody Woodpecker's exuberant display—that the addition of the Woody event made no difference. In the second place, if the 'action effect' is the very act of pressing then where does the 'action' end and the 'effect' begin? If this claim is seriously made the word 'effect' becomes otiose, and the empirical interest of the action-effect research program becomes nullified.

Furthermore, the finding that the arrow-with-outcome condition resulted in nearly as many acts of imitation as did the hand-with-outcome condition is something that cannot easily be assimilated by TCC. (Though note that performance on the hand condition had a lower mean latency.) If this result were to be generalised to other situations it would suggest, in the context of infancy at least, that the term 'action effect' would need to be replaced by 'event effect'. This is not to say that it is impossible for TCC to assimilate any kind of mechanical cause of an outcome into the action-effect approach; indeed this has been done in a looking-time study, with infants, using a mechanical grasping arm as opposed to a human one (Hofer, Hauf, & Aschersleben, 2005). But it could certainly be argued that a mechanical grasping arm is naturally assimilable to a real arm in the way in which a downward-travelling arrow is not naturally assimilable to a pressing hand.

That said, a supporter of the 'action effect' research programme could insist that, while the children saw no human action in the arrow-with-outcome condition they were naturally inclined to analogise the arrow event to the exertion of pressure by human agency, given that it had an effect (as do many human actions). This seems plausible in the light of Wagner, Winner, Cicchetti, and Gardner (1981) evidence for perceptual analogy-making in 9-month-old infants (with some of the events involving downward arrows). Perhaps young children analogise mechanical events with outcomes to (imitable) actions. If so indeed, this would account for Thompson and Russell's (2004) data on the 'ghost condition', previously interpreted in terms of emulation. Future research will determine whether what looks like emulation in young children is in reality children's analogising from a mechanical process with an outcome to human agency. If this is indeed the case it will strengthen Nagell et al.'s (1993) claim, mentioned above, that chimpanzees emulate but children imitate.

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