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Why Do Adult Dogs (*Canis familiaris*) Commit the A-not-B Search Error?

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It has been recently reported that adult domestic dogs, like human infants, tend to commit perseverative search errors; that is, they select the previously rewarded empty location in Piagetian A-not-B search task because of the experimenter's ostensive communicative cues. There is, however, an ongoing debate over whether these findings reveal that dogs can use the human ostensive referential communication as a source of information or the phenomenon can be accounted for by "more simple" explanations like insufficient attention and learning based on local enhancement. In 2 experiments the authors systematically manipulated the type of human cueing (communicative or noncommunicative) adjacent to the A hiding place during both the A and B trials. Results highlight 3 important aspects of the dogs' A-not-B error: (a) search errors are influenced to a certain extent by dogs' motivation to retrieve the toy object; (b) human communicative and noncommunicative signals have different error-inducing effects; and (3) communicative signals presented at the A hiding place during the B trials but not during the A trials play a crucial role in inducing the A-not-B error and it can be induced even without demonstrating repeated hiding events at location A. These findings further confirm the notion that perseverative search error, at least partially, reflects a "ready-to-obey" attitude in the dog rather than insufficient attention and/or working memory.

Keywords: dog, A-not-B error, social cognition, communication, motivation

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Object representational skills in human infants as well as in several animal species develop through successive steps that Piaget (1954) defined as six distinctive stages of object permanence. Stage IV is characterized by perseverative search errors, the so-called A-not-B errors. In the standard A-not-B task usually two (sometimes more; e.g., Wellman, Cross, & Bartsch, 1986) hiding locations, A and B, are used. The experimenter first repeatedly hides visibly a target object at the A location and following these A trials the same object is hidden visibly at the B location (B trials). The subject is allowed to search after each hiding and the A-not-B error emerges when the subject searches at location A even when the object is hidden at B.

This error was first described in infants between 8 and 12 months of age (Piaget, 1954). Originally Piaget accounted for the A-not-B error by suggesting incomplete comprehension of object permanence; however since then many different proposals have been put forward, including insufficient attention (Harris, 1989; Ruffman & Langman, 2002), deficits of the short-term memory (Cummings & Bjork, 1983), immature sensory motor integration system (Berthental, 1996; Baillargeon, Spelke, & Wasserman, 1985), inability to inhibit the previously rewarded motor response (Diamond, 1985), and covert imitation or automatic simulation of movements (Longo & Bertenthal, 2006). A recent study (Topál et al., 2008) proposed a quite different explanation based on infants' sensitivity to cues that signal a person's intent to communicate useful information ("pedagogical" receptivity - Csibra & Gergely, 2009). The authors argue that A-not-B search error can be effectively induced in an ostensive-communicative context because young infants, who are especially susceptible to ostensive-referential gestures, tend to misinterpret the object-hidings at location A as potential teaching demonstrations. Thus the ostensively induced A-not-B search error can be seen as a conceptual illusion, the "illusion of being taught."

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Humans are not the only species who commit the A-not-B error. Apes (Mathieu & Bergeron, 1981; Poti, 1989), monkeys (de Blois, Novak, & Bond, 1998; Kis, Gácsi, Range, & Virányi, 2012; Neiworth et al., 2003), birds (Pepperberg, Wilner, & Gravitz, 1997; Pollok, Prior, & Gunterkun, 2000; Zucca, Milos, & Vallortigara, 2007), and dogs (Topál, Gergely, Erdõhegyi, Csibra, & Miklósi, 2009; Watson et al., 2001; but see Gagnon & Doré, 1992, 1994) also show evidence of similar errors in object search tasks. Furthermore it has been revealed that, similarly to 8–12-month-old infants, adult dogs commit the A-not-B error in the communicative condition but do not show this response bias in a noncommunicative context (Topál, Gergely, et al., 2009). The authors concluded that dogs' performance in the A-not-B task might reflect their sensitivity to human communication and the increased perseverative error in the "communicative version" of the task is at least partly caused by dogs' willingness to obey experimenter's "instructions" expressed through ostensive communication. These results also raise the possibility that the experimenter's ostensive-communicative signals such as addressing, eye contact, and gaze shifts during the hiding event can guide the dogs' attention more efficiently than other salient, but noncommunicative attention getters (e.g., squeaky toy sound).

This communicative account for dogs' perseverative search bias has gained some indirect support from recent studies showing that dogs are sensitive to human cues that signal communicative intent (e.g., Téglás, Gergely, Kupán, Miklósi, & Topál, 2012) and often rely on human communication even when it conveys an inefficient or mistaken solution to food choice (Szetei, Miklósi, Topál, & Csányi, 2003; Prato-Previde, Marschall-Pescini, & Valsecci, 2008), object choice (Erdõhegyi, Topál, Virányi, & Miklósi, 2007; Kupán, Miklósi, Gergely, & Topál, 2011), or goal approach (Pongrácz, Miklósi, Kubinyi, Topál, & Csányi, 2003) tasks.

However, the notion that dogs' receptivity to human communication can account for A-not-B errors is still a matter of debate and alternative explanations (insufficient attention, learning based on local enhancement) have also been proposed. Some have suggested that dogs committed more error in the communicative condition of Topál, Gergely, et al., 2009 study because the object search task was attentionally more demanding in that context as compared to the nonsocial version of the task (Fiset, 2010). Others (Marshall-Pescini, Passalacqua, Valsecchi, & Prato-Previdel, 2010) have argued that perseverative search bias can emerge as a result of the local enhancing effect of the unbalanced cuing procedure. Namely, dogs were provided ostensive communicative signals adjacent to the A but not to the B location in the communicative condition, whereas the experimenter used noncommunicative attention getter (squeaky rubber toy) at both locations in the noncommunicative condition. Although most of these concerns have been addressed (Kis et al., 2012b; Topál et al., 2010) providing further support for the communicative account, there are some open questions that require further investigations.

First, although the aforementioned communicative account predicts different effects of communicative and noncommunicative signals the question whether or not communicative and noncommunicative attention getters have the same effects on dogs' performance has never been directly tested. A related point is that in Topál, Gergely, et al.'s (2009) study, the experimenter "marked" the A location using the same salient signals (either communicative or noncommunicative) in both phases of the task: in the A trials when the object was left there as well as in the B trials when the object was removed (sham baiting) and moved on to location B. Importantly, therefore, it was impossible to assess the relative significance of communicative signaling at location A in the A-trials versus in the B trials in eliciting the A-not-B errors.

Based on the above findings we may assume that addressing the dog and making eye contact next to location A as well as gaze shifts between the dog and the A location act as a "general instruction" for dogs that suggest selecting that location (no matter where the toy object is located). If so, then ostensive communicative signals at location A in the A trials should play an important role in the emergence of search error during the B trials. If, however, ostensive communicative signals simply act as here-and-now attention getters then these signals at location A in the B trials are expected to be more influential in provoking search errors.

Another important but often neglected factor of subjects' performance in studies assessing social–cognitive skills is motivation (Toates, 1995). For example, many argue that the willingness of food-deprived animals to work for food is higher (e.g., chicken [Bokkers, Koene, Rodenburg, Zimmerman, & Spruijt, 2004], sheep [Verbeek, Waas, McLeay, & Matthews, 2011], and rabbit [Seaman, Waran, Mason, & D'Eath, 2008]), and recently it has also been shown that highly motivated subjects (Indian Mynas, *Acridotheres tristis*) explore the feeder more and thus perform better in an innovation task (Sol, Griffin, & Bartomeus, 2012). Generally speaking, evaluating the motivation level is indispensable for deciding whether a subject is "unable or unwilling" to perform well at a task (Kirkden & Pajor, 2006). Motivation for food also strongly affects the dogs' willingness to participate in training and complete the task (training to give "paw" when commanded; Range, Leitner, & Viranyi, 2012), to our knowledge however, the effect of motivation on dogs' performance in object search tasks has not yet been investigated.

In the A-not-B object search, task motivation can be of great importance as this may effectively modulate subjects' attention toward the target object and/or the dogs' willingness to ignore the experimenter's communicative signals adjacent to the empty A location.

Thus we may hypothesize that highly motivated dogs will be more attentive toward the target object and even if A-not-B error stems from the dogs' "ready-to-obey" attitude they will be less eager to behave according the experimenter's ostensive communication and will search more often at location B in the B trials.

To address these points in the present study we investigated the associations between dogs' motivation to obtain the target object and their tendency to commit search error in different conditions in which we systematically manipulated the attention-getting signals in terms of their communicative character provided by the experimenter during object hiding.

Experiment 1

In the first experiment we investigated (a) whether or not the subjects' performance in the A-not-B object search task (Topál, Gergely, et al., 2009) is influenced by their motivation to obtain the target object, (b) whether human communicative and noncommunicative signals have different effects in directing dogs toward the empty A screen during the B trials (perseverative error), and (c) whether dogs perseverative search bias is more heavily affected by

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the human ostensive communication at location A presented during the "introductory" A trials or during the B trials.

Materials and Methods

Subjects. Eighty-two pet dogs were recruited on a voluntary basis. All were at least 1 year of age. The only criterion for selection was that the dog had never participated in an A-not-B object search task and was motivated to play with a ball. Ten dogs had to be excluded because they were unwilling to participate in the test (they showed signs of distress and/or did not show any interest in retrieving the target object during the warm-up trials). The remaining 72 dogs (*M* age $\pm$ *SD*: 3.71 $\pm$ 2.49 years, 36 males and 36 females, from 27 different breeds and 15 mongrels) were tested and included in the data analysis.

Experimental arrangement. The experiments took place in a room (5 m $\times$ 2.5 m) at the Eötvös University, Budapest, Hungary where two identical opaque plastic boxes (30 cm wide $\times$ 42 cm high $\times$ 23 cm deep) were placed 0.6 m apart to serve as hiding places. The owner held the collar of the dog that was facing the screens standing equidistant (2 m) from them. A squeaky rubber toy was placed on the floor 0.6 m from the A screen in line with the screens. (see Figure 1).

General procedure. Before the test trials, subjects participated in an object retrieval task (two trials). The purpose of this session was to familiarize the subject with the retrieval task as well as to categorize dogs in terms of their motivation to get the object. In these trials only one screen was placed on the floor (halfway between subsequent locations A and B) and the experimenter hid the ball behind it in full view of the dog that was then released to search for it. If the dog was unwilling to search it was encouraged by the owner. The dogs' level of motivation was assessed by scoring their behavior (see the Data Analysis section for more details).

The test trials consisted of four A trials followed by three B trials. During the A trials, the experimenter stood next to the dog

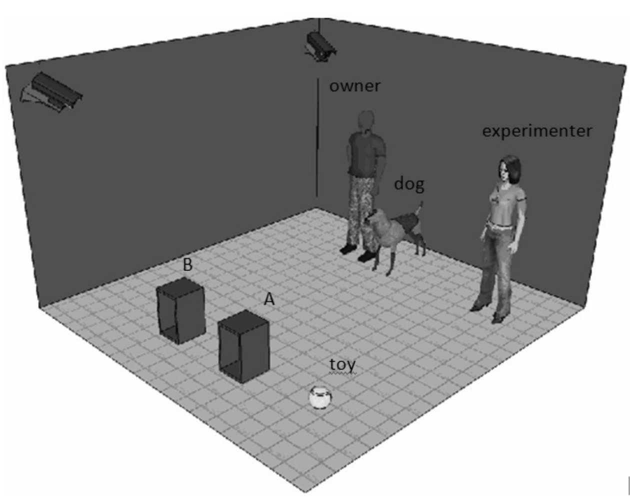

Figure 1. Experimental set up. Two identical opaque plastic boxes served as hiding places (A and B). The dog was facing the screens standing equidistant from them. A squeaky rubber toy was placed on the floor in line with the screens. The experimenter's starting point was next to the dog.

and attracted the dog's attention using communicative (addressing the dog and establishing eye-contact) or noncommunicative (clapping her hand) signals. Then she approached the ball and attracted the dog's attention again with the toy in her hand next to the A location (A_A) either in a communicative or noncommunicative manner. If she used communicative signals at the beginning of a trial (while standing next to the dog), she also used the same communicative signals (addressing the dog and establishing eye contact) when she picked up the ball from the floor. If the experimenter used noncommunicative signals while standing next to the dog, she attracted the dogs' attention in a noncommunicative manner (the toy in her hand made a squeaky sound) when she picked up the ball. Then she stepped behind screen A with the toy in her hand being constantly visible to the dog and placed the ball behind screen A. She passed behind screen B and went back to her starting point next to the dog. After showing her empty hands to the dog, the subject was allowed to approach the setup and inspect one of the locations.

The procedure in the B trials was similar to that of the A trials (either communicative or noncommunicative attention-getting both at the starting point and at location A; B_A) except that the experimenter did not leave the ball behind screen A, but after a few seconds of "sham baiting" the toy visibly reemerged in her hand and she attracted the dog's attention by squeaking the toy next to the B screen (B_B). She moved on to screen B and placed the toy behind it, then she went back to her starting point showing her empty hands and finally the dog was allowed to make a choice.

During the whole experiment the owner was not allowed to give any commands to the dog. If the dog chose the baited screen it was allowed to play with the ball, but if the dog first visited the empty screen it was called back by the owner (while the experimenter also tried to prevent it from visiting the baited screen and retrieving the toy) and the next test trial began. Note, that the experimenter put the ball inside the baited box, thus for dogs it was necessary to look into a box to check if it is empty or not. In a few cases (21 out of the 216 B-trials) however, the dog first visited the empty A location and yet could retrieve the ball from behind the baited screen. In such cases the owner took the ball away from the dog as quickly as possible, and the dog was not allowed to play with the toy.

Experimental conditions. Subjects were assigned to one of four groups, representing all possible combinations of communicative/noncommunicative cuing at the A screen during the first (A trials) and second (B trials) phases of the test. (see Table 1). Subjects in the four experimental groups did not differ by age (analysis of variance, $F_{(3,68)} = 0.761$, $p = .923$).

Data analysis. The number of dogs' correct choices was coded in all conditions. The first inspected location was regarded as the subject's choice, and a choice was scored as correct if the dog touched the baited screen with its nose or paw or stood close to the box and looked behind it. Dogs received scores of 1 or 0 depending on whether they chose the baited or the empty location respectively.

The dogs' level of motivation was assessed by scoring their behavior during the warm up trials according to the following criteria (for video protocols, see: http://www.cmdbase.org/web/guest/play/-/videoplayer/156).

Table 1
Signals Presented Next to the A and B Screen in the Different Experimental Conditions

	Signals presented		
Experimental conditions	During A trial: Next to the A screen (A_A)	During B trial: Next to the A screen (B_A)	During B trial: Next to the B screen (B_B)
(*N*; males/females)			
NonCom ($n = 19$; 10/9)	Noncommunicative	Noncommunicative	Noncommunicative
$ComA_A$ ($n = 18$; 9/9)	Communicative	Noncommunicative	
$ComA_AB_A$ ($n = 18$; 7/11)	Communicative	Communicative	
$ComB_A$ ($n = 17$; 10/7)	Noncommunicative	Communicative	

Note. During A trials, the experimenter ignored the B screen (no cuing there). Communicative signals: the experimenter turned with her face toward the dog during the hiding event, she addressed the dog (dog's name + watch!), and established eye-contact with it. Noncommunicative signals: the experimenter turned with her back toward the dog during the hiding event and she attracted the dog's attention making a conspicuous noise with the rubber squeak toy. Thus in this context there was no eye-contact, the experimenter did not look at, and did not talk to the dog. NonCom = noncommunicative; Com = communicative.

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0 = Unmotivated: Total ignorance of the toy during warm-up trials (these dogs had to be excluded from further tests).

1 = Low motivated: The dog calmly waits while the experimenter places the ball behind the screen. Approaches the baited screen indirectly and after 3 s or more delay, leaves the toy behind the screen or drops it onto the floor and leaves there at least once.

2 = Moderately motivated: The dog calmly waits while the experimenter places the ball behind the screen. Approaches the baited screen immediately and directly when released. Retrieves the toy object and readily gives it over to the owner.

3 = Highly motivated: The dog tries to release itself one to three times while the experimenter places the ball behind the screen. Approaches the baited screen immediately and directly when released. Subject retrieves the toy object, however, unwilling to give it over to the owner or to the experimenter, and/or tries to take the ball from the experimenter's hand at least twice.

4 = Overmotivated: The dog tries to release itself more than three times while the experimenter places the ball behind the screen. Approaches the baited screen immediately and directly when released. Picks up the toy, however, unwilling to retrieve and give it over to the owner or to the experimenter. When the toy is obtained by the experimenter the dog is trying to permanently retrieve it from her hand.

As the warm up phase was identical in all experimental conditions, it allowed us to carry out motivation scoring blind to the conditions and without knowing the later performance of subjects.

Furthermore, to check if dogs spent similar amounts of time gazing toward the human actor in the different conditions we measured the duration of time spent orienting toward the object-hiding events in the first A and the first B trials of each condition.

Subjects' motivation and choice behavior was assessed by the first author and the reliability of the coding was measured using Cohen's Kappa value. A second person scored a randomly selected sample of 50% and Cohen's Kappa value was 1.0 for dogs' choice and 0.96 for motivation. Concerning the motivation scores there was only one disagreement between coders (moderate or high motivation) and in this case the first coder's score was accepted. The reliability for the duration of time spent orienting toward the object-hiding events was assessed by means of parallel coding of the 25% of the first A and B trials total trials by two observers. Interobserver reliability was also excellent (Pearson's correlation $r = .925$, $p < .001$).

We used a Generalized Linear Model (binomial distribution) for the analysis of the effects of different signals (communicative vs. noncommunicative) during hiding and the dogs' motivation to retrieve the toy on the dogs' tendency to commit A-not-B error. Number of successful B trials (zero to three) was set as the dependent variable, type (communicative vs. noncommunicative) of the cuing next to the A screen and timing of the sign (during A vs. B trials) as fixed factors and motivation score as covariate.

We used Kruskal-Wallis and Dunn's multiple comparison post-tests to compare dogs' performance in the different motivation categories (1–4). The duration of time spent orienting toward the object-hiding events in the different conditions was also analyzed by Kruskal-Wallis test, because data didn't follow normal distribution. To assess the effect of the different cues given during the hiding procedure, the number of correct choices in the A and B trials was also compared to the 50% chance level using one-sample Wilcoxon signed-ranks test. To compare the dogs' performance in B trials of the different conditions, Wilcoxon's matched pairs tests and Kruskall-Wallis test were used. We also compared the percentage of dogs showing perseverative search bias toward the empty A location (A-not-B error) in the B-trial phase of the four different hiding-contexts using chi^2 test. *A-not-B error* was defined as selection of the empty (A) screen in the first B trial and at least one additional "incorrect" choice during the second and third B trials.

Statistical tests were two-tailed, the α value was set at 0.05 and the statistical package SPSS version 18 was used.

Results and Discussion

Analysis with a general linear model revealed that the type of attention getting signals (communicative or noncommunicative) used at the A screen during the B trials played a significant role in inducing the A-not-B error, $\chi^2(1) = 7.205$, $p = .007$; but the type of cuing during A trials had only a marginally significant effect on dogs' performance, $\chi^2(1) = 2.907$, $p = .088$. It is also worth mentioning that the context dependence of dogs' tendency to commit search error was probably not caused by dogs' selective attention because dogs paid as much attention to the object-hiding event in the noncommunicative conditions as they did in the communicative ones: A-trial-phase: $\chi^2(3) = 6.337$, $p = .096$, and B-trial-phase: $\chi^2(3) = 3.304$, $p = .347$. More importantly, although subjects in the four experimental groups showed similar levels of motivation to obtain the target object in the warm up phase (Kruskal-Wallis test, $\chi^2_{(3)} = 3.049$, $p = .384$; Table 2), dogs' tendency to commit A-not-B error was heavily affected by their motivation scores, $\chi^2(1) = 21.605$, $p < .001$). No interactions were found between the factors and covariate ($p > .1$ in all cases).

The effect of dogs' motivational characteristics on performance. The significant role of the level of motivation in the emergence of perseverative search errors is also clearly indicated by the comparison of the dogs assigned to the different motivation categories: Kruskal-Wallis test, $\chi^2(3) = 13.167$, $p = .004$. Dogs categorized as overmotivated committed significantly less search errors than subjects belonging to other motivation categories (Dunn's multiple comparison posttest, overmotivated vs. highly and low motivated [$p < .05$], overmotivated vs. moderately motivated [$p < .01$]; see Figure 2 and Table 2).

Our finding suggests that high level of motivation to take possession of the target object, together with other potential contributing factors such as lack of inhibition or training, effectively eliminates A-not-B error. This raises the possibility that extreme motivation can act as a confounding factor for the assessment of the effect of human ostensive communication on dogs' tendency to select the nonbaited (A) location.

Thus we removed the eight overmotivated dogs (2 subjects from each group), and as there was still no difference between groups concerning their motivation scores—Kruskal-Wallis test, $\chi^2_{(3)} = 4.732$, $p = .192$—we rerun the generalized linear model. This analysis revealed a significant effect of the type of attention getting signals (communicative or noncommunicative) used at the A screen during the B trials—$\chi^2(1) = 9.436$, $p = .002$—while the type of cuing during A trials had no similar effect on dogs' performance—$\chi^2(1) = 2.482$, $p = .115$—and motivation of the subjects did not play a role either, $\chi^2(1) = 1.961$, $p = .161$. No interactions were found between the factors and covariate ($p > .1$ in all cases).

Table 2
Number of Dogs in Each Motivation Category in the Four Groups

Experimental condition	Motivation: Low	Moderately	Highly	Over
NonCom ($n = 19$)	1	14	2	2
$ComA_A$ ($n = 18$)	5	9	2	2
$ComA_AB_A$ ($n = 18$)	3	9	4	2
$ComB_A$ ($n = 17$)	0	11	4	2

Note. NonCom = noncommunicative; Com = communicative; A_A = during A trial and next to the A screen; B_A = during B trial and next to the A screen; B_B = during B trial and next to the B screen.

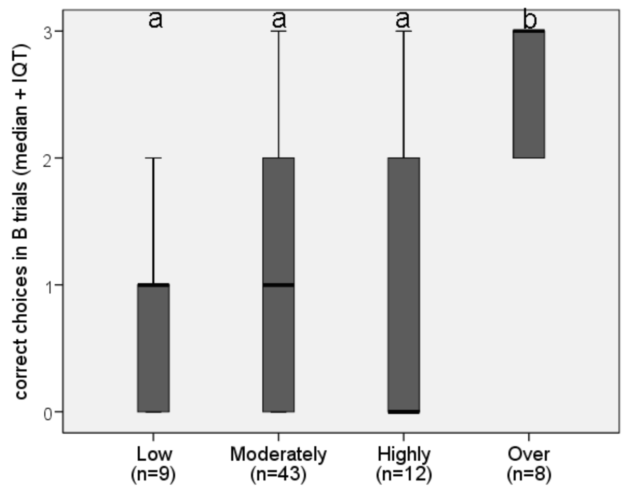

Figure 2. The effect of the level of motivation on dogs' choice behavior in the B trials. Overmotivated dogs made significantly less search errors than subjects belonging to other motivation categories (Kruskal-Wallis test, Dunn's multiple comparison posttest, different letters (a, b) indicate significant differences between groups $^* p < .05$).

The effects of communicative versus noncommunicative signals on performance. The remaining 64 dogs showed a similar performance in all four conditions during the A trials, Kruskal-Wallis test, $\chi^2(3) = 2.170$, $p = .538$. They fetched the toy reliably as they performed well above the success rate expected by random search (NonCom $T_+ = 153$, $p < .001$, $ComA_A$ and $ComA_AB_A$ $T_+ = 136$, $p < .001$; $ComB_A$ $T_+ = 120$, $p < .001$, Wilcoxon signed-ranks test).

However subjects' made fewer correct choices in the B trials than in the A trials in all conditions (Wilcoxon's matched pairs tests, NonCom $T_+ = 153$, $p < .001$; $ComA_A$ $T_+ = 78$, $p = .0078$; $ComA_AB_A$ $T_+ = 105$, $p = .001$; $ComB_A$ $T_+ = 120$, $p = .001$). Comparisons to the 50% chance level (Wilcoxon signed-ranks test) show that dogs displayed a significant search bias toward the empty (A) hiding place only in those conditions in which ostensive communicative signals were used adjacent to the A screen ($ComA_AB_A$ $T_+ = 26$, $p = .029$; $ComB_A$ $T_+ = 1$, $p = .0001$) and subjects performed at chance level in the other two groups (NonCom $T_+ = 44.5$, $p = .124$; $ComA_A$ $T_+ = 56$, $p = .56$, Figure 3).

The key role of ostensive communication adjacent to the empty A screen during the B trials in inducing the A-not-B error is further confirmed by the significant between-groups differences, $\chi^2(3) = 11.656$ $p = .009$, in percentage of subjects showing perseverative search bias toward the empty A screen. Again, more dogs showed perseverative search error if the human experimenter used communicative signals during the B trials next to the A screen (Com A_AB_A and $ComB_A$ vs. Com A_A and NonCom groups, Fisher's exact test, $p = .002$) (see Table 3).

In conclusion, dogs seem to react differently to communicative as opposed to noncommunicative human signals in the A-not-B task. Subjects in the $ComA_AB_A$ group similarly to subjects in the social-communicative group of Topál, Gergely, et al.'s (2009)

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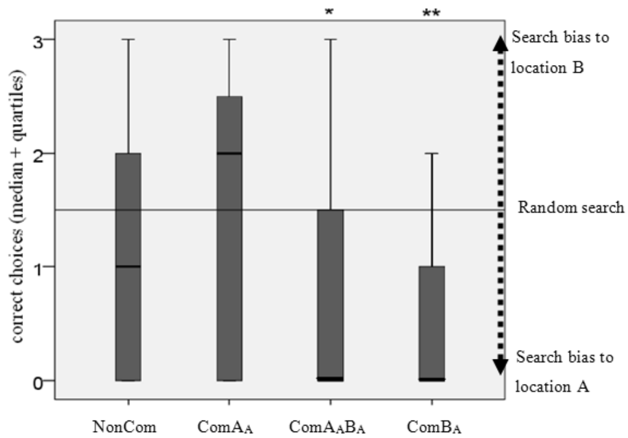

Figure 3. Number of correct choices in B trials in the four experimental groups (medians, quartiles, whiskers). Dogs in those conditions in which ostensive communicative signals were used adjacent to the A screen ($ComA_AB_A$ and $ComB_A$) show a search bias toward the empty (A) location, and subjects performed at chance level in the other two groups (NonCom and $ComA_A$). Comparisons to the 50% chance level (Wilcoxon signed-ranks test) (* $p < .05$; ** $p < .01$).

study displayed a search bias toward the empty A screen in the B trials, thus it seems that the noncommunicative attention getters presented close to the B screen are insufficient to eliminate the error. Moreover these results confirm our hypothesis suggesting a specific effect of motivation on dogs' overall search performance. Although the cues from the experimenter during hiding seem to affect the search behavior of dogs with low-to-high motivation in similar ways, subjects who were characterized by extreme high level of motivation tended to ignore the experimenter's signals and focused their attention toward the toy object.

In line with the findings from earlier studies (Kis, Topál, et al., 2012; Topál, Gergely, et al., 2009; Topál et al., 2010), the results of this experiment also support the differential effects of ostensive-communicative (vs. noncommunicative) signals on dogs' tendency to commit the A-not-B error. However, the present results do not seem to support the notion that ostensive communication next to location A acts as a "general instruction" for dogs. In contrast, it seems like dogs rely on the experimenter's ostensive-communication as episodic instructions and/or "here-and-now" attention getters in the B trials because human communicative cuing at location A in the B-trials plays a more important role in the emergence of A-not-B search errors.

Experiment 2

Based on the above results in a subsequent experiment we expected to induce A-not-B error in dogs without performing any A-trials. Although previous research (Topál et al., 2010; Kis, Topál, et al., 2012) has argued that local enhancement or sham-baiting of the A hiding place does not alter dogs' perseverative response in the A-not-B context, here we hypothesized that in the "only B trials" condition it becomes crucial whether or not the A hiding place is enhanced by the experimenter's ostensive communicative cues. Thus we planned a hiding procedure in which in addition to omitting the A trials we used three different types of B trials: a *social-communicative* (Topál, Gergely, et al., 2009) condition in which during the B trials the dog's attention is directed to location A ("sham baiting") after ostensively addressing the dog, the so-called *alleviated B trials* (Kis, Topál, et al., 2012) condition in which this sham baiting is omitted and the experimenter goes directly to location B, and a noncommunicative (Topál, Gergely, et al., 2009) control condition.

Materials and Methods

Subjects. Sixty-five task-naïve pet dogs participated in the study, all were at least 1 year of age (29 males, 34 females; *M* age: 3.92 ± 2.52 years). They were from 17 different breeds and 22 mongrels. Based on warm-up trials (see below), all dogs' motivation scores were ranked from low-to-high. Two dogs had to be excluded because of undermotivation and none of them was categorized as overmotivated (see Experiment 1 for criteria). Subjects were assigned to three hiding contexts (see below) so that the distribution of age would not differ across conditions.

Procedure. The experiment was conducted in another room (3.9 m × 4.1 m) but the experimental arrangement was the same as described in Experiment 1 (see Figure 1). Before the test trials, subjects participated in two warm-up trials where only one screen was placed on the floor using the same procedure as in Study 1.

Test trials consisted of three B trials without any previous A trials. Depending on the experimental group, subjects witnessed one of three different hiding procedures.

In the communicative hiding group (Com-H; n = 21, 14 males, 7 females) we aimed to test the role A trials play in inducing the A-not-B error, thus the hiding procedure was the same as reported in previous studies (Topál, Gergely, et al., 2009; Kis, Topál, et al., 2012) with the only difference that the A trials were omitted. During the three B trials the experimenter addressed the subject (dog's name + "Look!" in a high pitched voice), she approached the toy, picked it up and captured the dog's attention with the toy in her hand (by establishing eye-contact and addressing the dog). Afterward she walked to the adjacent screen (A) and placed the toy behind it, than the toy visibly reemerged in her hand and she showed the toy to the dog while looking at it. Finally she placed the toy behind screen B, returned to the dog showing her empty hands and the subject was allowed to make a choice (Figure 4a).

Testing a second group of dogs, the so called *alleviated B trials* group (Allev-B; n = 21, 8 males, 13 females) we aimed to test the

Table 3
Number of Dogs in the Four Different Conditions Performing Different Numbers of Erroneous Choices (Searching at The Empty Screen) in the Three B Trials

	Number of erroneous choices			
Experimental conditions	0	1	2	3
NonCom (n = 17)	2	5	2	8
$ComA_A$ (n = 16)	4	4	2	6
$ComA_AB_A$ (n = 16)	2	2	4	8
$ComB_A$ (n = 15)	0	1	4	10

Note. NonCom = noncommunicative; Com = communicative; A_A = during A trial and next to the A screen; B_A = during B trial and next to the A screen; B_B = during B trial and next to the B screen.

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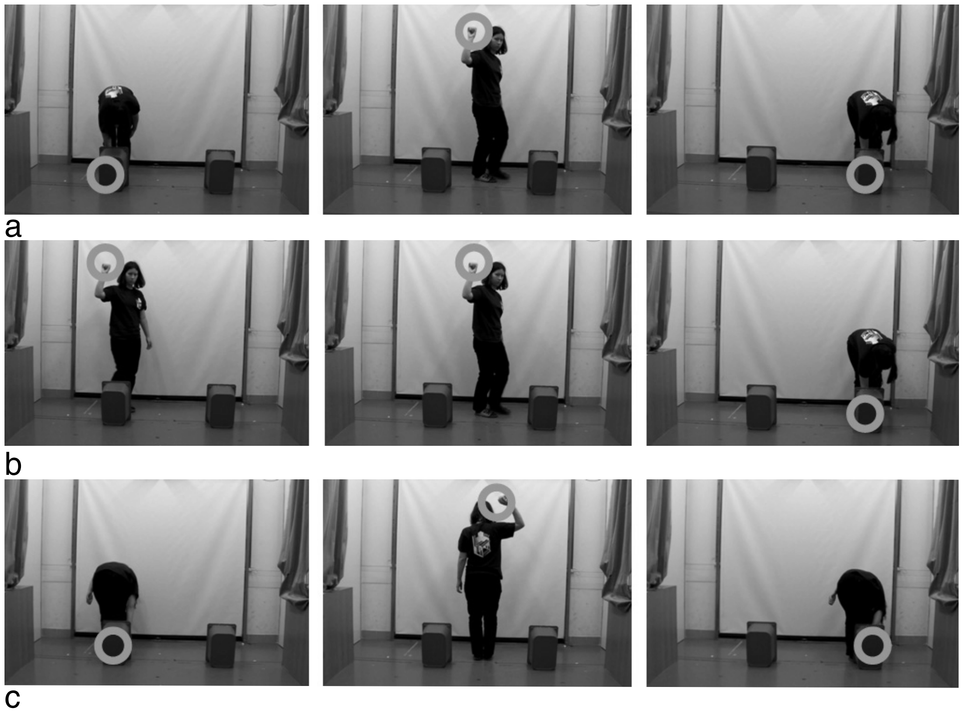

Figure 4. Hiding procedure for the (a) communicative hiding, (b) alleviated B trials; and (c) noncommunicative hiding conditions.

role sham baiting of the A hiding place plays in inducing the A-not-B error. Thus in this condition, dogs witnessed the same hiding procedure as previously described in Com-H (subjects were addressed in a communicative way, by calling their name and making eye-contact), with the only exception that the experimenter did not sham bait the toy behind screen A. She walked up to screen B following the same track as in the Com-H, whereas holding the toy visibly in her hand at the height of her eyes and looking continuously at the dog (Figure 4b).

Finally as a control group we tested a group of dogs in the noncommunicative hiding condition (NonCom-H; n = 21, 7 males, 14 females) following the procedure described in Topál, Gergely, et al. (2009) with the only difference that the A trials were omitted. The experimenter attracted the dog's attention by clapping her hands, she then approached the toy and made a beeping sound with it without facing the dog. Afterward she walked to the adjacent screen (A) with her back turned toward the dogs and placed the toy behind it, than the toy visibly reemerged and made a beeping sound while the experimenter was still turned with her back. Finally she placed the toy behind screen B, returned to the dog showing her empty hands and the subject was allowed to make a choice (Figure 4c).

Data analysis. The dogs' motivation, attention, and choices were measured in the same way as in Study 1. We used Kruskal-Wallis tests to check if dogs were similarly motivated to get the toy object and we used also Kruskall-Wallis test for the analysis of the time spent orienting toward the object hiding events in the different conditions during the first trial. The number of correct choices in all three groups was compared to the 50% chance level using a one-sample Wilcoxon signed-ranks test. Furthermore, planned pairwise comparisons between Com-H and Allev-B, as well as Com-H and NonCom-H conditions were performed (Mann–Whitney tests).

Results and Discussion

Subjects in the three experimental groups showed similar levels of motivation to obtain the target object in the warm up phase—Kruskal-Wallis test, $\chi^2_{(3)} = 1.573$, $p = .455$—and dogs in all three conditions watched the experimenter's activities for similar durations (Com-H, 96.8%; Allev-B, 98.2%; NonCom-H, 98.4%; Kruskal-Wallis test, $\chi^2(2) = 0.329$, $p = .848$).

In the Com-H condition subjects displayed a search bias to the empty (A) location performing well below the success rate expected by random search (25% correct, T = 190, $p = .008$) in the three B trials despite the fact that location A had never been baited. On the contrary when sham baiting at A was omitted (Allev-B condition) subjects performed above chance (70% correct, T = 49, $p = .019$), thus achieving a significantly higher number of correct choices than subjects in Com-H (U = 84, $p < .001$). Moreover in the NonCom-H group (neither sham baiting nor communicative cuing at location A) dogs also performed above chance (68% correct, T = 51, $p = .023$) and achieved a higher number of correct choices than subjects in the Com-H condition (U = 87; $p < .001$) (see Figure 5).

The analysis based only on the first test trials in the different conditions shows quite similar results. Dogs in the Com-H group preferred to choose the empty A location (binomial test, test proportion: 0.5; $p = .027$; only five dogs of the 21 ones chose the baited location), whereas dogs in the Allev-B and NonCom-H

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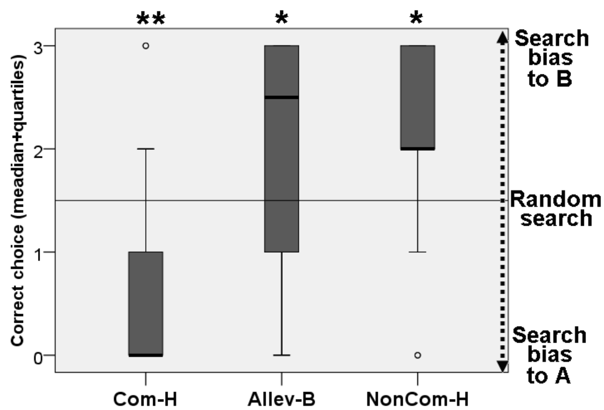

Figure 5. Number of correct choices in the different hiding conditions of Experiment 2; median, quartiles, whiskers, outliers. Comparisons to the 50% chance level (Wilcoxon signed-ranks test) (* $p < .05$; ** $p < .01$).

groups showed a nonsignificant trend toward above chance performance (binomial test, test proportion: 0.5; $p = .078$; 15 dogs from the 21 ones selected the baited location in both conditions).

These results are in line with previous findings (Kis, Topál, et al., 2012) and further confirm the hypothesis that A-trial phase is not an indispensable part of the procedure inducing A-not-B error in adult dogs. In addition, it seems that sham-baiting at location A and the attraction of the dogs' attention by ostensive addressing signals next to the A location can both play a role in eliciting erroneous choices. A summary of the present results and findings from recent studies (see Table 4) indicates that communicative (vs. noncommunicative) cuing and other attention-directing acts (sham baiting) affect dogs' search bias in an interactive manner.

Table 4 clearly shows that sham baiting of the A screen without directing the dog's attention toward that location in an ostensive-communicative manner is insufficient to elicit the A-not-B error in dogs. Moreover both the presence/absence and the timing of ostensive addressing signals are of great importance: Cues including eye contact and verbal addressing compared to noncommunicative salient attention-getters (squeaking the toy) are more effective in inducing the dog to select the empty (A) location especially if the experimenter provides these signals next to the A location during B trials. Importantly, however, the communicative cuing next to the A location during B trials can increase the dogs' tendency to commit A-not-B error if, and only if, it is either complemented with sham baiting of the A screen or the A location was previously repeatedly baited in an ostensive communicative context.

General Discussion

These experiments have revealed three main characteristics of the A-not-B error committed by adult dogs. We found that (a) subjects' performance in this object search task is influenced to a certain extent by their motivation, (b) human communicative and noncommunicative signals have different effects in directing dogs' attention to the A hiding place, and (c) no A trials are needed to induce A-not-B error.

Although the influence of the dogs' motivational characteristics in food-related test situations (inequity aversion: Range et al., 2012; working memory task: Miller & Bender, 2012) has been recently reported, the role of motivation has not yet been investigated in tasks designed to study dogs' search for objects. Experiment 1 provides the first evidence that motivation to obtain the toy object may be one of the key factors for dogs' tendency to commit the A-not-B error. We found that overmotivated individuals' search behavior was basically goal directed and, thus, they showed no tendency to commit search errors even in situations where location A was sham baited and/or the empty location was highlighted by the experimenter's ostensive addressing signals. This suggests that high motivation toward the reward object might overwrite or mask the effect of other cues and therefore it should be taken into account in virtually all cognitive tests.

Our results further support the notion that the communicative and noncommunicative signs have different effects in this task (see also Topál, Gergely, et al., 2009; Kis, Topál, et al., 2012). Thus we cannot exclude the possibility that dogs' erroneous choices in the B trials stems from their disposition to act in line with a human demonstration. This account suggests that the experimenter's ostensive addressing signals during object-hiding events acted as not only making the subject recognize the location of the toy but manifesting a specific behavior.

Obviously, however, several types of cognitive bias can occur because of an attentional bias (Eysenck, Derakshan, Santos, & Calvo, 2007). Thus the dogs' increased tendency to commit A-not-B errors in the communicative conditions could also be explained by a low-level, attentional account. In fact, it has been found (Clearfield, Dineva, Smith, Diedrich, & Thelen, 2009) that the salience of cues associated with hiding the object at location B significantly affect human infants' perseverative search bias. In line with this we may assume that the experimenter's "communicative" activities and sham baitings have simply attracted dogs'

Table 4
Experiment 2: Summary of Results and Comparison of Findings From Different Studies

	Cuing next to A during A-trials	Cuing next to A during B-trials	Sham baiting at A during B-trials	Search bias	Source
Com-H	—	Com	Yes	Toward the empty (A)	Exp. 2
	Com	Com	Yes	Toward the empty (A)	Kis et al. (2012) Animal cognition
NonCom-H	—	NonCom	Yes	Toward the baited (B)	Exp. 2
	NonCom	NonCom	Yes	No search bias	Topál, Gergely, et al. (2009) Science
Allev-B	—	Com	No	Toward the baited (B)	Exp. 2
	Com	Com	No	Toward the empty (A)	Kis et al. (2012) Animal cognition

Note. Com = eye contact and verbal addressing (dogs's name + watch!); NonCom = squeaking the toy while back is turned.

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attention more than the other conditions, facilitating their learning of the rule "this goes here." We should note, however, that the analysis of the dogs' amount of attention toward the object-hiding events in the different conditions does not seem to fully support this attentional account. By using a colorful toy object that emits salient sound cues while being hidden, our study was carefully designed to ensure that dogs pay as much attention to the object-hiding event in the noncommunicative conditions as they did in the communicative ones. As an alternative explanation, we can also presume a merely distracting effect of social cues: More errors could be attributed to the higher attentional demands required to follow the trajectory of the toy in the B trials (cf. Fiset, 2010).

Nevertheless, our results are in agreement with recent studies that proposed that dogs in object search tasks (Bräuer, Kaminski, Riedel, Call, & Tomasello, 2006; Erdõhegyi et al., 2007; Kupán et al., 2011) and in food search (Prato-Previde et al., 2008) tasks often rely on human communicative gestures. An interesting aspect of our findings is that the selection of the empty (A) location can be elicited without any previous A trials and the ostensive addressing signals presented next to the A location during B trials plays a key role in committing search errors. This seemingly contradicts with the results of Osthaus, Marlow, and Ducat (2010) showing that the number of A trials plays a crucial role in inducing the A-not-B error. But this can be explained by the fact that they used a different method (dogs had to make a detour through a gap at one end of a straight barrier to reach a target) with a noncommunicative hiding procedure.

The influential effect of the human communication on the dogs' behavior and several other functional similarities between infants and dogs (like committing the A-not-B error in communicative condition) are widely assumed to be affected by the domestication process (Hare, Brown, Williamson, & Tomasello, 2002; Hare & Tomasello, 2005; Miklósi, Topál, & Csányi, 2004; (Topál, Miklósi, et al., 2009). This hypothesis, among others, is supported by the fact that intensively socialized wolves do not commit the A-not-B error, not even when the experimenter presents ostensive-communicative signals during the hiding event (Topál, Gergely, et al., 2009). We should also note, that in this comparative study both wolves and dogs were tested with food reward, and the motivation for food may be different between the two species and this can also account for the species differences in search response.

Based on the fact that the overmotivated dogs perform better than the others (see Exp 1), and that wolves tend to show reward oriented behavior instead of looking at humans (Miklósi et al., 2003), we may assume that wolves in the A-not-B error task were simply much more motivated to get the reward and that is why they committed less errors. In any case, our results suggest that subjects' motivational level in object search tasks including the A-not-B error task must be carefully controlled.

In summary, the present study provides evidence that contrary to previous assumptions in the case of adult pet dogs no A trial is needed to induce the A-not-B error. The finding that search performance is affected by subjects' motivational level as well as by the ostensive communicative signals presented at location A during the B trials suggest that the phenomenon, at least partially, reflects a "ready-to-obey" attitude in the dog rather than insufficient attention and/or working memory.

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