

Object permanence in adult common marmosets (*Callithrix jacchus*): not everything is an “A-not-B” error that seems to be one

Anna Kis · Márta Gácsi · Friederike Range ·
Zsófia Virányi

Received: 28 December 2010 / Revised: 9 April 2011 / Accepted: 28 June 2011 / Published online: 8 July 2011
© Springer-Verlag 2011

Abstract In this paper, we describe a behaviour pattern similar to the “A-not-B” error found in human infants and young apes in a monkey species, the common marmosets (*Callithrix jacchus*). In contrast to the classical explanation, recently it has been suggested that the “A-not-B” error committed by human infants is at least partially due to misinterpretation of the hider’s ostensibly communicated object hiding actions as potential ‘teaching’ demonstrations during the A trials. We tested whether this so-called Natural Pedagogy hypothesis would account for the A-not-B error that marmosets commit in a standard object permanence task, but found no support for the hypothesis in this species. Alternatively, we present evidence that lower level mechanisms, such as attention and motivation, play an important role in committing the “A-not-B” error in marmosets. We argue that these simple mechanisms might contribute to the effect of undeveloped object representational skills in other species including young non-human primates that commit the A-not-B error.

Keywords Common marmoset · “A-not-B” error · Motivation · Attention · Behavioural flexibility

Introduction

Finding and keeping track of objects such as food, conspecifics or predators is a relevant task for virtually all animal species including humans (Dumas 1992). In human infants object searching skills develop in a series of successive steps that Piaget (1954) defined as 6 distinctive stages of object permanence. Newborns show no response when an object is hidden (Stage 0) whereas 18–24 month old infants succeed also in invisible hiding trials (Stage 6), where a target object is first put in a container which then visits different hiding places before the target object is left behind one of the places. At stage 4, typically a characteristic transitional error, the so-called “A-not-B” error, occurs at the age of 8–12 months. At this stage children successfully retrieve a hidden object several times from one of two locations (called “A”) but then fail to change to the other location (“B”) even if the object was placed there in their full view e.g. they persevere and continue to search in location “A”.

In the infant literature many explanations have been proposed for the “A-not-B” error. According to Gratch et al. (1974) the “A-not-B” error might occur due to the failure of understanding specific properties of the desired object. Deficits of the short-term memory may also lead to the “A-not-B” error (Cummings and Bjork 1983). Sophian and Wellman (1983) argued that the error might arise from the conflict between previous and recent information. Furthermore, Baillargeon et al. (1985) proposed that motor action coordination problems might cause the “A-not-B” error. According to Diamond (1985) this error results from the inability to inhibit previously rewarded action. Finally, Thelen and Smith (1994) suggested discussing the “A-not-B” error in terms of the repetition of motor schemes.

A. Kis (✉) · M. Gácsi
Department of Ethology, Eötvös University,
Pázmány P. s. 1/c., Budapest 1117, Hungary
e-mail: kisanna12@gmail.com

F. Range · Z. Virányi
Department of Cognitive Biology, University of Vienna,
Althanstrasse 14, 1091 Vienna, Austria

Z. Virányi
Konrad Lorenz Institute for Evolution and Cognition Research,
Adolf Lorenz Gasse 2, 3422 Altenberg, Austria

Recently, in human infants, committing the “A-not-B” error has been explained by the children’s misinterpretation of the communicative hiding game as a kind of teaching session where the repeated, communicative hiding of the object in location “A” conveys information that the goal of the task is to visit this place independently from the actual hiding location of the object (Topál et al. 2008). The general form of this interpretation, the Natural Pedagogy hypothesis, claims that human infants have a high preference for ostensive-communicative signals (e.g. eye-contact) and they are biased to learn semantic or generic information from demonstrations accompanied with such signals (Csibra and Gergely 2006).

Interestingly, object searching tasks have been conducted also with various animal species using the Piagetian categorization (Gómez 2005). In this framework, grey parrots (*Psittacus erithacus* (Pepperberg et al., 1997), domestic dogs (*Canis familiaris*) (Topál et al., 2009, but see Gagnon and Doré, 1992), Eurasian jays (*Garrulus glandarius*) (Zucca et al., 2007) cotton top tamarins (*Saguinus oedipus*) (Neiworth et al., 2003), magpies (*Pica pica*) (Pollok et al., 2000) and squirrel monkeys (*Saimiri sciureus*) (de Blois et al., 1998) have been reported to reach Stage 4 object permanence characterized by the “A-not-B” error. One study on common marmosets by Mendes and Huber (2004) reported that some of their subjects reached the Piagetian Stage 6. However, they also found a huge variation in the performance of different individuals. Regarding the “A-not-B” error in common marmosets, we have no conclusive results since the methods of this study were not designed to test this question. Similarly to most other animal research that study aimed at determining which levels of object permanence the species in focus can reach. Hardly any studies, however, investigated the underlying mechanisms why animals commit the “A-not-B” error (but see Dumas 1992, Gagnon and Doré 1992, 1994).

Similar to the infant study, (Topál et al. 2009) suggested that in domestic dogs committing the “A-not-B” error is facilitated by interpreting the repeated hiding in location “A” as being instructed by the experimenter to visit this location. This conclusion was based on comparing the search behaviour of the dogs in three different versions of the “A-not-B” task. In all conditions the dogs received 4 “A”-trials (saw the object disappear in location “A” and then were released to search for it) after which the object was hidden in location “B” in 3 additional trials. In one of the three experimental conditions the object was hidden remotely, while in the other two it was carried by an experimenter who either called the dog’s attention using ostensive-communicative cues or by making noise with the object. In the “B”-trials the dogs searched more often in location “A” if the experimenter used ostensive-

communicative cues during the hiding than in the other two conditions, indicating that such cues contributed to the dogs’ perseverative error. This sensitivity to human communicative cues was attributed to the evolutionary history (domestication) of dogs and/or their extensive experiences interacting with humans.

Moreover, there are indications that also non-human primates show similar preferences to gaze cues (Myowa-Yamakoshi 2003) and use face-to-face communication in mother-infant interactions similarly to humans (Ferrari et al. 2009). Obviously though, no non-human primates use eye contact and other communicate cues for teaching as do humans (Caro and Hauser 1992; Csibra 2007). Still, it is possible that the use of eye-contact in animals provides a basis for responding to human-given ostensive-communicative cues, especially if they have extensive experiences with humans. If human ostensive cues function as a kind of supernormal stimuli, the animal’s response on the receptive side may even exceed the range of the natural response typical in within-species contexts. Such responsiveness might explain why chimpanzee babies attend more to a human (making eye contact and talking to the subject) than to their own mother in an object manipulation task (Bard and Vaclair 1984). Most of the object permanence tasks conducted on primates avoided the social cuing of the experimenter (e.g. Neiworth et al. 2003; Mendes and Huber 2004). Therefore, until now, we have no information about whether, additionally to previous explanations, the Natural Pedagogy hypothesis also applies to primates. In our experiment we directly tested whether experimenter given social cues can induce the “A-not-B” error in marmosets.

The communicative explanation of the above mentioned dog study (Topál et al. 2009) why dogs commit the “A-not-B” error has been challenged and simpler mechanisms as in previous infant studies have been suggested (see above). Accordingly, Fiset (2010) argued that the attentional demands of tracking the object in the “B”-trials strongly depends on the trajectory of the object movement. It is easy to see that the memory of having the object in location “A” is again somewhat strengthened in the “B”-trials if the object passes location “A” before disappearing in location “B” in contrast to directly going to location “B”. Again, however, except for one single test in dogs (Topál et al. 2010), we do not know about experiments that aimed at systematically investigating how such attentional and memory related mechanisms contribute to the extent animals commit the “A-not-B” error.

Based on their ecology, also common marmosets may have such sensitivity to ostensive-communicative cues. Common marmosets live in family groups with a cooperative breeding system in which all members participate extensively in rearing the offspring (Tardif et al. 1993). The youngsters learn socially about food preferences of

older animals (Voelkl and Huber 2006) and even food sharing occurs exceptionally often (Feistner and Price 1991; Kasper et al. 2008). It has been shown in manipulative tasks that social learning as well as cooperative problem solving are facilitated by the joint interaction and the relaxed relationship between the animals (Caldwell and Whiten 2003; Werdenich and Huber 2002; Dell’Mour et al. 2009). Based on these characteristics one can expect high interest and sensitivity towards others’ behaviour, which has been demonstrated by the firm evidence that common marmosets are capable of imitation (Voelkl and Huber 2000, 2007).

This paper takes a mechanistic approach to study the “A-not-B” error in common marmosets. In our first experiment, with a 2×2 design we tested whether marmosets commit the “A-not-B” error more often after social-communicative hiding than in a non-social context (which would follow from the Natural Pedagogy hypothesis), and whether their success in the “B”-trials is influenced by the trajectory of the hiding of the target object. In the second experiment we tested whether in seven consecutive “A” trials marmosets perform worse in the last trials due to decreased motivation or exhaustion. In the third experiment we tested whether in alternating “A” and “B” trials marmosets’ performance is worsened due to their limited flexibility of changing from one hiding place to another.

Experiment 1

Materials and methods

Subjects

The experiment was carried out on 26 adult marmosets (11 males and 15 females, mean age: 8.44 ± 4.03 years) living in 5 family groups. One animal had to be excluded due to motivational problems. All animals were born in captivity

and lived in the research facilities at the University of Vienna (Department of Cognitive Biology) and the Konrad Lorenz Institute for Evolution and Cognition Research (Altenberg).

The families were kept separately in indoor cages of $250 \times 250 \times 250$ cm (in Vienna) and $200 \times 350 \times 300$ cm (in Altenberg), equipped with branches and ropes. The monkeys were fed fruits, vegetables, monkey pellets, and protein supplements; water was continuously available. Before the onset of the experiment all marmosets had participated in other cognitive tasks including the manipulation of boxes to recover food.

Subjects were assigned to two groups, and accordingly they participated either in the *Asymmetric* or the *Symmetric* “A-not-B” test (see “Methods”) (Table 1). Each marmoset participated in the social as well as the non-social condition in a randomized order.

Methods

Apparatus The apparatus (Fig. 1) consisted of a wooden platform that could be moved back and forth in front of the experimental cage. Two identical containers were placed on the platform one of which was baited with a piece of coconut. The containers could be moved remotely via pulling on two strings connected to them. A wire mesh separated the subject from the platform. The subject could reach the containers through the mesh when the platform was pushed close. Each marmoset was familiarized with this action in the pre-test when they had to retrieve two times a piece of food from below a single container placed in the middle of the platform.

General procedure The experiment was carried out in the same way as in the infant study by Topál et al. (2008). In four subsequent “A”-trials the subject could observe the bait being hidden under the same (“A”) hiding place (for half of the animals it was the right container, for the other half the left container). After each hiding the experimenter allowed

Table 1 Subjects and their participation in the study

Family group	Test group	Experiment	Condition first tested (in random order)	N	♂	♀	Mean age (years)
Altenberg gr1; N = 5	I.	Asymmetric “A-not-B” test	Social	14	4	10	11,07
Altenberg gr2; N = 5			Non-social				
Vienna gr1; N = 2			Non-social				
Vienna gr2; N = 1			Non-social				
Vienna gr3; N = 1			Non-social				
Vienna gr1; N = 5	II.	Symmetric “A-not-B” test	Social	11	5	6	5,75
Vienna gr2; N = 5			Non-social				
Vienna gr3; N = 1			Non-social				

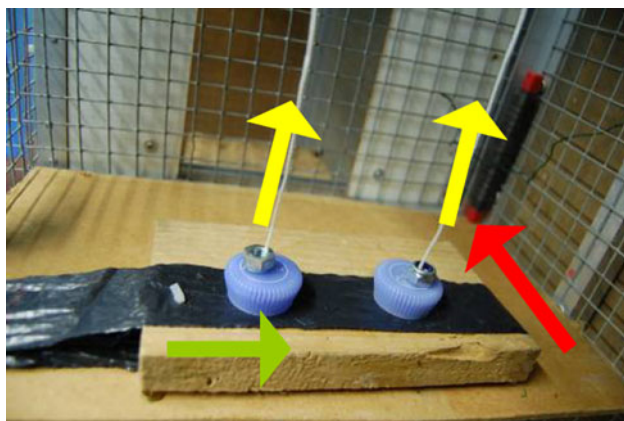


Fig. 1 The apparatus used in the experiment. The arrows indicate the moving of the entire platform towards the subjects, the moving of the food reward and the moving of the containers. During the non-social trials the black stripe was used to move the food reward

the subject to choose one of the two containers by pushing the platform within reach of the animal (Fig. 2). If the subject had at least three correct choices out of the four trials we continued with the “B”-trials. If the animal did not reach the primary criterion, two additional “A”-trials were presented. In the latter case, the criterion was set at four correct choices out of six trials before the B-trials were administered.

Asymmetric and symmetric “A-not-B” tests In the asymmetric test trials, the reward always started from the

same location next to container “A” on the right/left end of the wooden platform. Accordingly during the “A” trials the reward was moved directly to the adjacent “A” container, but in the B-trials the reward first moved below the “A” container and reached the “B” location only afterwards. The two containers were lifted at the approach of the object and lowered only after the reward reached location B (Fig. 3). In the symmetric test the “A”-trials were identical to those of the asymmetric test but in the “B”-trials the reward started from the opposite side of the platform and went directly to the “B” hiding place without moving below the “A” container (Fig. 3).

Social and non-social conditions The moving of the containers and the reward was identical in both conditions but the context of hiding varied in regard to the visibility and the behaviour of the experimenter (E).

In the *non-social* condition, the E stood behind a curtain and hence the subject could not see her. She followed the marmoset’s behaviour on the LCD display of a camera that was placed opposite to the subject. Before each hiding, the E waited until the subject came to the wire mesh, then lifted the two containers remotely, and via pulling on a stripe (see Fig. 1) she moved the reward to either “A” or “B” location from behind the curtain.

In the *social* condition, the E sat opposite to the subject who could see her face, upper body and hands during the

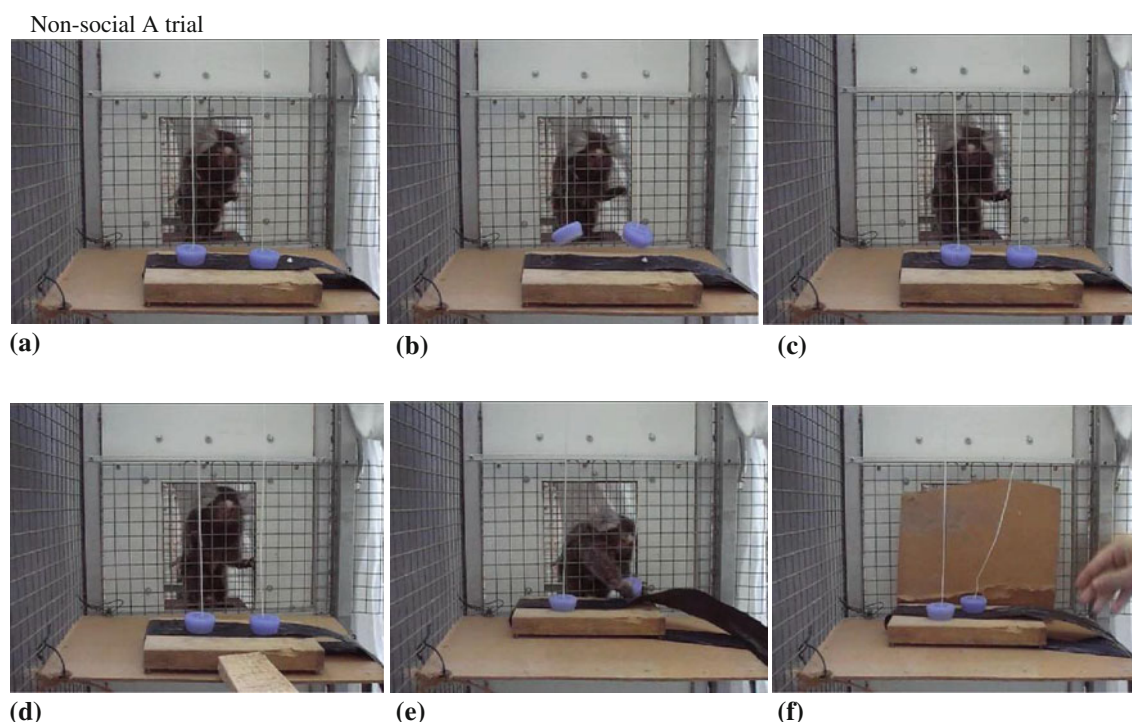


Fig. 2 Non-social A trial. **a** The reward starts from location “A”, **b** the containers rise up, the reward goes under “A”, **c** the reward disappears under location “A”, **d** the platform is moved towards the test cage, **e** the subject can choose, **f** a veneer is put to the experimental cage

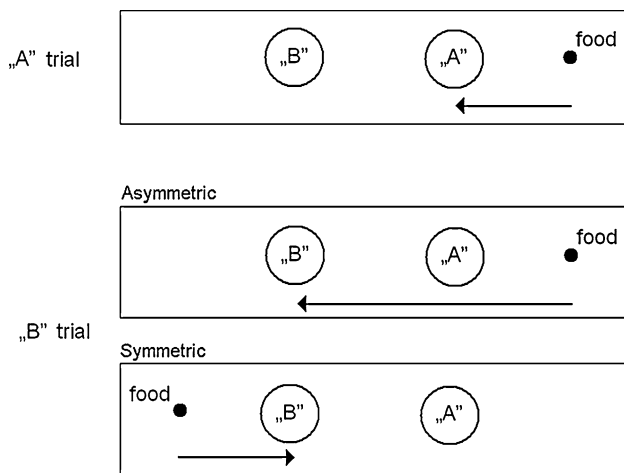


Fig. 3 Hiding trajectory in the different trials

entire test. Before hiding, she called the subject's name and established eye-contact with it. She waited until the subject came to the wire mesh, then lifted the two containers remotely. Then she picked up the reward (that was at the same starting position as in the non-social trials) from the stripe, and following the same path as in the non-social condition e.g. she moved the reward with her hand to location "A" or "B" without pulling on the stripe.

In *both* conditions the manipulations were stopped if the subject did not pay attention, and restarted when the subject oriented again towards the apparatus. After hiding, the E pushed the apparatus into reach of the subject so that it could choose a container. A choice was coded when the subject touched one of the two containers. After a correct choice the subject was allowed to retrieve the reward. If the choice was incorrect, the E immediately put a veneer in front of the mesh separating the subject from the platform (see Fig. 2). The next trial was prepared similarly, without the subject seeing it. If the subject did not make a choice within 20 s, the hiding was repeated (similarly to Mendes and Huber 2004).

A daily test session for a subject took about 8–12 min. All the tests were videotaped for later analysis.

Data analysis In all of the four test conditions, we coded the number of correct choices separately for the "A"- and for the "B"-trials. Based on the number of correct choices in the first 4 "A"-trials (performed in the same way in all conditions), we found that neither age (Spearman-correlation: $r = 0.1$; $P = 0.616$) nor sex (Mann–Whitney-test; $Z = 1.263$; $P = 0.263$) of the marmosets influenced their performance. Accordingly, we analysed the effect of 3 factors with a Generalised Estimating Equations model (SPSS16 programme): within subject factors: "A" versus "B" trials, social versus non-social situation; between subject factor: asymmetric versus symmetric test.

According to the results of this analysis, we compared the number of correct choices to the chance level of 50% with one-sample Wilcoxon tests (InStat programme).

Results

The Generalised Estimating Equations model revealed that both "A" versus "B" trials ($\chi^2 = 32.487$ $P < 0.001$) and asymmetric versus symmetric tests ($\chi^2 = 8.724$, $P = 0.003$) had a significant effect on the subjects' success while social versus non-social test situation had no significant effect ($\chi^2 = 0.352$, $P = 0.553$). No interactions were found between the factors. Accordingly we pulled together the data from the social and non-social tests.

Both in the asymmetric and symmetric tests subjects performed above chance level in the "A" trials (one-sample Wilcoxon test: $P < 0.001$), but the number of successful trials in the "B" trials did not differ from the chance level (asymmetric: $P = 0.162$; symmetric: $P = 0.137$). This result was supported by the fact that subjects were more successful in the "A" trials than in the "B" trials (Wilcoxon matched-paired test; asymmetric: $Z = 4.036$, $P < 0.001$; symmetric: $Z = 3.001$, $P = 0.003$). At the same time, subjects in the asymmetric "B" trials were less successful (made more mistakes) than in the symmetric ones (Mann–Whitney test; $U = 166.000$, $P = 0.007$) (Fig. 4).

Discussion

Our results show that, in contrast to human infants (Topál et al. 2008) and domestic dogs (Topál et al. 2009), the marmosets' success in the B-trials was not influenced by the communicative context of the hiding e.g. the the

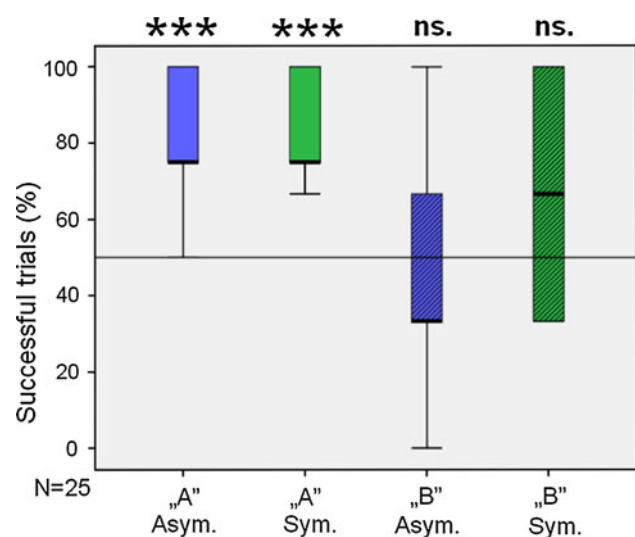


Fig. 4 Subjects' performance in experiment 1

Natural Pedagogy hypothesis cannot account for the A-not B error committed by Common Marmosets. These results seem to be in line with arguments stating that though non-human animals may well be similarly sensitive to eye-contact as humans are, the meaning of this signal can still vary across species (Csibra 2010). Up to now there has been no evidence showing that animals, with the possible exception of the domestic dog, would interpret eye-contact as a signal that calls for attributing additional meaning to the others' behaviour. In experiment 1, we directly examined this question and found negative results.

On the other hand, we found that the trajectory of the hiding in the "B"-trials influenced the marmosets' success. In the asymmetric test (when the target object first crossed location "A" before arriving to location "B") the monkeys made more mistakes than in the symmetric test. This difference may be explained by the fact that in the "B"-trials, hiding took longer in the asymmetric test than in the symmetric tests, posing increased attentional demands. The attention span of common marmosets is rather short and the individual variation is high (Range and Huber 2007), which can result in a difference in their success between the two tests. Alternatively or in parallel, the asymmetric test is likely to have higher memory requirements. Crossing location "A" in the "B"-trials in the asymmetric test might have strengthened the memory of having the target in this location. Based on these results it seems that the marmosets' limited attentional and/or memory capacities contribute to their decreased success in the "B"-trials compared to the "A"-trials. In the following experiments we investigated whether other simple mechanisms may also affect their performance.

Experiment 2 and 3

Experimenters studying marmosets in cognitive tasks frequently use a low number of trials and keep daily sessions as short as possible (Mendes and Huber 2004; Voelkl and Huber 2000; Bugnyar and Huber 1997). This is likely to indicate that common marmosets get tired easily in such tasks and/or quickly lose motivation due to their small body and stomach size. An inherent feature of studying the "A-not-B" error is that we compare success in the initial "A"-trials to success in the "B"-trials that always follow the "A"-trials. Therefore it is possible that subjects perform worse in the "B"-trials simply because they are conducted later than the "A" trials when the animals are already tired or full. To test this hypothesis we ran experiment 2, where subjects received 7 consecutive "A"-trials.

Alternatively, it is possible that the marmosets do not show enough flexibility in their food searching behaviour, and their lower success in the "B"-trials has nothing to do

with the repeated "A"-trials, but changing from one place to another in itself is the problem. Although there is some evidence that marmosets do show flexibility in their feeding behaviour (e.g. Ferrari et al. 1996; Passamani and Rylands 2000), it refers to the use of different types of food sources and, to our best knowledge, no study investigated the spatial flexibility in this context. Thus, erroneous responses in the "A-not-B" test situation also might be due to this attention factor. We know from previous studies that for infants it is not a problem to change from one location to another since, with decreased number of "A" trials, they do not reach back to the "A" location in the "B"-trials (Smith et al. 1999; Spencer et al. 2001). In order to test this last hypothesis in experiment 3 the subjects received 7 alternating "A" and "B"-trials.

Subjects

The same subjects ($N = 17$) participated in experiments 2 and 3 in a counterbalanced order except for one individual that only participated in experiment 3. These subjects were 5 male and 11 female, mean age: 10.31 years and 6 male and 11 female, mean age: 9.94 years in experiments 2 and 3 respectively. All subjects have previously participated in experiment 1 1 month earlier.

Experiment 2

In this test, subjects received seven non-social "A" trials in a row and we compared the number of their successful choices to the 50% chance level both in the first 4 and the last 3 trials (one-sample Wilcoxon tests).

Results

There was no significant difference between the subjects' performance in trials 1–4 and 5–7 (Wilcoxon matched pair test; $Z = 0.052$, $P = 0.959$), but in the first 4 trials subjects performed above chance level ($P = 0.002$) whereas in the last 3 trials their success did not differ from chance level ($P = 0.065$) (Fig. 5). Accordingly it seems that participating in 7 consecutive A-trials can result in an "A-not-B" error.

Experiment 3

In this test subjects received seven alternating "A"- and "B"-trials in which the hiding was done in the same way as in the non-social condition of the symmetric test of experiment 1. We again compared their performance to the 50% chance level in the first 4 ("ABAB") and last 3 ("ABA") trials (one-sample Wilcoxon tests).

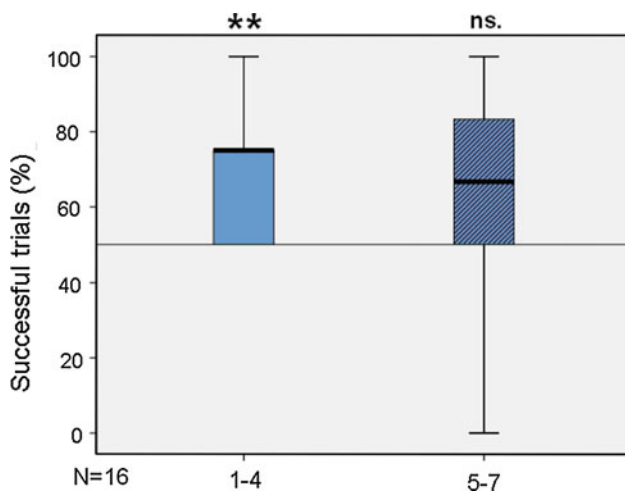


Fig. 5 Subjects' performance in experiment 2

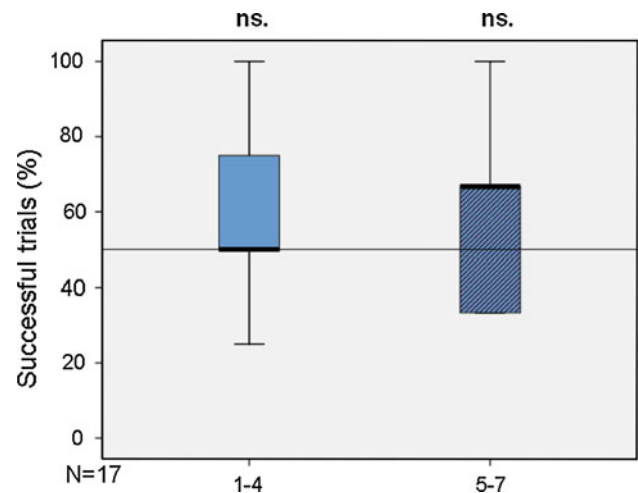


Fig. 6 Subjects' performance in experiment 3

Results

We found that subjects were not successful even in the 1–4 trials when they received alternating “A” and “B” trials (1–4 trials: $P = 0.109$; 5–7 trials: $P = 0.051$) (Fig. 6). Their performance in trials 1–4 did not differ from the performance in the trials 5–7 (Wilcoxon matched pairs test; $Z = 0.573$, $P = 0.576$). From these results we can conclude that changing from one location to another can be a problem per se for the marmosets. Additionally we could find no difference among the performance in the alternating “A” and “B” trials group and the 7 “A” trials group (trials 1–4: $Z = 1.155$, $P = 0.248$; trials 5–7: $Z = 0.439$, $P = 0.660$).

Discussion experiment 2 and 3

Our results show that participating in 7 consecutive “A” trials already might be a problem for marmosets as their performance in the last three trials did not differ from the chance level. This is seemingly in contradiction with what we found in the 7 alternating “A” and “B” hidings where in the last three trials subjects' performance almost increased above chance performance opposed to the first four trials. One possible explanation is that the alternating trials were more interesting for the subjects compared to the 7 “A” trials and this led to the increased—although not significantly above chance—performance in the last 3 trials. However, if that were true we would have expected more invalid trials with the marmosets losing attention and not responding in the less interesting 7 “A” condition, which was not the case (6% invalid trials in the 7 “A” condition and 9% invalid trials in the alternating “A” and “B” condition). We should also note that there is no significant difference when directly comparing the performance in the

two test conditions suggesting that the almost above chance performance of the subjects in the alternating “A” and “B” trials might merely be an artefact.

In sum, the results from experiments 2 and 3 show that both the effect of getting tired and/or full and the difficulties caused by changing from one location to another can cause an “A-not-B” error with above chance performance in the first four trials on chance level performance in the last three trials.

General discussion

Originally, the “A-not-B” task was developed to test the object representational skills of human infants. Contrary to Piaget's (1954) classical explanation about the deficit of object permanence skills, Topál et al. (2008) suggested that the “A-not-B” error can be explained on the basis of the Natural Pedagogy hypothesis (Csibra and Gergely 2006). They claim that infants' error is at least partially due to misinterpretation of the hider's ostensibly communicated object hiding actions as potential ‘teaching’ demonstrations during the A trials. In contrast to these high level explanations, our results point to the possible influence of lower level, attentional and motivational processes.

Based on the results of our three experiments it seems that rather basic mechanisms contribute to the decreased success of common marmosets in “B”-trials following repeated “A”-trials. Limitations in their attentional and memory capacities, in the flexibility of their search behaviour as well as exhaustion and/or decreased food motivation appear to cause lower success in the later “B”-trials compared to the initial “A”-trials.

Generally speaking the different mechanisms are likely to cause a drop in success in the “B”-trials to a different

extent. From this perspective it is especially important to recognize that different procedures are used and different changes in performance from “A”- to “B”-trials are pulled together under the term of committing the “A-not-B” error. The general definition of the “A-not-B” error is that the subject persists to search for an object/food reward where it was previously hidden even when it is placed visibly behind a second location (Topál et al. 2008). Most experiments differ in their test setup, including the number of “A”- and “B”-trials (Zucca et al. 2007: 2A + 2B; Neiworth et al. 2003: 9A + 9B; Pollok et al. 2000: 3A + 1B; de Blois et al. 1998: 3A + 3B or 3A + 2B; Pepperberg et al. 1997: 2A + 4B) and the trajectory of the reward during the hiding (asymmetric conditions with the reward passing under or behind the “A” container in “B” trials: Topál et al. 2008, 2009; symmetric conditions with the reward starting from the middle, sometimes with the experimenter holding up the reward: Gratch et al. 1974; Diamond 1985; de Blois et al. 1998; or starting from above: Fedor et al. 2008). Authors also use different definitions of the “A-not-B” error: if the subject shows a perseverative response in the “B” trials, that is searches in the “A” location during the “B” trials (Pepperberg et al. 1997), if in “B”-trials subjects perform significantly worse than expected by chance (Topál et al. 2009; de Blois et al. 1998; Neiworth et al. 2003) or if there is a significant decrease in success from “A” to “B” trials (Topál et al. 2008). In the infant psychology literature there are two other definitions: Topál et al. (2008) define the “A-not-B” error as the subjects searching more than once at location “A” in the 3 “B”-trials, while Longo and Bertenthal (2006) define the “A-not-B” error as the subjects performing worse in the “B”-trials than in the “A”-trials, although they also discuss the possibility of accepting only the performance worse than 50% as an “A-not-B” error. According to some of the above mentioned criteria the common marmosets in our study did commit the “A-not-B” error (some of the subjects did show a perseverative response in the “B” trials and at a group level they performed significantly worse in the “B” trials than in the “A” trials) whereas according to other criteria they did not (they did not perform significantly worse than expected by chance in the “B” trials).

The “A-not-B” error that we found in marmosets can be interpreted in a certain way as a similar phenomenon to the one described in human infants and adult dogs, although less robust. However, the Natural Pedagogy hypothesis that seems to explain infants’ as well as dogs’ error pattern, is certainly not true for marmosets, as their performance is not affected by human communicative cues. The explanation for this “A-not-B” error seems to be simply resulting from an attentional problem (see results from the symmetric vs. asymmetric test setup), the effect of getting tired

and/or less motivated as receiving more trials and being unable to solve a two-way choice task with alternating hidings.

In connection with object permanence it was already described both in humans and in dogs (Watson et al. 2001; Gácsi et al. 2009), that the explanation for their choice in the test is not strictly connected to object representation skills, but rather to their tendency to follow social rules, that put the whole concept about the “A-not-B” error to another context (Topál et al. 2008, 2009). Our results in marmosets show that other factors such as attention and tiring can also influence the performance in object choice tasks. These simple mechanisms might be at work also in other species and may explain to some extent the “A-not-B” error in young individuals of non-human primates, displaying undeveloped object representational skills.

Acknowledgments We thank Ludwig Huber and Ádám Miklósi for their support and András Kosztolányi for his help with the statistics. Funded by the ÖAD Foundation (grant 74öu3).

References

- Baillargeon R, Spelke ES, Wasserman S (1985) Object permanence in five-month-old infants. *Cognition* 20:191–208
- Bard KA, Vaclair J (1984) The communicative context of object manipulation in ape and human adult-infant. *Pairs J Hum Evol* 13:181–190
- Bugnyar T, Huber L (1997) Push or pull: an experimental study on imitation in marmosets. *Anim Behav* 54:817–831
- Caldwell CA, Whiten A (2003) Scrounging facilitates social learning in common marmosets, *Callithrix jacchus*. *Anim Behav* 65: 1085–1092
- Caro TM, Hauser MD (1992) Is there teaching in nonhuman animals? *Q Rev Biol* 67:151–174
- Csibra G (2007) Teachers in the wild. *Trends Cogn Sci* 11:95–96
- Csibra G (2010) Recognizing communicative intentions in infancy. *Mind Lang* 25(2):141–168
- Csibra G, Gergely Gy (2006) Social learning and social cognition: the case for pedagogy. In: Munakata Y, Johnson M (eds) *Processes of change in brain and cognitive development*. Oxford University Press, Oxford, pp 249–274
- Cummings EM, Bjork EL (1983) Search behavior on multi-choice hiding tasks: evidence for an objective conception of space in infancy. *Int J Behav Dev* 6:71–87
- de Blois ST, Novak MA, Bond M (1998) Object permanence in orangutans (*Pongo pygmaeus*) and squirrel monkeys (*Saimiri sciureus*). *J Comp Psychol* (Washington, DC: 1983) 112:137–152
- Dell’Mour V, Range F, Huber L (2009) Social learning and mother’s behavior in manipulative tasks in infant marmosets. *Am J Primatol* 71:503–509
- Diamond A (1985) Development of the ability to use recall to guide action, as indicated by infants’ performance on AB. *Child Dev* 56:868–883
- Dumas C (1992) Object permanence in cats (*Felis catus*): an ecological approach to the study of invisible displacements. *J Comp Psychol* 106:404–410
- Fedor A, Skollár G, Szerencsy N, Ujhelyi M (2008) Object permanence tests on gibbons (Hylobatidae). *J Comp Psychol* 122:403–417

- Feistner ATC, Price EC (1991) Food offering in new world primates: two species added. *Folia Primatol* 57(3):165–168
- Ferrari SF, Correa HKM, Coutinho PEG (1996) Ecology of the “southern” marmosets (*Callithrix aurata* and *Callithrix flaviceps*) how different, how similar? In: Norconk MA, Rosenberger AL, Garber PA (eds) Adaptive radiations of neotropical primates. Plenum Press, New York, pp 157–172
- Ferrari PF, Paukner A, Ionica C, Suomi SJ (2009) Reciprocal face-to-face communication between rhesus macaque mothers and their newborn infants. *Curr Biol* 19:1768–1772
- Fiset S (2010) Comment on “differential sensitivity to human communication in dogs, wolves, and human infants”. *Science* 329:142-b
- Gácsi M, Györi B, Virányi Zs, Kubinyi E, Range F, Belényi B, Miklósi Á (2009) Explaining dog wolf differences in utilizing human pointing gestures: selection for synergistic shifts in the development of some social skills. *Plos One* 4(8):e6584
- Gagnon S, Doré FY (1992) Search behavior in various breeds of adult dogs (*Canis familiaris*): object permanence and olfactory cues. *J Comp Psychol* 106:58–68
- Gagnon S, Doré FY (1994) A cross-sectional analysis of object permanence development in dogs (*Canis familiaris*). *J Comp Psychol* 108:220–232
- Gómez JC (2005) Species comparative studies and cognitive development. *Trends Cogn Sci* 9(3):118–125
- Gratch G, Appel KJ, Evans WF, LeCompte GK, Wright N (1974) Piaget’s stage IV object concept error: evidence of forgetting or object conception? *Child Dev* 45:71
- Kasper C, Voelkl B, Huber L (2008) Tolerated mouth-to-mouth food transfers in common marmosets. *Primates* 49:153–156
- Longo MR, Bertenthal BI (2006) Common coding of observation and execution of action in 9-month-old infants. *Infancy* 10:43–59
- Mendes N, Huber L (2004) Object permanence in common marmosets (*Callithrix jacchus*). *J Comp Psychol* 118(1):103–112
- Myowa-Yamakoshi M (2003) Preference for human direct gaze in infant chimpanzees (*Pan troglodytes*). *Cognition* 89:113–124
- Neiworth JJ, Steinmark E, Basile BM, Wonders R, Steely F, DeHart C (2003) A test of object permanence in a new-world monkey species, cotton top tamarins (*Saguinus oedipus*). *Anim Cogn* 6:27–37
- Passamani M, Rylands AB (2000) Feeding behavior of Geoffroy’s marmoset (*Callithrix geoffroyi*) in an Atlantic forest fragment of South-eastern Brazil. *Primates* 41:27–38
- Pepperberg IM, Willner MR, Gravitz LB (1997) Development of piagetian object permanence in a grey parrot (*Psittacus erithacus*). *J Comp Psychol* 111(1):63–75
- Piaget J (1954) Intelligence and affectivity: their relationship during child development. *Annual Review, Inc, Palo Alto*
- Pollok B, Prior H, Gunturkun O (2000) Development of object permanence in food-storing magpies (*Pica pica*). *J Comp Psychol* 114:148–157
- Range F, Huber L (2007) Attention in common marmosets: implications for social-learning experiments. *Anim Behav* 73:1033–1041
- Smith LB, Thelen E, Titzer R, McLin D (1999) Knowing in the context of acting: the task dynamics of the A-Not-B error. *Psychol Rev* 106(2):235–260
- Sophian C, Wellman HM (1983) Selective information use and perseveration in the search behavior of infants and young children. *J Exp Child Psychol* 35:369–390
- Spencer JP, Smith LB, Thelen E (2001) Tests of a dynamic systems account of the A-not-B error: the influence of prior experience on the spatial memory abilities of two-year-olds. *Child Dev* 72:1327–1346
- Tardif SD, Harrison ML, Simek MA (1993) Communal infant care in marmosets and tamarins. In: Rylands AB (ed) Marmosets and tamarins: systematics, behaviour and ecology. Oxford University Press, Oxford, pp 220–234
- Thelen E, Smith LB (1994) A dynamic systems approach to the development of cognition and action. MIT Press, Cambridge
- Topál J, Gergely Gy, Miklósi Á, Erdőhegyi Á, Csibra G (2008) Infants’ perseverative search errors are induced by pragmatic misinterpretation. *Science* 321:1831–1834
- Topál J, Gergely Gy, Erdőhegyi Á, Csibra G, Miklósi Á (2009) Differential sensitivity to human communication in dogs, wolves and human infants. *Science* 325:1269–1272
- Topál J, Miklósi Á, Sümegi Z, Kis A (2010) Response to comments on “differential sensitivity to human communication in dogs, wolves, and human infants”. *Science* 329:142-d
- Voelkl B, Huber L (2000) True imitation in marmosets. *Anim Behav* 60:195–202
- Voelkl B, Huber L (2007) Imitation as faithful copying of a novel technique in marmoset monkeys. *PloS One* 2:e611
- Voelkl B, Huber L (2006) Hand rearing of infant common marmosets (*Callithrix jacchus*). In: Sackett GP, Ruppenthal GC, Elias K (eds) Nursery rearing of nonhuman primates in the 21st century. Springer, New York, pp 121–129
- Watson JS, Gergely Gy, Topál J, Gácsi M, Sárközi Zs, Csányi V (2001) Distinguishing logic versus association in the solution of an invisible displacement task by children and dogs: using negation of disjunction. *J Comp Psychol* 115:219–226
- Werdenich D, Huber L (2002) Social factors determine cooperation in marmosets. *Anim Behav* 64:771–781
- Zucca P, Milos N, Vallortigara G (2007) Piagetian object permanence and its development in Eurasian jays (*Garrulus glandarius*). *Anim Cogn* 10:243–258