Revista de Etologia 2001, Vol.3, N°2, 89-94

Observational Learning in the Manipulation of a Problem-Box by Tufted Capuchin Monkeys (*Cebus apella*)

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Our aim was to study tufted capuchin monkeys' (*Cebus apella*) observational learning skills under captivity conditions. We trained two subjects from different groups to solve a task that consisted of opening three bolts from a problem-box following a pre-defined order. These subjects acted as models to each other member of their group (observers). When the demonstration was over, the model was removed and the observer could try to open the bolts, that, in this phase, could be opened in any order. Two out of six observers turned their eyes to the model during the demonstration and those were the only subjects who could open the box later, even though they did not open the bolts in the order the model was forced to follow.

Index terms: Social learning. Capuchin monkeys. Cebus apella.

Aprendizagem por observação da manipulação de uma caixa-problema por macacos-prego (*Cebus apella*). Com o objetivo de estudar a aprendizagem por observação em macacos-prego (*Cebus apella*) em cativeiro, treinamos dois sujeitos de grupos diferentes para solucionar uma tarefa que consistia na abertura de três trincos de uma caixa-problema seguindo uma seqüência pré-determinada. Tais sujeitos atuaram, após o treino, como modelos para os outros membros de seus respectivos grupos (observadores). Ao término da demonstração, o modelo era removido e o observador tinha a oportunidade tentar abrir os trincos que, nesta fase, poderiam ser abertos em qualquer ordem. Dois dos seis observadores voltaram os olhos para o modelo durante a demonstração e estes foram os únicos sujeitos que conseguiram abrir a caixa no teste, apesar de não terem usado a mesma seqüência que o modelo foi forçado a seguir.

Descritores: Aprendizagem social. Macaco-prego. Cebus apella.

Animals that live in social groups may have the opportunity to benefit from other individuals' experiences, besides learning about their environment by themselves by trial-and-error. Laland, Richerson, and Boyd (1996) suggest that individual learning may be costful and social learning can reduce such costs in a stable and homogenous environment. Galef (1976) points out the importance of learning from the experience of others, so that one animal does not need to start its learning from the very beginning.

Observational learning is a term that includes a wide range of phenomena. The term imitation, in particular, is a very controvertial one (Byrne & Russon, 1998; Byrne & Tomasello, 1995; Heyes, 1993;Whiten & Ham, 1992), having been used in many different senses by different authors. Recently, Byrne and Russon (1998) proposed a categorization of social learning, including the processes of stimulus enhancement, response facilitation, emulation and imitation. They point out to the existence of two kinds of imitation: program level imitation (the subject learns which subgoals it has to achieve to solve a problem) and impersonation, also known as action level imitation (Byrne 1995) (the subject learns the

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Agradecimentos: We thank the staffs of the Quinzinho de Barros Zoo and Bosque Municipal de Catanduva, for allowing the use of their animals and facilities, and Patrícia Izar for her comments on the manuscript. This research was funded by FAPESP (proc.#97/14443-7) and CAPES grants.

exact movements it has to do to solve a task). Program level imitation implies a hierarchical organization of behaviour and more complex cognitive skills.

Here, we use the concepts of *program level imitation* and *impersonation* (as defined above) and *stimulus enhancement*, the tendency to pay attention to, or aim responses towards a particular place or objects in the environment after observing a conspecific's actions at that place or in conjunction with those objects (Byrne & Russon, 1998).

In order to study observational learning processes in budgerigars, Dawson and Foss (1965) developed a procedure in which three groups of birds were trained to remove the lid from a feeder. First each group learned a different way to remove the lid. Later, they performed the task being watched by observers who could, after demonstration trials, remove the lid by themselves. The researchers analysed if the observers used the same acts the models did. In 1986, Galef, Manzing, and Field replicated the experiment with some procedural improvements, such as increasing the sample, specifying models' motor variability during training and feeding observers during the test phase. More recently this procedure has been used to study social learning in other species, such as rats (Heyes & Dawson, 1990; Heyes, Dawson, & Nokes, 1992), marmosets (Bugnyar & Huber, 1997, Voelkl & Huber, 2000), capuchin monkeys (Custance, Whiten, & Fredman, 1999), orangutans (Call & Tomasello, 1995), chimpanzees and children (Tomasello, Savage-Rumbaugh, & Kruger, 1993; Whiten, Custance, Gomez, Teixidor, & Bard, 1996). Adams-Curtis and Fragaszy (1995) trained one member of a group of capuchin monkeys to solve a task that consisted of performing sequential actions to open a mechanical puzzle. When this subject was proficient, the rest of the group was allowed inside the smaller chamber where the equipment was set. One observer increased his activities related to the equipment immediately after watching the model's performance. The authors attributed that to the occurence of learning by stimulus enhancement. In Custance et al. study (1999), human models opened an "artificial fruit" while watched by enculturated capuchins and, according to the authors, their subjects provided evidence of more complex social learning (what they call *object movement reenactment* and perhaps simple imitation, that is, impersonation).

Our aim was to study tufted capuchin monkeys (*Cebus apella*) observational learning skills using Dawson and Foss paradigm and Galef's improvements. We trained a model per group to solve a task that consisted of opening three bolts using a predetermined sequence, to act as models to the other group members, who individually watched the models' performances from a cage in front of the equipment and were immediately afterwards allowed to try to solve the task.

Methods

Subjects

Two tufted capuchin (*C.apella*) groups were used: one from Quinzinho de Barros Zoo (group A), and another from Bosque Municipal de Catanduva (group B). Group A was composed of 4 subjects: two adult males (AM1 and AM2) and two adult females (AF1 and AF2), all with unknown age. Group B was composed by 4 males: two subadults (BM1 and BM2), one adult who was the others' father (BM3) and one juvenile (BM4). Subjects were daily fed with fruits, vegetables and eggs. On experiment days, food was only given after testing.

Housing conditions. Group A: the subjects lived in a 4 x 4 x 3m cage. During the night, they were housed in a 1 x 1 x 3m compartment. Group B: the subjects lived in a 12 x 4 x 5m cage and were housed in another 1,5 x 1,7 x 1,8 m compartment during the night.

Equipment. A 15 x 15 x 25cm plexiglas box was fixed in the subjects´ cage at the beginning of each session. It had a 8 x 15cm front lid in which it was possible to set bolts in two horizontal positions (left and right) and one vertical position (central). Thus, the box could be locked by one, two or three bolts. A mechanism interconnected the bolts in order to force a determined sequence for opening. In this situation (three dependent bolts condition), the subject had to open the horizontal right bolt (RB) first, then the vertical central bolt (CB) and finally the horizontal left bolt (LB). (Fig.1).

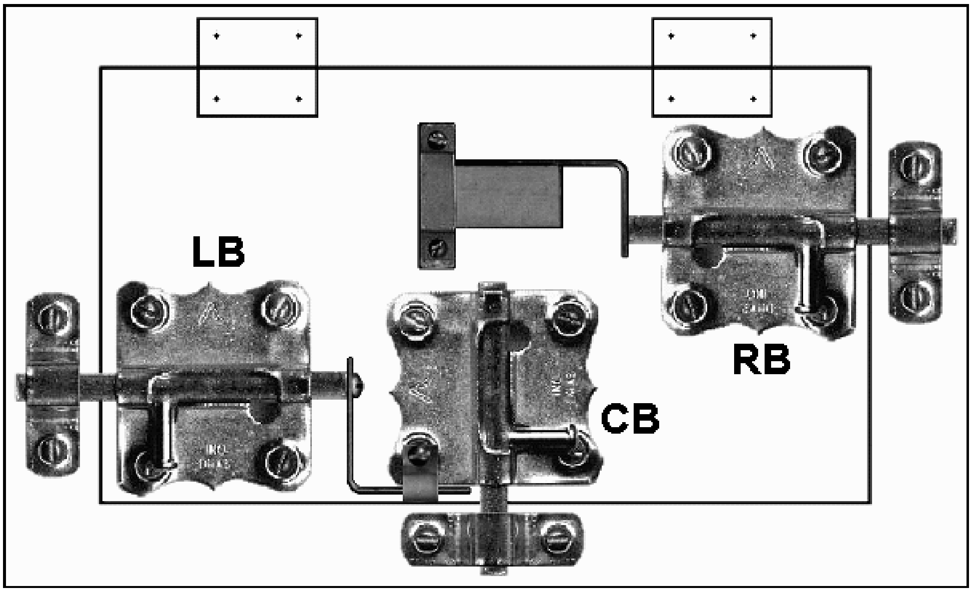

Figure 1. Plexiglas box with three bolts (RB: right bolt, LB: left bolt and MB: middle bolt). In this condition (thre dependent bolts) right and left bolts have metal devices that force the monkeys to open first RB, then, MB and LB.

Procedure

Models' training phase. One animal from each group (AM1 and BM1) was trained to solve a task which consisted of opening a three-bolted problem-box to reach a food item (peanut). To pass to the observational learning phase, they should be able to solve the task in three steps, that is, to open the box without trying to unlock the bolts in the wrong order, manupulating other parts of the box or locking already unlocked bolts. When the learning curves (success using only three steps) reached an assimptote (training processes described in Resende, 1999), we finished training and started the demonstration phase procedure.

Observers' habituation phase. Before the demonstration phase, observers were submited to nine one-bolt box trials: the bolt was set three trials in each position (right, left, middle). The purpose of these trials was to familiarize the observers with the apparatus.

Demonstration phase. At the demonstration phase, the model had to solve the task in 16 trials while an observer from his group, who had already had the opportunity to manipulate a box with only one bolt, watched from a cage placed 1m in front of the box. Although the observer could see the model solving the task, it could not manipulate it (until the test phase). During trials, we registered if the observer turned its eyes to the box while the model was solving the task (i.e, oriented its body and/or head in a manner that enabled observation), even if it was only a glance (it took the proficient model less than 5 seconds to open the box).

Test phase. After the demonstration trials, the model was removed, the observer was released and the test phase started. At this phase, the observer was immediately submitted to eight trials with the problem-box, but in their turn the apparatus was modified so that the three bolts could be unlocked in any order (three independent bolts condition). If the observer used significantly the same order the model did, it would constitute an indication of impersonation. If the time they spent interacting with the bolts in relation to the time they spent interacting with anything else during the sessions increased, it would point to learning by stimulus enhancement.

We noticed behavioral and/or motivational differences among groups and individuals during the experiments which we considered relevant, so qualitative comments about them were added post-hoc, whenever we judged they might have interfered on the results.

Results

Observers' habituation phase

When the observers had the opportunity to manipulate the problem-box with one bolt (before watching the demonstration), subjects AM2 , AF1 and AF2 were sucessful in, respectively, 8, 9 and 5 out of 9 trials. Subjects from group B never opened the bolt (Table 1).

Demonstration phase

We started the demonstration phase when the models' perfomance reached an assimptote (around 60% of 3-movement successful trials per session). When group A's model was paired to the other subjects of the group, he used three movements to solve the task in eight (AF2 as observer), 13 (AM2 as observer) and 16 (AF1 as observer) out of 16 trials. During these 16 trials, AF2 turned her eyes to the model 3 times and in all these occasions the model used only three movements to open the box (Table 1). AM2 turned his eyes to the model in five out of the 16 trials and in four of these trials, the model used three movements (Table 1). AF1 did not turn her eyes to the model during the demonstration (Table 1). Group B's model used three movements in ten, six and one out of 16 trials, but observers did not turn their eyes to the task (Table 1).

Table 1 - Comparison between the number of trials the observers turned their eyes to the task and the number of trials they solved the task at the test and at the habituation phases

observer[1]	**I**[2]	**II**[3]	**III**[4]
AM2	5	8/9	7/8
AF2	3	9/9	8/8
AF1	0	5/9	0
BM2	0	0	0
BM3	0	0	0
BM4	0	0	0

1 - A and B: origin group; M and F: gender
2 - number of trials the subject turned its eyes to the model's performance at demonstration
3 - subject's success at habituation phase (one-bolted box) (success/trials)
4 - subject's success at test phase (three-bolted box) (success/trials)

Test phase

In the test phase, AM2 and AF2 were sucessful at opening the three-bolts box—AM2 opened the box in seven out of eight trials and AF2 opened it in all the eight trials—but they did not use just three movements and used different sequences from the model. During the test situation, the time AM2 and AF2 spent manipulating the bolts and the box increased, while the time spent with other behaviours—not related to the box—decreased, as, like the models, they tended to gradually focus their manipulation in the box and the bolts.

Only subjets that were successful during training phase and turned their eyes to the model during the demonstration phase were able to open the box at test phase.

Individual Differences

AM1, group A's model, exhibited a better performance in the demonstration phase than during the training, whereas BM1, group B's model, did the opposite. We noticed other differences between the models: AM1 was more curious and less disturbed by situations that interfered with his normal daily routine. BM1, on the contrary, seemed more frightened and easily changed his behaviour if something unusual happened.

Discussion

Four out of six observers did not watch the models' performances. AM2 and AF2 were the only subjects who turned their eyes to the model and the only ones who opened the three-bolted box afterwards. Since they did not use just three movements nor opened the bolts using the same order the model did, there is no evidence of imitation. It is possible, on the other hand, that stimulus enhancement process occurred, since their interaction time with the box increased after they watched the model manipulating it and achieving a food item. However, we cannot attribute their success in the test phase only to stimulus enhancement because when these two animals were first submited to the problem-box with one bolt, they were more sucessful and curious than the other subjects. Learning by stimulus enhancement in this situation is as plausible as individual learning.

The subjects who turned their eyes to the equipment during demonstration (AM2 and AF2) were also the most successful during the habituation. It suggests that paying atention to the model can be related to previous experience of solving a similar task. But AF1, who was also successful (though less than AM2 and AF2) during habituation, failed to pay attention to the model.

Previous research concerning capuchins' social learning concluded that these monkeys do not readily learn about instrumental relations by observation of others, but they do learn about the relationship between conspecifics' activities and the appearance of food (Fragaszy &Visalberghi 1989). Visalberghi (1993) reports that she did not observe the acquisition of new tool-using behaviours by observers who watched skillful models, although other processes of social learning—especially local enhancement—were implicated. Visalberghi and Tomasello (1997), discussing an experiment where chimpanzees, children and capuchins were submitted to a similar task, concluded that the latter were not able to imitate and that their visual atention was not focused on the events relevant for learning, whereas three and four years-old chimpanzees and 15 and 18 months-old children solved the task in smaller number of trials if exposed to skilled models. Fragaszy and Visalberghi (1990), discussing the learning process by one of their subjects, report that individual experience with a similar task was clearly more effective than observation of a skilled model in the acquisition of the correct skill. Observers' behaviour was not affected by details of model's behaviour. Thus our results are in agreement with the literature on capuchins learning skills, once observers failed to observe the demonstration and imitation was absent.

On the other hand, Custance et al. (1999) submitted capuchin monkeys to a task where, after watching a human subject opening an "artificial fruit" using an specific action pattern for opening it, they had their opportunity to try to open it. These authors concluded that these monkeys may show different and more complex social learning processes than stimulus or local enhancement, as object movement reenactment or simple imitation, since there was a systematic difference in their manipulations of the latch. Bugnyar and Huber's marmosets observers (Bugnyar & Huber, 1997), in an experiment following Dawson and Foss (1965) paradigm, showed a tendency to copy the model's way of opening a lid, at least in the first trials of the test. Heyes and colleagues also performed experiments based on that paradigm (Heyes & Dawson, 1990; Heyes et al., 1992): in these experiments, rats that observed conspecific models pushing a stick to left or to the right in order to get a food reward tended to copy the model's behaviour in the test trials, even though they were rewarded no matter the side they pushed the stick. One might expect that, since rats and marmosets are able to copy a model's behaviour, capuchins should do that too, being the most proficient New World monkey tool user and having a high encefalization rate (Visaberghi, 1993). But it is necessary to be a good observer to copy other individual's behaviour —and it requires attentional capabilites beyond what they exibit, at least in these unnatural experimental conditions.

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Received September 14, 2001
Revision received June 11, 2002
Accepted July 15, 2002