The Role of Observational Learning in Perceiving Object Properties in Infants (March 2008)

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***Abstract*—Infants become skilful at manipulating objects around the end of the first year of life. The question asked here is how do they learn about object properties and what is the role of observation in learning to manipulate objects. In order to answer these questions we designed an experiment where we compared the effect of practice versus observation on learning new motor skills. We tested 84 infants aged 8, 10, 12, 15 and 18 months on two different tasks: a simple grasping task and a more complex retrieval task. We compared two groups of infants: an observation group where the experimenter presented directly the infants with the demonstration of the targeted action and then gave the infant the object to manipulate; and a self-exploratory group where infants were presented with a spontaneous trial before the demonstration. The results show that for a simple grasping task, only the youngest infants benefit both from practice and observation because of their poor performance at the very first, spontaneous, trial. As for the retrieval task, infants learned only by observation and not before 15 month of age.**

***Index Terms*—Observational learning, practice, object properties, infant**

I. Introduction

Grasping an object requires both the knowledge of its affordances and the organisation of the gesture regarding the object characteristics (hand orientation, shape, opening, deceleration at the end of reaching…). Grasping can be made more complex when, to the adaptation to the object's physical characteristics, one adds another problem to be solved (object presented behind a barrier, inserted in another object, for instance). How do infants learn about these object properties and what is the role of observation in learning to manipulate objects? The aim of the research presented here was to study the developmental path by which human infants acquire new motor skills via observing and without executing actions?

Although there is a long and rich tradition of infant studies in imitation, the role of learning by observation in the building of infant's motor repertoire has received little interest so far. We mean by observational learning a novel action via a demonstration with a minimum delay before acting. In addition learning must have a long term effect. Elsner (2003) claims that it is impossible for infants in their first year of life to acquire by themselves all the knowledge about actions because they are constraints by their motor development. Observational learning would be an alternative to acquire action-effect knowledge. She showed in her study (2007) that 9-to 15 month-olds were capable of reproducing actions they observed compared to infants who have seen a part of the targeted action or infants with no demonstration.

Also studies on non human primates have shown some sort of observational learning in great apes (Call et al., 2005, Hopper et al., 2008), even though they did not always agree on the way great apes copy a model in terms of emulation (copying the end) or imitation (copying the mean).

In the motor neuron system literature, studies have shown that common neural areas are involved in observing others performing movements, motor imagery and executing a motor performance. Much of the evidence comes from work on adults. Studies on adults have shown that motor training as well as mental training improves performance of motor skill tasks. It has been demonstrated (Nyberg, 2006) that distinct neural pathways are involved in the two conditions, whereas common neural areas are involved in observing and performing movements (Petrosini, 2003). The motor-simulation theory proposes that perceiving actions involves internal simulation of the movement to be produced (Jeannerod, 2001). This internal simulation involves not only action programming but also the generation of a copy of the movement to be reproduced. It is also proposed that when the action has to be learned, the intention to produce the task enhances observation (Badets, 2006). Different neuronal structures are involved with and without intention to reproduce the observed behaviour (Decety, 1997). Recently the role of the Mirror Neuron System in imitation has been emphasized (Rizzolatti, 2001).

According to these behavioral and imaging studies, observation seems to play an important role in the

This work was supported in part by the europeen contract Mathesis under Grant IST-027574.

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development of one's motor repertoire. The study reported here attempts to investigate the role of observation in acquiring new motor skills and the age at which infants begin to benefit from observation. It involves a direct comparison between learning by observation and learning through practice in the first and second year of life.

II. METHODS

A. Participants

Eighty four infants participated in this study. There were 17 8-month-olds, 18 10-month-olds, 17 12-month-olds, 18 15-month-olds and 14 18-month-olds. Infants were recruited from Paris' birth records. Parents were contacted by letter and they participated on a voluntary basis. Data from additional 10 infants were not included in the analyses due to fussiness (N=3) or technical problems during the recording (N=7).

B. Procedure

Infants were tested in a quiet room in presence of their parents (mother, father or both) who were instructed not to intervene with their child during the whole experiment, if possible. Each infant sat on a high chair in front of a table, in front of which sat the experimenter. The experimenter presented the objects to the infants on the table and performed the demonstration out of their reach. A digital video camera directed at the infant recorded the whole experiment. A frame by frame analysis was then done on all recordings.

C. Stimuli

We designed two kinds of tasks: (1) A grasping task, designed to test the organization of appropriate movement for grasping as a function of the object's physical characteristics, and (2) A retrieval task, designed to test a complex problem solving in grasping. The grasping task, common to all age groups, consisted in grasping a small plastic ball placed on a base. This task required from the subject to prepare his hand (shape hand orientation) while reaching in order to catch the ball off its base. The ball diameter was constant for all age groups (4cm) but we varied the diameter of the base (the older the subjects, the thinner the base, from 1.5cm to 0.8cm, so that the relative task difficulty remains approximately constant across age groups. The interest of this set-up was that, although the object was visible, its instability was not, so insufficient deceleration and/or hand preparation before touching resulted in failure.

The retrieval task, specific for each age group, consisted in retrieving an object presented in such a way that its grasping was not obvious but required solving an additional problem, such as reaching for an object behind a transparent barrier, for instance. The tasks were different for each age group, so that each was just slightly too difficult for the targeted age, and for the infant to be spontaneously successful. The tasks have been chosen on the basis of previous observations made in our laboratory or read in the literature.

The specific task for the 8 month-olds consisted in *detour reaching* (getting a toy behind a transparent barrier). The object was a rectangular transparent plastic box (8.2 x 5.5 cm, 12.6 cm high), with only the two lateral sides open. A small toy was placed right behind the front wall of the box. The subject had to resist the tendency to grasp the seen object straight ahead, and make a detour; for the 10 month-olds the task consisted in getting *a tube out of its container*. The object was a wooden container (2.4 x 2.5 cm, 9.2 cm high) inside which was inserted a plastic tube with a bright coloured cap, protruding from the container by 2.5 cm; for the 12-month-olds the task consisted in opening a box in order to *retrieve the toy inside the box*. The object was a 9 x 12 cm, 4 cm high semi transparent plastic box with a lid hinged to the box, and with a small toy visible inside. Infants had to raise the lid with one hand while grasping the object with the other hand; the 15 month-olds had to turn upside down a small bottle to *get a peg out of a bottle*. The object was a 8 cm long bottle with an opening of 1cm1/2, and the peg was a small wooden object of 1.8cm long and 0.8cm large; finally, the 18 month-olds' task involved *tool use*. The object was a 5.5 x 7.2 cm, 8.5 cm high transparent plastic box, with a half-covered lid (using a piece of tape), and a small toy inside the box. The tape prevented from grasping the toy with the hand. A wooden stick of 14 cm long and 2 cm in its largest side, with a piece of velcros at its end, was placed to the side of the box, and the task consisted in using the stick as a tool to grab the toy (also covered with a piece of velcros). Thus, the interest of these five tasks was that they required the understanding of a different relationship between the object to be grasped and its environment, for which a developmental gradient has been demonstrated (Bruner, 1969, Fagard and Pezé, 1997, Lockman, 2000, Bojczyk and Diamond, 2004): behind (8 months), inside without need for opening (10 month), inside after opening a lid (12 months), inside after turning upside-down (15 months), inside with the need of a tool (18 months). The actions to be used for successful retrieval changed from making a detour (at 8 months) to using bimanual complementary movements with only one hand active (at 10 months), performing a two-steps action with both hands (at 12 months), changing the orientation of the container (at 15 months), and finally performing a two-steps action with a tool (at 18 months).

D. Procedure

For each age two groups of infants were compared: (1) an observation group, and (2) a self-exploratory group. For the observation group, the experimenter directly demonstrated the action to be done, three times in a row (left – right – left hand) out of reach from the infant. Then a two-minute delay was introduced systematically, during which the infant was given distracters (toys) to play with. After the two-minute delay, the infant was presented with the object for 30 seconds. In the self-exploratory group, the infant was given the object before

the demonstration (three spontaneous trials for the simple grasping task and 30 seconds of spontaneous manipulation for specific task). In addition, they received another trial following demonstration. In the observation group, there were eight 8-month-olds (one boys and seven girls), nine 10-month-olds (five boys and four girls), eight 12-month-olds (five boys and three girls), nine 15-month-olds (four boys and five girls), and seven 18-month-olds (five boys and two girls). In the self-exploratory group, there were nine 8-month-olds (six boys and three girls), nine 10-month-olds (seven boys and two girls), nine 12-month-olds (five boys and four girls), nine 15-month-olds (seven boys and two girls), and seven 18-month-olds (three boys and four girls).

The comparison between the self-exploratory group and the observation group allowed us to evaluate the effect of practice and the effect of observation on the building of motor repertoire as a function of task (adaptation to the object's physical characteristics for grasping vs. problem solving for retrieving) and age.

E. Data scoring

For the grasping task the dependent measures were the outcome (failure or success), qualitative hand preparation (strategy and hand orientation), reaction time, and time between touching and grasping or tentative grasping. For the age-specific tasks, the dependent measures were the outcome (success and failure) and the time course of the spontaneous successes within the 30 seconds allowed in the self-exploratory group.

Outcome

The trial was coded as a "no try" when the infant was interested in something else than the target object (including the base itself for the ball); failure when the infant tried to grasp the ball or to retrieve the object but failed; success when the infant succeeded in grasping the ball or retrieving the object.

Qualitative assessment for hand preparation to grasping (strategies for ball only)

We analysed hand shape in the frame where the infant touched the ball (T) (either the arm stops moving or the object starts moving), and in the two previous frames (T-2 and T-1). We noted where was the hand relative to the ball (in front, on top, besides); what was the orientation of the hand (horizontal, vertical or oblique). Several strategies were noted to grasp or try to grasp the ball depending on these two criteria (front horizontal, front oblique, etc.) (see Figure 1).

Figure 1: Qualitative assessment for ball grasping

III. RESULTS

A. Spontaneous success for the different age groups

Since the tasks have been devised to be equivalent across age groups, we first ensured that the rate of success did not differ significantly across age groups. This was made by comparing the self-exploratory group's frequency of success at the first trial as a function of age, for the ball grasping task and for the trial before demonstration at the retrieval tasks.

For the ball grasping task, one can see on Table 1 that the 8-mo-olds have a lower percentage of success than the other age groups at the 1st trial. However, a chi^2 analysis showed that the difference was not significant. For the retrieval tasks, there was a low percentage of success also at eight months of age, and no success at eighteen months. A chi^2 analysis showed that the age-related difference was not significant. It appears then that our set-up allows us to compare the effects of practice versus observation on learning across the age groups studied.

Age group	**8-mo**	**10-mo**	**12-mo**	**15-mo**	**18-mo**
Grasping the ball	12.5%	44.4%	44.4%	57.1%	50%
Retrieving objects	11.11%	37.5%	50%	44.4%	0%

Table 1: Spontaneous success (self-exploratory group) as a function of age, for the grasping (first trial) and the retrieval task

B. Learning through practice

Grasping task

We compared the frequency of success across the three trials in the self-exploratory group. One can see on Figure 2 that, except for the 8-month-olds, there was no increase in frequency of success between the first trial and the following trials. The 8-month-olds, however, succeeded significantly more often at the second than at the first trial, and the difference between their score of success (0 or 1) at the two trials was significant ($t(7)= -2.6$; $p<.05$). It is difficult to explain the lesser frequency of success of the 15-month-olds at the second trial. It might be due to the restlessness frequently reported for this age group. A MANOVA calculated on the score of success for age (independent measure) and trial (repeated measure), indicated no significant effect for age or for trial, and no age x trial significant interaction.

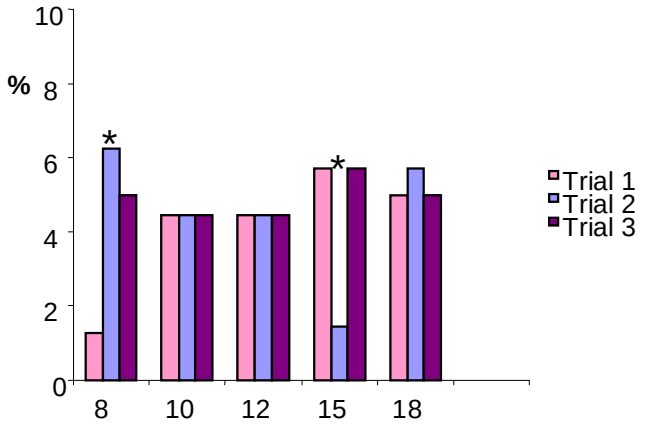

Fig 2: Spontaneous success (self-exploratory group) as a function of age and trials for the grasping task

The qualitative assessment of hand preparation helps understand the 8-month-old results. At the first trial, 37.5% of the 8-month-olds tried to grasp the ball by approaching it from the front. This resulted most of the time in pushing it off its base before being properly secured. A Banner test showed that the failure was significantly related to this strategy (0% success when approaching from in front at 8 months). At the second trial, only 15% of the 8-month-olds used this strategy, and the infants who succeeded at the second trial after failing at the first
changed their approach of the ball. This strategy tended to disappear with age, being still observed in 22.2% of the 10-month-olds, but never in the older infants.
For the retrieval tasks, we compared the first 10 seconds of the 30-second trial, with the following 10 seconds and with the last 10 seconds, to see if the infants succeeded after some practice with the objects. This analysis of the 30-second exploration showed that the infants did not succeed significantly better after 10 or 20 seconds practice.

C. Learning by observation

To evaluate the influence of observation we analysed first the difference in frequency of success between the first trial of the self-exploratory group and the trial of the observation group. Secondly, we also looked for a possible change in success between the third trial of the self-exploratory group (before observation) and their test trial (after observation).

Ball grasping task

The comparison between self-exploratory and observation groups, all age considered, showed that the percentage of success was higher in the observation group (63.4%) than in the 1st trial of the self-exploratory group (41%). A chi^2 analysis showed that the difference was significant (x^2 (1) = 4; p <.05). However, an analysis on each age group separately showed that the group effect was due to the 8-month-olds (x^2 (1) = 6.3; p <.02). The 8-month-olds from the observation group succeeded better than the 8-month-olds from the self-exploratory group at the 1st trial (see Figure 3). When the 8-month-old observation group was compared to the 3rd trial of the 8-month-old self-exploratory group, the difference was no longer significant.

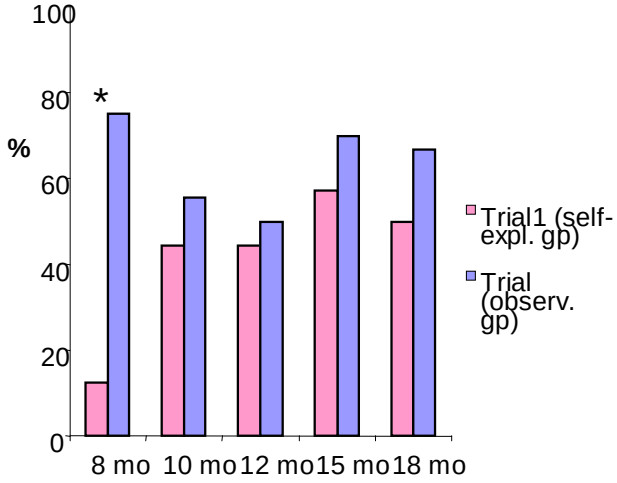

Figure 3: Spontaneous success (self-exploratory group) vs success after demonstration (observational group) as a function of age for the grasping task

To compare between the 3rd trial of the self-exploratory group and their test trial, we performed an age x trial MANOVA on the success rate. There was a tendency for more success after demonstration at 8, 15, and 18 months of age, but a MANOVA on the success score showed no age effect, no trial effect and no interaction (see Table 2).

Age group	**8-mo**	**10-mo**	**12-mo**	**15-mo**	**18-mo**
Before demo (3rd tr	50%	44.4%	44.4%	57.1%	50%
After demo Test trial	62.5%	44.4%	44.4%	71.4%	100%

Table 2: Frequency of success before and after demonstration (self-exploratory group) as a function of age for the ball grasping task

Retrieval tasks

The comparison between self-exploratory and observation groups, all age considered, showed that the percentage of success was higher in the observation group (53.6%) than in the self-exploratory group (28.6%). A chi^2 analysis showed that the difference was significant (x^2 (1) = 5.4; p <.05). An analysis on each group separately showed that the effect was due to the 18-month-olds, the only group for which the difference is significant (x^2 (1) = 14; p <.001). All 18-month-olds from the observation group succeeded, as compared to none of the infants from the self-exploratory group (see Figure 4).

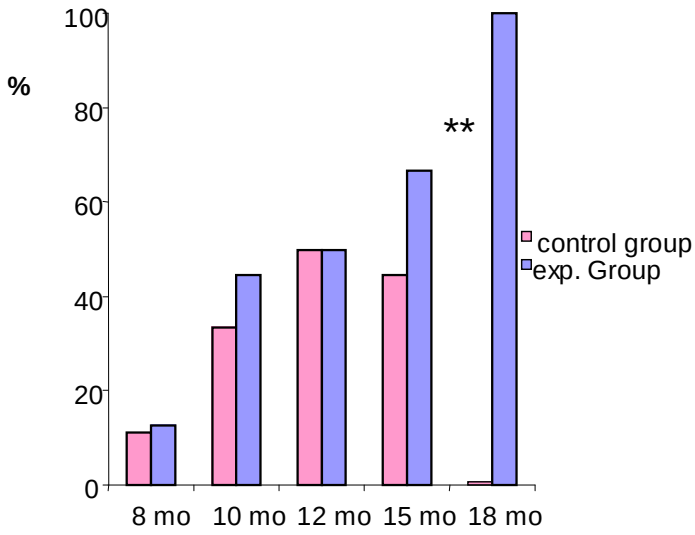

Figure 4: Spontaneous success (self-exploratory group) vs success after demonstration (observational group) as a function of age for the retrieving task

To compare between the trial before demonstration of the self-exploration group and their test trial, we performed an age x trial (repeated measures) MANOVA on the success rate. This showed no age effect, but a significant effect for trial effect ($F(1,37) = 19.6$; $p<.0001$), and a significant age x trial interaction ($F(4,37) = 8.2$; $p<.0001$; see Table 4). A post-hoc LSD test showed that the difference in success between before observation and the test trial following observation was significant only at 15 ($p<.05$) and 18 months ($p<.0000$).

Age group	**8-mo**	**10-mo**	**12-mo**	**15-mo**	**18-mo**
Before demo (3rd tr	11.11%	33.3%	50%	44.4%	0%
After demo Test trial	11.11%	55.6%	44.4%	77.8%	100%

Table 4: Frequency of success (%) before and after demonstration (self-exploratory group) as a function of age, for the retrieval tasks

IV. DISCUSSION

Devising tasks representing the same level of difficulty for infants of a different age was not easy. For the ball grasping task, we changed the basis on which rested the ball, the older the infant the smaller the basis, so that the instability of the same ball increased. For the retrieval tasks, we changed the object-environment relationship (behind, inside, etc.) so that the retrieval becomes increasingly difficult (involving detour, bimanual, two-steps, etc.). There was some variation in the frequency of success at the first spontaneous trial for the different age groups. However, we succeeded in devising tasks which were never spontaneously succeeded by more than 50% of the infants, for each age group, and for which the age effect on the rate of success was never significant when all age groups were compared.

Learning through practice was observed mainly for the ball grasping task, only for the 8-month-olds. These infants corrected their strategy for approaching the object after their failure at the first trial.

Learning by observation showed different results for the ball grasping task and for the retrieval tasks. For the ball grasping task, intergroup comparison showed that learning by observation was efficient for the 8-month-olds only. This was so because the first trial at that age lead to many failures. Thus, observation appears to be as efficient as practice to induce an adapted strategy for approaching the ball. By the time the 8-month-olds reach their third trial, they had corrected their strategy, so that the demonstration following this trial does not induce better outcome.

For the retrieval tasks, intergroup comparison showed that observation was globally efficient (only the 12-month-olds showed no tendency to be better after demonstration). However, only the 18-months infants were significantly better if they had a demonstration first. Intragroup comparison gave about the same results. All infants tended to be better after demonstration than before, except the 12-month-olds, but only the 15-months and the 18-months were significantly better after demonstration. In order to check whether observation had a long term effect on learning, we saw some of the 18-month olds a week after the first observation. Infants succeeded immediately the task after a week of delay which is consistent with the definition of observational learning.

The effect of observation is significant at 15 mo for the intragroup comparison (before and after observing), but not for the intergroup comparison (the infants from the Observation group are non significantly better than the infant from the self-exploratory group before demonstration). This might be due to the variability between the two groups. It could also indicate that, at this age, observation is more efficient once the infant had manipulated the object first.

Considering these results, Elsner claim about observational learning being an alternative to acquire action-effect knowledge seems to be confirmed here. However we didn't find any significant effect of observation before the age of 15 month which is not consistent with her findings.

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