Testing for Localized Stimulus Enhancement and Object Movement Reenactment in Pig-Tailed Macaques (Macaca nemestrina) and Young Children (Homo sapiens)

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Four puzzle boxes were used to investigate localized stimulus enhancement and object movement reenactment (OMR) in 13 pig-tailed macaques (Macaca nemestrina) and 30 human infants (Homo sapiens). Participants received contrasting demonstrations on each box. A circular lid was gripped by its rim or handle and swiveled to the left or right. A flap door was pushed or flipped. A sliding lid was pushed to the left or right. A pin bolt was demonstrated being pushed down, or the participants were left to solve the puzzle for themselves. Despite the fact that the monkeys watched the demonstrations about 60% of the time, only a weak OMR effect was found on the sliding lid. In contrast, the children watched significantly more, and there was clear evidence of socially mediated learning on all of the boxes.

Humans are clearly the most cultural of creatures (Meltzoff, 1988; Tomasello, Kruger & Ratner, 1993). Even from very early childhood, we seem to possess a drive to watch and learn from others, so much so that human infants will often copy others even when there is no extrinsic reward involved (Meltzoff, 1996). According to anecdotal reports, other species of primates also seem very curious about the actions of others (Whiten & Ham, 1992). However, the evidence for complex social learning, particularly imitation (i.e., “learning to do an act by seeing it done”; Thorndike, 1898), is much weaker in nonhuman primates compared with humans (Visalberghi & Fragaszy, 1990, p. 50). Indeed, in recent years, comparative psychologists have tended to treat imitation as the Holy Grail of social learning research (Matheson & Fragastry, 1998). However, there are other issues related to socially mediated learning that are equally deserving of scientific attention. For example, just how closely do humans and other species watch a model? Precisely what kinds of things do they learn? To what extent do humans and other primates exhibit other nonimitative forms of social learning? In the light of these questions, we conducted four experiments that focused on two nonimitative social learning mechanisms in pig-tailed macaques and young children.

As Whiten, Horner, Litchfield, and Marshall-Pescini (2004) noted, “The terminology and underlying conceptual framework of social-learning research has become infamous for its complexities and confusions” (p. 38). Hence, it is important to define carefully all relevant terminology. We adopted Caldwell and Whiten’s (2002) broad definition of social learning so that it refers to “any situation in which the behaviour, or presence, or the products of the behaviour, of one individual influence the learning of another” (p. 193). For example, observers can either learn directly about at least some aspect of the form of another’s behavior (i.e., imitation, as defined by Whiten & Ham, 1992) or have their attention drawn to salient aspects of the environment (i.e., stimulus enhancement, as defined by Thorpe, 1963), or they can learn about the various properties of objects, substrates, or substances within the physical environment (emulation, as defined by Tomasello, 1998). It is the two latter social learning mechanisms that most concern us here.
According to Thorpe (1963), stimulus enhancement involves a model directing the attention of an observer to a particular object. One might also then pay more attention to that whole class of objects or pay attention to particular parts of an object (a process dubbed localized stimulus enhancement [LSE] by Caldwell & Whiten, 2004). Once an observer’s attention has been directed toward the salient stimulus, he or she individually learns the actions needed to manipulate it. Hence, the cognitive processes underpinning stimulus enhancement are thought to constitute a combination of neural priming (Byrne, 1995) and individual learning.

Two of the present studies were designed to test for LSE. In one of our studies, participants saw a model use either the handle or the rim of a circular lid to open a box. In the other study, participants either saw a demonstrator push down a pin bolt before opening a circular lid or were in a control condition in which they received no demonstrations. We tested whether the participants in each condition would touch the particular part of the box they had seen the model manipulating sooner or more than the other group.

Only a few published comparative studies have focused on LSE. Kubinyi, Topal, Miklosi, and Csányi (2003) presented domestic dogs (Canis familiaris) with a human demonstrator who touched either the top of a box or a protruding handle. The “top touch” group did not touch the top of the box sooner or more often than the “handle touch” group, and vice versa. Fritz and Kotrschal (1999) presented ravens (Corvus corax) with a box that could be opened by either pulling a flap or levering a top compartment. Only those birds who had been paired with a conspecific who had been trained to pull the flap subsequently used the flap to open the box. Caldwell and Whiten (1999, 2004) found that common marmosets (Callithrix jacchus) focused their initial explorations of an artificial fruit on whichever of two parts they had seen a conspecific preferentially acting on previously. Huber, Rechberger, and Taborsky (2001) found that kea parrots (Nestor notabilis) touched a pin-and-bolts latch on an artificial fruit more if they had seen a conspecific model do so than if they had not.

In addition to LSE, the present studies were designed to test for a particular kind of emulation. Emulation has been defined in a number of different ways (e.g., Call, 1999; Custance, Whiten, & Fredman, 1999; Tomasello, 1990, 1998; Whiten & Ham, 1992). In contrast to imitation, emulation involves learning about different aspects of the properties of a physical situation, rather than the behavior of a demonstrator or model (Tomasello, 1998). Hence, an observer might learn about the goals or rewards associated with certain objects, the affordances of an object, its relationship to other objects, its final state after manipulation, or the direction in which it or parts of it can be moved. The latter mechanism was dubbed object movement reenactment (OMR) by Custance et al. (1999), and three of the experiments presented here focused on this kind of emulation. A swivel lid, flap door, and sliding lid were moved in contrasting directions to test whether observers would move these box parts in the same direction as shown.

Some of the types of emulation listed above are probably cognitively very complex (Byrne, 2003; Want & Harris, 2002; Whiten et al., 2004). For example, Whiten and Ham’s (1992) goal emulation involves an observer learning the goal of a model’s behavior but then achieving it by its own means. Thus, on seeing a model play soccer, an observer might discern that the goal is to place the ball into the net. However, instead of imitating the kicking action, the observer might pick the ball up and throw it into the net instead. Goal emulation so defined requires some degree of intentionality (Call & Carpenter, 2002). In contrast, some types of emulation are likely to be based on relatively simple cognitive mechanisms. On watching nut-cracking an observer may make the simple association between the outer appearance of the nut and food (Byrne, 2003).

Whiten et al. (2004) even suggest that OMR can be subdivided into a cognitively complex imitative type and a less complex emulative type. For instance, they suggest that “if A copies the trajectory of a hammer swung by B, this may draw on imitative processes not so different from those involved when A copies the way B hammers with a fist” (Whiten et al., 2004, p. 39). In contrast, there are circumstances in which OMR can be explained in terms of relatively simple associative mechanisms. For example, on seeing the association between a panel moving from left to right and a food reinforcement, if the observer subsequently starts pushing the panel in the same direction, it may be motivated to continue to do so because of the previously observed positive association. Matching the direction of opening on our boxes would indicate this type of matched-dependent learning (Whiten & Ham, 1992), but only if there was evidence of trial and error in the direction of movement prior to participants settling on moving the lids or flap door in the direction shown. If on the very first movement the participants matched the direction shown, one cannot readily explain this by matched-dependent learning. To match on the very first attempt, the participants must visually encode the direction of movement and be able, without trial and error, to apply force in the same direction.

By incorporating elements that can be moved in two opposing directions, three of our boxes used bidirectional methodologies to test for OMR. Bidirectional methodologies have been used in a number of previous studies (see Table 1). Participants can match the direction in which objects are moved either egocentrically (with respect to their own bodies) or allocentrically (with respect to the apparatus) (Ray & Heyes, 2002). Hence, observers may compensate for a 180° difference in perspective from a model, so that although they saw an object, such as a vertical lever, move from right to left through their own field of view, when they are given access to the lever they may push it left to right in the same way as the model did (e.g., Heyes & Dawson, 1990; but see Mitchell, Heyes, Gardner, & Dawson, 1999). To use Whiten et al.’s (2004) categorizations, such egocentric encoding would indicate imitative OMR (because it is based on matching the model’s direction of force), whereas allocentric responding would indicate emulative OMR (because it is based on matching the object’s movements from one’s own perspective).

It is also possible to imitate allocentrically by producing a mirror image of a demonstrated action. Hence, if a demonstrator waves his or her right arm back and forth, an observer might wave his or her left arm in a similar manner. Such behavioral matching complies with Whiten and Ham’s (1992) definition of imitation because it involves reproducing at least some part of the form of the modeled action. In other words, it is the model’s actions that are being matched rather than the movement of an object.

Because OMR has been found in a number of species, including other nonhuman primates, we had good reason to suspect that
pig-tailed macaques would be capable of this type of social learning. We decided to test human children also, partly to provide a benchmark against which to compare the monkeys’ performance and partly because only a few studies with children have focused on any social learning mechanisms other than imitation (Want & Harris, 2002). Although there is little doubt that children from a very early age are capable of stimulus enhancement (both generalized and localized), there is limited empirical data on the subject.

Want and Harris (2002) have also argued that there is, as yet, no convincing evidence from children of emulation in the sense of learning about the properties of and causal relations between objects. There is, however, evidence for less complex forms of emulation. Huang, Heyes, and Charman (2002) provided evidence in young children of a type of emulation labeled final state recreation by Custance et al. (1999). Huang et al. found that 19-month-old infants were just as likely to perform certain target acts on objects (such as dropping beads into a pot) when shown just the start and end states of the objects as compared with when they saw full demonstrations or failed attempts.

In addition, some of the target acts in various imitation studies with children can be interpreted in terms of OMR. For example, Meltzoff (1988) showed 14-month-old children the act of closing a hinged panel. It is difficult to determine whether they were reproducing the movement of the object or imitating the pushing action of the demonstrator. Meltzoff (1995) was able to tease these issues apart somewhat by presenting children with a small plastic dumbbell that could be divided into two parts by grasping the ends and pulling in opposite directions. Meltzoff found that 18-month-old children were less likely to perform this act if they saw a robotic device pulling the dumbbell apart as compared with an adult human demonstrator. Because in order to reproduce the target act the children seemed to require to see not only the two segments of the dumbbell moving apart but also the act of a human demonstrator pulling, the results may indicate imitative OMR as defined by Whiten et al. (2004).

In the light of Meltzoff (1995) and Huang et al.'s (2002) findings, we decided to test a similarly aged sample of children. We also tested 2- and 3-year-olds because Whiten, Custance, Gomez, Teixidor, and Bard (1996) found that the fidelity of matching the actions performed on an artificial fruit (of similar complexity to the present pin-bolt box) was remarkable, particularly in the 3-year-olds tested. Therefore, we predicted that we would find developmental trends in terms of fidelity of matching on our puzzle boxes.

Finally, we also collected data on the extent and pattern of attention the monkey and children paid to the demonstrations of each box. If an individual does not watch a model, then the scope of his or her social learning will be greatly restricted. Yet relatively few studies have systematically recorded the degree to which participants appear to watch a model. Carpenter, Tomasello, and Savage-Rumbaugh (1995) found numerous instances of bonobos and chimpanzees following the gaze of humans to objects (see also Bard & Vauclair, 1984). Adams-Curtis and Fragaszy (1995) found that the only effect on a group of capuchins of a model solving a three-step puzzle was an increase in the time that juveniles spent in the vicinity of the apparatus. Visalberghi and Trinca (1989) found that an observer capuchin did not look at a tube any more often when a conspecific was engaged in poking food out of it with a stick than when the model was merely near the tube (see also Visalberghi, 1993). Thus, we predicted that our sample of pig-tailed macaques would pay significantly less attention to the demonstrations than the children tested. We also predicted that the

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Table 1

<table>
<thead>
<tr>
<th>Reference</th>
<th>Species</th>
<th>Task details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collins (1988)</td>
<td>Mice (Mus musculus)</td>
<td>Matched a model (M) by pushing a pendulum door to the left more often</td>
</tr>
<tr>
<td>Heyes &amp; Dawson (1990)</td>
<td>Rats (Rattus norvegicus)</td>
<td>Pushed a vertical bar in same direction as an M compensating for</td>
</tr>
<tr>
<td>Bugnyar &amp; Huber (1997)</td>
<td>Common marmosets (Callithrix jacchus)</td>
<td>Lifted a flap door on a box upward if they had seen a model do so; otherwise</td>
</tr>
<tr>
<td>Campbell et al. (1999)</td>
<td>Starlings (Sturnus vulgaris)</td>
<td>Matched the direction in which an M removed differently colored</td>
</tr>
<tr>
<td>Custance et al. (1999)</td>
<td>Capuchin monkeys (Cebus apella)</td>
<td>Removed a pair of bolts on a puzzle box either from the back or</td>
</tr>
<tr>
<td>Stoinski et al. (2001)</td>
<td>Gorillas (Gorilla gorilla)</td>
<td>Removed a pair of bolts on a puzzle box from either the back or</td>
</tr>
<tr>
<td>Akins et al. (2002)</td>
<td>Japanese quail (Coturnix japonica)</td>
<td>Matched the direction in which an M removed differently colored</td>
</tr>
<tr>
<td>Heyes &amp; Saggerson (2002)</td>
<td>Budgerigars (Melopsittacus undulatus)</td>
<td>Matched the direction an M removed a stopper, either up or down, but not a</td>
</tr>
<tr>
<td>Fawcett et al. (2002)</td>
<td>Starlings (Sturnus vulgaris)</td>
<td>Matched the direction an M removed a stopper, either up or down, but not a</td>
</tr>
<tr>
<td>Ray &amp; Heyes (2002)</td>
<td>Rats (Rattus norvegicus)</td>
<td>Matched an M who pushed a lever either up or down, but only on a lever</td>
</tr>
<tr>
<td>Gardner et al. (cited in Visalberghi &amp; Fragaszy, 2002)</td>
<td>Capuchin monkeys (Cebus apella)</td>
<td>Pushed a bidirectional screen in the same direction as demonstrated</td>
</tr>
</tbody>
</table>
children would exhibit much higher levels of social learning than the monkeys.

Experiment 1: The Swivel Lid

The swivel lid was designed to test for both LSE and OMR. Participants watched a demonstrator use either the handle or the rim of a circular lid and swivel it to the left or right.

Method

Pig-Tailed Macaques

Subjects and housing. The subjects were 13 pig-tailed macaques (Macaca nemestrina; 12 females and 1 male) who belonged to a social group composed of a total of 23 monkeys. The ages of the subjects ranged from 5 to 13 years ($M = 8.15$ years, $SD = 3$ years). They were divided into two groups that were counterbalanced for age. One female had to be excluded from Experiment 1, because, despite having performed well during the habituation phase, she refused to approach the experimental object. The monkeys were not food deprived during the experiments, and water was always available. The monkeys were housed at the Centre of Primatology HSR, Milan, Italy. Their enclosure had two indoor and two outdoor living spaces that could be locked off from one another (Figure 1a). The indoor areas had solid walls but were linked to each other by a wire runway with sliding doors at either end.

Materials and testing conditions. The swivel lid consisted of an open-topped box made of 1.5-cm-thick mahogany, which was 7 cm high, 11 cm wide, and 11 cm deep. A transparent circular Perspex lid, 15 cm in diameter and 1.5 cm thick, was attached to the top of the box with a screw (Figure 2a and 2b). A small rectangular wooden handle was attached to the center of the lid. Upon each trial, the box was baited with four banana-flavored pellets (Bio-Serv Dustless Precision Pellets, 300 mg; Frenchtown, NJ).

All of the experimental boxes were presented on a specially designed testing cabinet (45 cm high, 45 cm wide, and 50 cm deep; Figure 1b). The sides of the cabinet were made of opaque double-laminated panels, and the ceiling was made of transparent Perspex. The cabinet was separated from the monkeys’ indoor area by a vertical rolling shutter. Once the shutter was raised, a macaque could enter the cabinet and sit on a metal platform. In this position, the monkeys could comfortably manipulate objects placed over a presentation shelf, which was 10 cm above their seating platform, and they could also observe a human demonstrator by looking through a grid of eight vertical steel bars (5 mm thick and 5 cm apart). The central bars formed a vertically rising gate through which the test box could be passed. Directly in front of this opening was a trolley with a greased rail fixed to its surface. A stainless steel rectangular plate, with the test box screwed to it, could be pushed along the rails and through the raised gate so that it protruded over the presentation shelf. The monkeys could manipulate the box when it was pushed over the presentation shelf but not when it was pulled back 50 cm along the rail. At this distance, they could only observe the demonstrator manipulating the box.

![Image](image-url)

*Figure 1.* a: Ariel view of the monkeys’ living area. The arrow indicates the location of the testing platform. b: The testing platform.
After the fourth demonstration, the monkey exited the platform, and the rolling shutter was lowered. The box was then pushed through the gate onto the presentation shelf, and the rolling shutter was raised again. There was a delay of approximately 25 s between the end of the final demonstration and the monkey gaining access to the box.

Each subject performed a total of 16 trials: 4 trials per day on 4 consecutive days. On each trial, from the moment that the rolling shutter was raised, the monkey was given a maximum of 2 min in which to open the box. If the monkey did not approach the box or did not succeed in opening it after 2 min, the rolling shutter was lowered and the box was retrieved in readiness for the next trial. However, if the monkey succeeded in opening the box within 2 min, he or she was given time to collect the pellets before the box was retrieved. After the fourth trial, the monkey was returned to the outside enclosure.

Children

Participants. Thirty children (16 boys and 14 girls) from four South East London nursery schools were divided into three distinct age cohorts. There were 10-, 15-, to 20-month-old infants \( (M = 18.2 \text{ months}, SD = 1.69) \); 10-, 26-, to 32-month-olds \( (M = 29.3 \text{ months}, SD = 2.06) \); and 10-, 40-, to 45-month-olds \( (M = 42.1 \text{ months}, SD = 1.29) \). The participants were placed into different experimental groups that were counterbalanced for age and gender.

Materials and testing conditions. The same swivel-lid box was used as with the monkeys. Various rewards were placed inside the box: stickers, small biscuits, sweets, and raisins. The children were tested in a separate room from the main play group. The box was placed on the floor. A video camera on a tripod was placed at such an angle that one could see not only the child’s actions and his or her visual orientation during the demonstrations but also, partially, the demonstrator’s actions from behind.

Procedure. Each child was tested individually. The child was asked to sit on the floor, opposite the demonstrator. The demonstrator made no other comment with regard to the box except to say, “Today we are going to play with this box. You can choose a prize for me to put into the box.” The child was allowed to select the prize. The demonstrator was careful not to give specific instructions with regard to the child paying attention or watching her. Just as with the monkeys, the demonstrator did not start the first demonstration until she was sure that the child was looking at the box.

Pilot work indicated that some children became bored and uncooperative if they received 16 trials on the same task over the span of 4 days. Therefore, unlike the monkeys, the children each received 8 trials on 2 separate days (4 trials per day). After the fourth demonstration, before each trial, the child was instructed to remain seated; the demonstrator waited 25 s before presenting the box to the child. Thus, the children and monkeys experienced a similar delay between demonstration and presentation of the box. The box was presented for 2 min; however, if the child opened it within this time, it was removed immediately after she or he had collected the reward.

The videotaped demonstrations and trials for the monkeys and children were analyzed using identical protocols. The data related to the participants’ attention during the demonstrations were collected in two different ways. First, the overall percentage of time that the participants were oriented toward the box was collected for each set of demonstrations. The overall duration of each set of four demonstrations was calculated from the moment the monkey had entered the presentation platform until the point that the demonstrator released the lid after the fourth demonstration. The duration of the monkeys’ looking behavior during each of these periods was collected using frame-by-frame analysis. Second, the percentage of instances (i.e., based on counts or frequencies) in which each participant was looking at the box at the critical moments of all of the demonstrations (i.e., from the moment the lid was swiveled from the fully closed to the fully open position) was recorded. To make direct comparisons between...
the monkeys and the children, only the first eight trials of the monkeys’ data were included in the analysis.

When the participants were given access to the swivel box, the following information was collected from the videotaped trials: the lid part that was first touched (handle vs. rim), the lid part that was gripped when the lid was first moved and when it was first completely opened (i.e., allowing access to the food), the direction (to the participant’s left or right) in which the lid was first moved, the direction in which it was first completely opened, and time to solution. Time to solution was calculated in terms of the amount of time in interaction with the boxes, excluding those periods of time when the participants sat back from the test apparatus, turned, or walked away from it. Interobserver reliability probabilities (calculated by Cohen’s kappa) indicated good to excellent agreement for all categories on all four boxes.

Owing to the relatively low subject numbers and because there were a small number of outliers in the data sets, nonparametric statistics were adopted throughout (Howell, 1987). There were clear directional hypotheses on the swivel-lid, flap-door, and sliding-lid boxes in relation to matching the demonstrated direction of lid movement and the part of the lid grasped: hence, one-tailed z-ratio binomial tests were used (Siegel & Castellan, 1988, pp. 38–39). When comparing the degree of matching adopted throughout (Howell, 1987). There were clear directional hypotheses (calculated by Cohen’s kappa) indicated good to excellent agreement for all categories on all four boxes.

Results

Table 2 contains the means and standard deviations for the attention data. The children were oriented toward the box for an average of 95% of the time during the demonstrations, whereas the monkeys were similarly oriented only 58% of the time (see Figure 3). There was a significant main effect for percentage of time oriented toward the box, Kruskal–Wallis $\chi^2(3, N = 42) = 22.3$, $p < .001$. No significant differences were found in post hoc Mann–Whitney U tests comparing the child samples, but they were all oriented toward the box during the demonstrations significantly more than the monkeys were ($p < .01$ in all cases). Similarly, the children were looking during, on average, about 93% of the critical moments of the demonstrations (i.e., as the lid was being swiveled open), whereas the monkeys looked for an average frequency of 68%. When the samples of children and monkeys were compared, there was a significant main effect, Kruskal–Wallis $\chi^2(3, N = 42) = 23.54$, $p < .001$. None of the child samples significantly

<table>
<thead>
<tr>
<th>Behavioral category</th>
<th>Pig-tailed macaques</th>
<th>1-year-olds</th>
<th>2-year-olds</th>
<th>3-year-olds</th>
<th>Monkeys vs. children</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Swivel lid</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time oriented toward the model: $M$ (SD)</td>
<td>58.29 (7.49)</td>
<td>95.86 (5.04)</td>
<td>94.56 (9.21)</td>
<td>90.59 (5.59)</td>
<td>$p &lt; .01$</td>
</tr>
<tr>
<td>% times looking at critical moment: $M$ (SD)</td>
<td>67.97 (12.08)</td>
<td>94.62 (6.23)</td>
<td>90.21 (9.04)</td>
<td>92.58 (7.53)</td>
<td>$p &lt; .001$</td>
</tr>
<tr>
<td>Lid part first touched (handle vs. rim)</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
</tr>
<tr>
<td>Lid part first touched (handle vs. rim) across Trials 1–8</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
</tr>
<tr>
<td>Lid part gripped (handle vs. rim) when first moved</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
</tr>
<tr>
<td>When opened first time</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
</tr>
<tr>
<td>When opened across Trials 1–8</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
</tr>
<tr>
<td>Direction in which lid was first moved</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
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<tr>
<td>Direction in which lid was first moved across Trials 1–8</td>
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<td>ns ns ns ns</td>
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<tr>
<td>Direction in which lid was first opened</td>
<td>ns ns ns ns</td>
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<tr>
<td>Direction in which lid was first opened across Trials 1–8</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
</tr>
<tr>
<td>Time to solution in seconds: $M$ (SD)</td>
<td>41.58 (48.65)</td>
<td>49.50 (85.06)</td>
<td>5.40 (5.68)</td>
<td>6.30 (5.1)</td>
<td></td>
</tr>
<tr>
<td><strong>Flap door</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% time oriented toward the model: $M$ (SD)</td>
<td>59.43 (9.64)</td>
<td>86.44 (9.50)</td>
<td>87.53 (11.52)</td>
<td>93.16 (4.22)</td>
<td>$p &lt; .001$</td>
</tr>
<tr>
<td>% times looking at critical moment: $M$ (SD)</td>
<td>57.02 (13.92)</td>
<td>86.57 (9.09)</td>
<td>78.36 (17.03)</td>
<td>81.04 (13.91)</td>
<td>$p &lt; .01$</td>
</tr>
<tr>
<td>Direction in which the door was moved (flip vs. push) on first solution</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
</tr>
<tr>
<td>Direction in which the door was moved (flip vs. push) across Trials 1–8</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
<td>ns ns ns ns</td>
</tr>
<tr>
<td>Time to solution in seconds: $M$ (SD)</td>
<td>5.85 (7.84)</td>
<td>6.90 (4.95)</td>
<td>4.30 (4.03)</td>
<td>4.30 (3.56)</td>
<td></td>
</tr>
<tr>
<td><strong>Sliding lid</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% time oriented toward the model: $M$ (SD)</td>
<td>59.41 (11.64)</td>
<td>92.20 (8.57)</td>
<td>93.97 (6.53)</td>
<td>93.85 (6.70)</td>
<td>$p &lt; .01$</td>
</tr>
<tr>
<td>% times looking at critical moment: $M$ (SD)</td>
<td>57.96 (18.07)</td>
<td>91.88 (9.24)</td>
<td>90.11 (6.03)</td>
<td>87.23 (7.95)</td>
<td>$p &lt; .001$</td>
</tr>
<tr>
<td>Direction in which the lid was first moved</td>
<td>p = .048</td>
<td>p = .013</td>
<td>p = .002</td>
<td>p = .057</td>
<td>ns</td>
</tr>
<tr>
<td>Direction in which the lid was first moved across Trials 1–8</td>
<td>ns</td>
<td>p = .057</td>
<td>p = .002</td>
<td>p = .057</td>
<td>ns</td>
</tr>
<tr>
<td>Direction in which the lid was first opened</td>
<td>ns</td>
<td>p = .013</td>
<td>p = .013</td>
<td>p = .057</td>
<td>ns</td>
</tr>
<tr>
<td>Direction in which the lid was first opened across Trials 1–8</td>
<td>ns</td>
<td>p = .013</td>
<td>p = .013</td>
<td>p = .057</td>
<td>p = .0013</td>
</tr>
<tr>
<td>Time to solution in seconds: $M$ (SD)</td>
<td>9.58 (8.02)</td>
<td>11.1 (17.9)</td>
<td>1.9 (0.74)</td>
<td>1.9 (1.2)</td>
<td></td>
</tr>
</tbody>
</table>
differed from one another, but they all looked significantly more at
the critical moment compared with the monkeys \((p < .001\) in all
cases).

To evaluate whether there was a relationship between the
amount the participants looked during the demonstrations and their
subsequent performance, we calculated the percentage of visual
orientation toward the demonstrations and the percentage of crit-
ical moments observed prior to the participants’ first solution of
the puzzle box. All but two of the children were at ceiling in terms
of their attention. There were no significant correlations between
the monkeys’ attention data and their times to solution. Similar
results were found for the flap-door and sliding-lid boxes.

As Figure 4 indicates, only the 3-year-old children matched the
lid part that was first touched (i.e., handle vs. rim) above chance on
the first trial (binomial tests \([9\ out\ of\ 10], z = 2.22, p = .013\)).
When the children’s data were combined, they did not match the
box part first touched on the first trial significantly more than the
monkeys, Fisher’s exact \((12, 30), p > .05\). To calculate whether
the participants were matching above chance in terms of the box
part first touched across the first eight trials, separate probabilities
were calculated for each participant. None of the samples matched
above chance (z-ratio binomial tests, \(p > .05\) in all cases; Figure
4). There was also no significant difference in terms of the degree
of matching shown by the children compared with the monkeys,
Fisher’s exact \((12, 30), p > .05\).

None of the samples matched above chance in terms of the lid
part gripped when participants very first moved it, although the
3-year-olds’ data approached significance (binomial test \([8\ out\ of
10]: z = 1.58, p = .057\)). There was also no significant difference
between the monkeys and the children in this respect, Fisher’s
exact \((12, 30), p > .05\). Similarly, none of the child samples or the
monkeys matched above chance in terms of the lid part used when

![Figure 3](image_url)

*Figure 3.* The mean percentage of time each sample was oriented toward the demonstrations for the swivel lid,
flap door, and sliding lid boxes.

![Figure 4](image_url)

*Figure 4.* The percentage of participants in each sample who matched the demonstrated box part (handle vs.
rim) when they first touched and opened the lid.
first opening the lid completely (binomial tests: \( p > .05 \); Figure 4). Nor was there a significant difference between the children and the monkeys in this respect, Fisher’s exact (12, 30), \( p > .05 \). To assess whether the participants were matching above chance in terms of the box part used when first completely opening the lid across the first eight trials, probabilities were calculated for each participant. None of the samples matched above chance (binomial tests: \( p > .05 \) in all cases; Figure 4), and there was no significant difference between the monkeys and the children, Fisher’s exact (12, 30), \( p > .05 \).

As depicted in Figure 5, only the 2- and 3-year-old children matched above chance in terms of the direction in which they first moved the lid (binomial test [9 out of 10]: \( z = 2.22, p = .013 \) in both cases). The children combined matched significantly more than the monkeys in terms of the very first lid movement, Fisher’s exact (12, 30), \( p = .02 \). The 2- and 3-year-olds bordered on significance across the first eight trials (binomial test [8 out of 10]: \( z = 1.58, p = .057 \) in both cases; Figure 5), and when the data from the child samples were combined, they matched significantly more than the monkeys across the first eight trials, Fisher’s exact (12, 30), \( p = .014 \). Similarly, only the 2- and 3-year-old children matched above chance in terms of the direction they moved the lid when they first completely opened it (binomial tests [9 out of 10]: \( z = 2.22, p = .013 \); Figure 5). The children combined matched significantly more than the monkeys did in this respect, Fisher’s exact (12, 30), \( p = .02 \). When the probabilities across the first eight trials were calculated for each participant, again the 2- and 3-year-olds bordered on significance (binomial test [8 out of 10]: \( z = 1.58, p = .057 \) in both cases Figure 5). In addition, the children combined matched across the first eight trials significantly more than the monkeys did, Fisher’s exact (12, 30), \( p = .014 \).

Although the monkeys did not significantly match the direction of opening shown, they showed great consistency in the direction they preferred to open the lid. Every monkey pushed in a consistent direction on between 80% and 100% of its 16 trials (\( M = 91.67\%, SD = 8.16 \)). Eleven out of the 12 monkeys consistently pushed in one direction above chance level according to z-score binomial tests (\( p < .05 \)). The 2- and 3-year-olds consistently matched the direction demonstrated (see above). The 1-year-olds were more variable in their direction of opening, consistently pushing in one direction on between 50% and 100% of their eight trials (\( M = 78.75\%, SD = 15.65 \)).

The monkeys and the 1-year-old children spent much longer first opening the box on average than the 2- or 3-year-olds (see Table 2 for means and standard deviations). There was a significant main effect between the samples in terms of times to the first solution, Kruskal–Wallis \( \chi^2(3, N = 42) = 23.84, p < .001 \). There was no significant difference between the monkeys and the 1-year-olds, \( U(12, 10) = 54.5, p = .716 \). Both the 2-year-olds, \( U(12, 10) = 2.5, p = .001 \), and the 3-year-olds, \( U(12, 10) = 10.0, p = .001 \), solved the box significantly faster than the monkeys. They also both solved it faster than the 1-year-olds: 2-year-olds, \( U(10, 10) = 4.5, p = .001 \); 3-year-olds, \( U(10, 10) = 12.0, p = .004 \). There was no significant difference between the 2- and the 3-year-olds, \( U(10, 10) = 36.0, p = .284 \). Table 2 provides a summary of the results for the behavioral categories related to the swivel lid.

**Experiment 2: The Flap Door**

The flap door was designed to test for OMR. A demonstrator either pushed the door inward or pulled it up (Figure 2c and 2d).

**Method**

**Pig-Tailed Macaques**

**Subjects.** The subjects were as in Experiment 1.

**Materials and testing conditions.** The experimental wooden box (12 cm high, 20 cm wide, and 17 cm deep) was made of 1.5-cm-thick pieces of mahogany (see Figure 2c and 2d). All sides of the box were solid except for the front wall, which was a free-swinging flap door (9 cm wide and 14.5 cm high). The flap was suspended by metal pins that passed through the top side walls of the box. There was a gap of 0.5 cm between the top of the flap and the front edge of the ceiling of the box and a gap of 1 cm between the inside floor of the box and the bottom edge of the flap.

**Procedure.** The procedure was similar to that of Experiment 1. The same human demonstrator presented flipping the lid to one group of subjects and pushing it inward to the second group (Figure 2c and 2d). Each subject received four demonstrations prior to each of eight 2-min trials. The subjects received four trials per day over the span of 2 days.
Attention data similar to those used with the swivel lid were collected. The overall duration of each set of four demonstrations was calculated from the moment the demonstrator started to push or pull to the moment she was no longer in contact with the flap door. Whether the monkeys were looking at the critical moment was recorded during the period when the flap door was in the fully closed position to when it was either flipped fully upward or when it was pushed in to the point that the demonstrator could grasp the reward.

**Children**

The participants, materials, and testing conditions were as in Experiment 1.

The same flap-door box was used as with the monkeys. The children were tested using a similar procedure as outlined for Experiment 1.

**Results**

The children were oriented toward the demonstrator and box during the demonstrations for an average of 89% of the time, whereas the monkeys were similarly oriented only 60% of the time (see Figure 3 and Table 2). There was a significant main effect for percentage of time oriented forward, Kruskal–Wallis $\chi^2(3, N = 42) = 24.61, p < .001$. No significant differences were found in post hoc tests comparing the child samples, whereas all three child samples were oriented forward significantly more than the monkeys ($p < .001$ in all cases). The children were looking during, on average, 82% of the critical moments of the demonstrations, whereas the monkeys looked with an average frequency of 57%. A significant main effect was found, Kruskal–Wallis $\chi^2(3, N = 42) = 17.56, p = .001$, with none of the child samples significantly differing from one another but all of them looking significantly more than the monkeys did ($p < .01$ in all cases; Table 2).

None of the samples matched the method demonstrated (flip vs. push) significantly above chance on the very first solution, although the 2-year-olds approached significance (binomial test $[8$ out of $10]; z = 1.58, p = .057$). There was no significant difference between the children and the monkeys in terms of matching on the first solution, Fisher’s exact ($12, 30), p > .05$. None of the child samples or the monkeys matched the method demonstrated above chance across the first eight trials (binomial test: $p > .05$ in all cases). Hence, there was no significant difference between the children and monkeys in terms of matching across trials, Fisher’s exact ($12, 30), p > .05$.

The monkeys were on average 1.68 s slower than the 1-year-olds, who were on average 2.6 s slower than the older children in first opening the box. There was a significant main effect for time to first solution, Kruskal–Wallis $\chi^2(3, N = 42) = 9.29, p = .026$. There was no significant difference between the 1-year-old and the monkeys or between the 2- and 3-year-olds. However, the monkeys and 1-year-olds took significantly longer to open the box than the 2-year-olds and the 3-year-olds ($p < .05$ in all cases). Table 2 provides a summary of results for the behavioral categories related to the flap door.

**Experiment 3: The Sliding Lid**

The sliding lid was designed to test for OMR. A demonstrator slid the lid either to the left or to the right. In all of the other experiments, there was a 25-s delay between the demonstrations and the presentation of the boxes to the participants. In the hope of further promoting a social learning effect, we reduced the memory requirements on the sliding lid in comparison with the other boxes by providing continued demonstrations during the presentation phases.

**Method**

**Pig-Tailed Macaques**

**Subjects.** All 13 subjects took part in the experiment. They were divided into two groups, which were counterbalanced for age.

**Materials and testing conditions.** A small wooden rectangular box (10 cm wide, 6 cm deep, and 3 cm high) with a lid that could be slid in either direction along a horizontal plane was attached to the presentation plate (Figure 2f). The lid had two small screws fixed to its underside that prevented it from being separated from the body of the box. Four banana pellets were placed inside the box. Five identical boxes were placed on the trolley, out of reach of the monkey, prior to testing.

**Procedure.** One group of subjects saw the lid slide to the left, the other to the right. The demonstrator used her left hand to slide the lid to the left and her right hand to slide it to the right. She placed the tips of all four fingers on the surface of the lid to slide it.

Once the subject had entered the testing platform, the demonstrator placed one of the five boxes in front of the box that was fixed to the steel plate. When the demonstrator was sure that the monkey was looking toward the box, she demonstrated opening the lid and dropped a pellet into the box. She then placed the box to the right of the steel plate and repeated this procedure for the other four boxes. Finally, she demonstrated opening the test box and dropped four pellets inside it.

Once the monkey had jumped down from the platform and the experimenter had lowered the rolling shutter, all of the box lids were closed and the five unattached boxes were placed on the trolley to the left of the steel plate. The demonstrator then pushed the test box along the rails, out onto the testing platform, and placed one of the other boxes onto the sliding rails where the steel plate had been. Once these preparations were complete, she raised the rolling shutter again. As soon as the monkey entered the platform and approached the test box, the demonstrator began to open each of the five demonstration boxes in turn while the monkey was free to manipulate the test box within its own space. As soon as the monkey had retrieved the pellets, or once 2 min had elapsed, the rolling shutter was lowered again to allow preparations to be made for the next trial. Each monkey received a total of 16 trials, performing 4 trials per day over the course of 4 days.

Similar attention measures were used as with the swivel lid and flap door. The overall duration of each set of demonstrations was measured from the moment the demonstrator first started to open the first box to the moment she was no longer in contact with the sixth box. The critical moment was calculated from when the demonstrator started to slide open the lid from a fully closed position to the moment it was fully open, which took about a second.

**Children**

**Participants.** Participants were as in Experiments 1 and 2.

**Materials and testing conditions.** Identical boxes were used as with the monkeys. The test box was screwed onto a large wooden base (40 cm wide, 90 cm deep, and 0.5 cm thick) to prevent the children from picking it up, thereby causing the lid to slide open by gravity.

**Procedure.** An almost identical procedure was used as with the monkeys. After the presentations, the boxes were removed from sight for approximately 25 s. During this period, all of the lids were closed and the
The children were oriented toward the demonstrator and box for an average of 93% of the time, whereas the monkeys were similarly oriented only for 59% of the demonstration periods (see Figure 3 and Table 2). There was a main effect of percentage of time oriented forward, Kruskal–Wallis $\chi^2(3, N = 43) = 23.6, p < .001$. None of the child samples significantly differed from one another, whereas they were all oriented forward significantly more than the monkeys ($p < .01$ in all cases). Similar results were obtained with regard to looking at the box at the critical moments of the demonstrations (i.e., when the lid was being slid to the left or to the right). The children were looking toward the box during, on average, 90% of the critical moments of the demonstrations, whereas the monkeys were looking at a frequency of only 57%. There was a significant main effect of looking at the critical moment, Kruskal–Wallis $\chi^2(3, N = 43) = 22.04, p < .001$ (Table 2). None of the child samples differed significantly from one another, and they all looked at the critical moment significantly more than the monkeys ($p < .001$ in all cases).

Figure 6 illustrates that all of the samples except for the 3-year-olds, who bordered on significance, matched the direction demonstrated when they moved the lid for the very first time (binomial tests: monkeys [10 out of 13], $z = 1.67, p = .048$; 1-year-olds [9 out of 10], $z = 2.22, p = .013$; 2-year-olds [10 out of 10], $z = 2.85, p = .002$; and 3-year-olds [8 out of 10], $z = 1.58, p = .057$). There was no significant difference between matching on the very first lid movement between the children and monkeys (Fisher’s exact, $p > .05$). The 2-year-olds significantly matched the direction demonstrated when first moving the lid across the first eight trials (binomial test [10 out of 10]; $z = 2.85, p = .002$), whereas the 1- and 3-year-olds approached significance (binomial test [8 out of 10]; $z = 1.58, p = .057$ in both cases; Figure 6). The monkeys showed no evidence of matching the lid direction when they first moved it across the first eight trials (binomial test [5 out of 13]; $z = -0.56, p = .29$). A significant difference was found between the children and the monkeys in this respect, Fisher’s exact (12, 30), $p = .002$.

The monkeys did not show the same degree of consistency in their preferred direction of opening on the sliding lid as compared with the swivel lid. The consistency ranged from 50% to 100% ($M = 71.9\%, SD = 14.45$). The children were more consistent, as they tended to match the direction demonstrated when opening the box.

All of the children and all but one of the monkeys succeeded in opening the sliding lid. The 1- and 2-year-olds, but not the 3-year-olds or monkeys, matched the direction demonstrated when they first opened the lid (binomial tests: 1-year-olds [9 out of 10], $z = 2.22, p = .013$; 2-year-olds [9 out of 10], $p = .013$; the 3-year-olds bordered on significance [8 out of 10], $z = 1.58, p = .057$; Figure 6). However, there was no significant difference between the monkeys and the children in this respect, Fisher’s exact (12, 30), $p > .05$. Similarly, the 1- and 2-year-olds, but not the 3-year-olds or monkeys, matched the lid direction when first opening it across the first eight trials (binomial tests: 1-year-olds [9 out of 10], $z = 2.22, p = .013$; 2-year-olds [9 out of 10], $z = 2.22, p = .013$; the 3-year-olds bordered on significance [8 out of 10], $z = 1.58, p = .057$; Figure 6). There was a significant difference between the children and the monkeys (Fisher’s exact, $p = .0013$).

Table 2 shows that the monkeys and 1-year-olds had similar times to solution on the sliding lid; they took on average about 8 to 9 s longer than the 2- and 3-year-olds to open the box. Hence, there was a significant main effect for time to very first solution on the sliding lid, Kruskal–Wallis $\chi^2(3, N = 43) = 11.42, p = .01$. Unlike with the swivel lid, the monkeys did not show such great consistency in the direction of opening the sliding lid (irrespective of the demonstrations). Only four of the monkeys consistently pushed the lid in one direction above chance according to $z$-score binomial tests (i.e., $p < .05$).
Experiment 4: The Pin Bolt

The pin bolt was designed to test for LSE. Unlike in the other experiments, an individual learning control group was included to test whether these participants would touch the pin proportionally less and take longer to disable the pin than experimental participants who had witnessed a demonstrator.

Method

Pig-Tailed Macaques

Subjects. The subjects were as in Experiment 3.

Materials and testing conditions. The same swivel-lid box was used as in Experiment 1 except for the fact that a notch had been cut into the front of the rim of the lid, and a pin-bolt mechanism was attached to the front wall of the box (Figure 2e). When the pin was raised up into the notch, the lid could not be swiveled.

Procedure. One group of subjects saw the demonstrator push the pin down using her index finger (Figure 2e); the other group acted as control subjects and were presented with the box without receiving a demonstration. When demonstrating, the experimenter pushed the pin down only when she was certain that the subject was looking toward the box. If the participant looked away at the last moment, the pin was reset and the demonstration was repeated. The demonstrator then swiveled the lid open in the same manner as the subject had seen in Experiment 1. Each subject received one demonstration prior to each of four 2-min trials. The control subjects also received four 2-min trials. However, they received no demonstration. The box was pushed out onto the presentation platform, and the monkey was given access to it for 2 min. After 2 min, the rolling shutter was lowered for 30 s (the approximate length of time that it took to demonstrate pushing the pin down and opening the box). The shutter was then raised again, and the next trial began. Each subject received a total of four trials on 1 day.

Children

Participants. The participants were as in Experiment 3.

Materials and testing conditions. Materials and testing conditions were as described above.

Procedure. The procedure was in all major respects identical to that used for the monkeys, except that instead of lowering a shutter after each demonstration, the experimenter picked the box up and removed it from the child’s sight.

Results

None of the monkeys and only two 1-year-old children (both from the experimental group) solved the pin bolt. One 2-year-old child from the control group and two 3-year-old children (one from the control group and one from the experimental group) failed to open the box. All of the other participants solved the pin bolt within the first trial. Four of the 2-year-old and two of the 3-year-old control participants solved the task not by pushing down the pin but by vigorously agitating opposite sides of the lid until the pin was jiggled loose. The data from the participants who solved the task were pooled to compare the time to first solution between the experimental and control groups. The children in the experimental group solved the pin-bolt box significantly faster than those in the control group, Mann–Whitney \( U(11, 8) = 12, p = .008 \), one-tailed (Figure 7).

It was hypothesized that the experimental participants would touch the pin proportionally more than the controls, because they had seen a model touch it. The mean percentage of time each participant touched the pin compared with the rest of the box was calculated. There was no significant difference between the control and experimental subjects in the 1-year-old and monkey samples (see Figure 8). In contrast, the 2- and 3-year-old experimental participants touched the pin proportionally more than the controls, \( U(5, 5) = 1, p = .016 \) in both cases (Figure 8).
Discussion

Overall, the children exhibited much greater evidence of socially mediated learning than the pig-tailed macaques. The monkeys provided only very fragile evidence of matching the demonstration above chance when they first moved the sliding lid. The children, in contrast, matched above chance, to varying extents, on all of the boxes except the flap door. The children also paid significantly more attention to the demonstrations than the monkeys.

On the swivel-lid, flap-door, and sliding-lid boxes, the children were oriented in the correct direction (i.e., looking toward the demonstrator and box) about 90% of the time, and they also looked during, on average, 90% of the critical moments of the demonstrations (i.e., as the boxes were being swiveled, pushed, pulled, or slid open). The monkeys were similarly oriented and looking at the level of about 60%. Although the monkeys paid significantly less attention than the children, they nevertheless saw the critical moments of opening for an average of between two and three occasions before each trial. Indeed, the procedure of the pin bolt was designed so as to ensure that the children and monkeys in the observational groups were looking at the box each time the pin was pushed down. However, there was little evidence that the monkeys had learned much from what they had seen. Therefore, we found, just as Visalberghi and Trinca (1989) did with capuchin monkeys, that pig-tailed macaques seem to rely more on individual learning than on socially mediated learning. As expected, there was much clearer evidence of social learning from the children than from the monkeys.

We also found no evidence of a relationship between levels of attention and performance on the swivel-lid, flap-door, and sliding-lid boxes. Prior to their first solution on each of these boxes, the vast majority of the children looked at the demonstration 100% of the time. Even though the monkeys’ attention was much more variable, no significant correlations were found between their levels of attention and the times to first solution. Of course, it would also have been of interest to establish the extent to which the levels of attention were related to the degree of social learning exhibited. However, most of the data constituted bipolar frequencies, which are not suitable for correlational analysis. At a crude level, it was true that the monkeys looked less than the children and subsequently exhibited less evidence of social learning. However, the 1-year-old children did not look significantly less than the 2- and 3-year-olds, but they still provided only marginally more evidence of socially mediated learning than the monkeys did. Hence, whatever the relationship between attention and social learning, it does not appear to be straightforwardly correlational.

Quite apart from the issue of attention, one of the main purposes of the swivel-lid and pin-bolt experiments was to test for LSE. The swivel lid provided evidence of LSE only in the 3-year-old children. They significantly more often first touched the same box part as demonstrated before the alternative (i.e., the handle before the rim or vice versa), and there was a trend toward using the same box part when they first opened it. Hence, the 3-year-olds, in contrast to the other samples, seemed to organize their initial approach to the box in close accordance with what they had seen demonstrated.

Of course, there was no particular advantage to the participants in using the same box part as demonstrated. There was, however, a clear advantage in paying close attention to the pin bolt. Observing the demonstrator clearly advantaged the 2- and 3-year-old children so that they solved the puzzle box significantly more quickly than control participants. The two 1-year-olds who solved the pin bolt also came from the experimental condition. None of the monkeys solved it. In addition, when compared with the control group, the monkeys and 1-year-olds in the experimental condition showed no significant tendency to focus proportionally more of their manipulations on the pin as compared with the rest of the box. Hence, we found clear evidence of LSE in the older children and perhaps marginal evidence from 2 of the 1-year-olds, but there was no evidence of it among the monkeys.

In contrast to our negative results, Caldwell and Whiten (2004) found evidence of LSE in common marmosets, and it has also been reported in ravens (Fritz & Kotrschal, 1999) and keas (Huber et al., 2001). So why did we find no evidence of it in our pig-tailed...
monkeys? It is possible that on the pin bolt they were perseverating on the previously learned swiveling technique. Although, on the whole, they tended not to match the direction demonstrated on the swivel lid, most of the monkeys were remarkably consistent in the direction in which they preferred to push the lid. When they were faced with the pin bolt, they spent a great deal of their time apparently trying to swivel the lid and for the most part ignored the pin, only seeming to touch it in passing. One possible advantage of social learning is that it can suggest alternative, and sometimes more efficient, methods for solving problems. The monkeys showed impressive individual learning on the other boxes; however, their apparent rigidity in strictly adhering to previously learned techniques could have somewhat limited the scope of both their individual and the socially mediated learning. To elicit LSE in the monkeys, it might have been better to have used a box that looked markedly different from any of those they had previously manipulated.

It is also possible that the children were imitating the demonstrator’s actions with respect to pushing down the pin, whereas the monkeys were not. However, the children almost never held their index finger and hand in a vertical aspect, as shown in Figure 2e. They tended to hold their index finger in a horizontal position. Many children used their thumb in preference to their index finger. The pin bolt was designed to test principally for LSE, and we were not so concerned about distinguishing emulation from imitation on this task. In retrospect, it may have been better to have used a wide bar rather than a pin that could be pushed down using several digits. Such a device may have been easier for the monkeys to manipulate. The present task may have disadvantaged the monkeys in comparison with the children, as nonhuman primates have more limited use of individual digits compared with humans (Napier, 1993).

In addition to LSE, we tested for OMR using the flap-door, swivel-lid, and sliding-lid boxes. Neither the children nor the monkeys matched the direction demonstrated on opening the flap door (although the 2-year-olds approached significance the very first time they opened the box). The 2- and 3-year-olds allocentrically matched the demonstrated direction when they first moved and opened the swivel lid. All of the samples (except for the 3-year-olds, who approached significance on all measures) exhibited some allocentric matching on the sliding lid. However, the monkeys’ matching was very short lived: They matched above chance only on the very first movement of the sliding lid. Hence, the swivel lid and sliding lid, but not the flap door, provided evidence of OMR.

The fact that the 3-year-olds matched the direction of movement the very first time they moved the swivel lid and the monkeys, 1-year-olds, and 2-year-olds matched the direction when they first moved the sliding lid suggests that the underlying cognitive mechanism was not matched-dependent learning. If it were based on matched-dependent learning, one would expect some degree of trial and error on moving the lids before the positive association with previously observed reinforcement contingencies could be triggered. So what was the likely underlying cognition? One possibility is that it was based on neural priming (Byrne, 1995; Byrne & Russon, 1998). Hence, when the objects’ movements were visually encoded, this may have somehow neurally primed associated, previously performed, and hence neurally stored motor actions that were related to applying an allocentrically matching direction of force. Once the participants gained access to the objects, because they had been neurally primed, they may have been more likely to apply a matching direction of force on their very first manipulation of the box.

An alternative explanation is that the participants were allocentrically imitating the demonstrator’s pushing action. There are several reasons why the matching found in the children on the swivel lid is not well explained in terms of imitative OMR. First, the 2-year-olds tended not to use the same lid part as demonstrated. Hence, they would have used quite different actions to move the lid compared with the demonstrator. Second, the design of the box itself and the perspective from which it was demonstrated made imitation difficult to achieve. When the demonstrator performed the action of swiveling using the rim, she grasped the edge furthest away from her and pulled it in a semicircular arc back toward her body (clockwise with the right hand, counterclockwise with the left). The participants were not able to imitate this action, because the edge that was furthest from them was adjacent to the screw that fixed the lid to the box, and it was impossible to swivel the lid from this position. They could grip the rim at 90° or 270° (i.e., if the screw was taken to be at 0° on the lid’s circumference). However, such a grip required a different hand position for swiveling from that demonstrated, and it involved more of a pushing action rather than pulling, neither of which would have been indicative of imitation.

Similarly, when the demonstrator used the handle to swivel the lid, she employed a reversed pincer grip (see Figure 2b). If the participants had used the same grip, it would have been extremely awkward for them to swivel the lid in the same direction as shown. In fact, when facing the front of the box, if one used a reversed grip on the handle, it was much easier to push the lid in the direction opposite that shown. Hence, whether using the handle or the rim, the children’s matching of direction on the swivel lid is better explained in terms of emulation than imitation.

There was also little evidence of imitative matching on the sliding lid. The monkeys never matched the precise hand configuration used by the demonstrator for sliding the lid, and only 6 of the children did. Many of the children and the monkeys used quite different techniques, such as reaching to one end of the lid and pushing it with one or a combination of digits or grasping and pulling from one end of the lid. Hence, although 6 of the children may have been allocentrically imitating, the majority of them and all of the monkeys appeared not to do so. The results are therefore more consistent with emulative rather than imitative OMR.

Bugnyar and Huber (1997) claimed to have found evidence of imitative OMR in marmosets using a flap-door device. However, it is unclear whether the monkeys were learning about the direction of lid movement (i.e., emulative OMR) or the lifting action used by the model (i.e., imitative OMR). The 2-year-old participants in our study tended to use quite different pushing and lifting actions compared with the demonstrator, mainly because of their different perspectives on approaching the box. On pushing, the demonstrator reached toward her body with her palm facing partially up (Figure 2d), whereas the children pushed away from their bodies with their palms down. On lifting, the demonstrator turned her hand so that her fingers were pointing back toward her body (Figure 2c), whereas the children hooked the bottom of the flap
door with their fingers pointing away from them. Hence, the children’s matching was more indicative of emulation than of imitation.

Nevertheless, the very weak evidence of matching that we found using a flap door does not concur with Bugnyar and Huber’s (1997) previously positive results. Our flap door was a little different and probably easier to solve than their design. Their door had to be pulled open using a handle, and then the marmosets had to hold the door open while retrieving the food. Our flap door had a gap at the bottom, which allowed the participants to hook their fingers underneath it in order to flip it. Once the door had been flipped up, it would stay in place, allowing one to reach inside the box with both hands. One of the main problems with our flap door was that it swung too freely. With the other boxes one needed to apply a particular direction of force on the apparatus to open them. However, on touching practically any part of the flap, one could cause it to swing back and forth. Hence, it was easy for the participants to discover the alternative directions of movement. With the advantage of hindsight, it is clear that we should have fitted a much stiffer hinge.

One of the general limitations of the bidirectional method is that the alternative directions can always be reasonably easily discovered, and there is usually no functional advantage in matching the particular direction demonstrated. With just two response alternatives, a degree of matching is likely to occur by chance. Hence, one relies on strong group tendencies in order to find matching levels above chance. With low subject numbers, if there is a reasonably high degree of individual difference in the tendency to match, then all empirical trace of OMR is obscured.

Bugnyar and Huber (1997) used a modified version of the standard bidirectional procedure. First, they presented an individual learning control group with their flap door. The control subjects showed a strong preference for pushing. Next, experimental subjects were presented with conspecific models who used the pulling method. Three out of five experimental subjects subsequently solved the door by pulling. The authors identified four behavioral components involved in pulling the door (using the left hand to pull on the handle, pulling up from the right-hand gap, holding the door open, and finally reaching for the food). They calculated that the probability of their subjects matching this combination was well below chance. However, some of the behavioral components could have occurred through individual learning once the marmosets had committed themselves to pulling. Hence, despite the use of combinatorial probabilities, larger subject numbers were still needed to provide statistically convincing evidence of social learning.

Our sample of monkeys strongly preferred to lift the door rather than push it. One might be tempted to suggest that a control group should have been incorporated to establish individual learning preferences. However, a control group on a bidirectional task actually tells one very little. Each group serves as a control for the other. If we had included a control group, they would have no doubt also all flipped the door. The push group clearly illustrated that lifting was the preferred method without the need for a control group. Similarly, the monkeys preferred to use the rim of the swivel lid in contrast to the handle. The handle group clearly showed that using the rim was the preferred method irrespective of the demonstrations. A control group would no doubt have shown the same preference and thereby added no further information.

Nevertheless, if we had had access to a greater number of habituated monkeys, it would still have been useful to have included control groups. Although we found no evidence of LSE in the monkeys, a control group might have revealed evidence of generalized stimulus enhancement. It might have been the case, for example, that although the monkeys did not differentiate between manipulating the handle versus the rim on the swivel lid, they paid more attention to the lid in general than to the rest of the box because of the demonstrations they received. Indeed, our informal impression was that the subjects did pay more attention to the lids compared with the bodies of the boxes. However, this is probably because the lids were the most salient part of the boxes. One could establish whether this was a social learning effect only by showing that an individual learning control group would pay proportionally less attention to the lids as compared with experimental subjects.

Control groups are also useful for providing evidence that social learning can convey an advantage in terms of reducing the latency to solution of a problem. Without control groups on the swivel lid, flap door, and sliding lid boxes, we do not know whether nonobservers would have taken longer to open the boxes than observers. The pin-bolt experiment was included to explore just this issue. As mentioned earlier, it was clear on the pin bolt that such an advantage was gained by the 2- and 3-year-old children and possibly 2 of the 1-year-olds, but none of the monkeys.

The inclusion of control groups may also have helped explain why the 1-year-olds and monkeys provided evidence of social learning only on the sliding lid. It is possible that the simultaneous demonstrations during the presentation of the sliding lid reduced the cognitive load on this box compared with the other boxes. There was always a 25-s delay between the last demonstration and gaining access to the swivel-lid, flap-door, and pin-bolt boxes. On the sliding lid the participants tended to glance up at a demonstration and then immediately afterward manipulate their own box. Hence, the conditions under which the sliding lid were presented could have reduced the memory load involved and promoted social learning on this task. Indeed, the simultaneous demonstrations were included precisely for this reason. However, we cannot be sure that they had this effect, because we had too few monkeys to be able to include a control group that could have been presented with the box without receiving simultaneous demonstrations.

One reason why the children exhibited more social learning than the monkeys may have been that the children were faced with a conspecific demonstrator whereas the monkeys were not. However, it is an open question whether nonhuman primates are more likely to learn from conspecifics than humans. Human demonstrators can provide clear and slow demonstrations that are sensitive to the attention of the subjects. Indeed, some of the most convincing evidence of social learning in monkeys and apes has come from studies that used human demonstrators (e.g., Call, 2001; Custance, White, & Bard, 1995; Custance, White, & Fredman, 1999; Tomasello, Savage-Rumbaugh, & Kruger, 1993; Whiten et al., 1996).

The children may have matched to a greater degree than the monkeys because the two species were differently motivated. In contrast to the monkeys, many of the children seemed uninterested in the food rewards. A number of children put the sweets to one
side after retrieving them. Many children seemed more interested in solving the puzzles for their own sake and gaining the social approval of the demonstrator than gaining the prizes. Three of the older children reproduced some nonfunctional aspects of the demonstrations, such as opening and closing the lids several times before retrieving the sweets. On these occasions, 2 of the children looked up and smiled apparently playfully at the demonstrator. The majority of the children, at least in the early stages of testing, looked up at the demonstrator when they opened a box. If the children held the expectation that they would gain social approval for matching the demonstrations, then perhaps it is not surprising that they exhibited much greater evidence of social learning than the monkeys.

One issue that we did not address, to any great extent, was the longevity of the social learning exhibited. The monkeys’ matching on the sliding lid was very short lived. Matching across trials was much more robust in the children for both the sliding and swivel lids. However, all of the participants received demonstrations before (or even during) each trial. We do not know how long the children would have continued to match in the absence of continued demonstrations. However, the degree to which a species exhibits fidelity and longevity in its social learning has an impact on the debate as to whether its members are deemed capable of cultural transmission (Heyes, 1993; Tomasello et al., 1993).

In summary, we found clear evidence of LSE in the 2- and 3-year-old children (and perhaps marginal evidence for it in 2 of the 1-year-olds on the pin bolt). We also found evidence of emulative OMR on the sliding lid among both the children and the monkeys. The fact that the children and monkeys matched the direction of movement the very first time they moved the sliding lid suggests that matched-dependent learning was not the underlying cognitive mechanism. Instead, it might have been based on some kind of neural priming. Social learning among the monkeys was evident on only one box and was highly transitory. Therefore, it would be advisable to seek replication of this result before drawing any strong conclusions.

References


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