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Importance of Social Behaviour in Eliciting A-not-B error in Domestic Dogs (Canis lupus familiaris) with "Unidentified Moving Object" (UMO) as Partner

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Abstract

Domestic dogs (*Canis lupus familiaris*) are highly sociable animals that are observed to be experts at interacting, understanding and cooperating with humans (*Homo sapiens*). Social behaviour is difficult to study due to the lack of full control over interactions, but is important for understanding and interacting effectively with dogs. Robots have recently been introduced into canine research as a tool to investigate dog social behaviour. *Unidentified Moving Object* (UMO) is a term to explain a robotic agent unfamiliar to the dog. Previous research done with UMO's mostly focuses on dogs' responses to the appearance of a UMO. To investigate the importance of the UMO's social behaviour in interaction with dogs, the traditional Piagetian A-not-B error test was used to compare three treatment groups each comprising 16 dogs: a Human partner group, a Social UMO partner group and a Non-Social UMO partner group. The two UMO groups had the same UMO but the behaviour of the UMO was different. The Social UMO interacted with the dog in a problem-solving task that the dog was not capable of solving but the UMO was, leading to the UMO giving the reward to the dog. The Non-Social UMO had a treatment phase where it drove in a mechanical manner continuously around in a circle, not responding to any of the dog's actions. The Human group served as a positive control group. Dogs in the Non-Social treatment group performed well above chance level in the crucial trials, not performing the A-not-B error, indicating that they did not consider the behaviour of the UMO to be of importance in solving the problem. Dogs in the Social-UMO treatment group on the other hand had a similar pattern to dogs in the Human group in the crucial trials, just not of the same levels of magnitude. These results suggest that the social behaviour of the UMO in the test prompted the dogs to perform the A-not-B error, implying that they considered the information gained during interaction with the UMO to be of importance. This experiment showed that the type of interaction the dog had with the UMO immediately prior to the test (in the Social or Non-Social treatment phase) was an important factor in whether or not the UMO would elicit the A-not-B error. The results indicate that dogs may not be just good at interacting with humans ("man's best friend"), but might in fact be very plastic for interaction with mutually inclined partners or agents, and that in these interactions social behaviour is an important factor.

SAMMENDRAG

Hunden (*Canis lupus familiaris*) er en sosial art med ekspertise på samspill og samarbeid med mennesker (*Homo sapiens*). Sosial atferd er et vanskelig felt å studere grunnet blant annet mangelen på kontroll over de medvirkende partene. Likeledes er det et viktig felt for å forstå og samarbeide effektivt med andre arter som hunder. Roboter har de siste årene kommet inn i forskningsarenaen på hund som et verktøy for å forske på hundens sosiale atferd. *Unidentified Moving Object* (UMO) er en terminologi som beskriver en robot agent som er ukjent for hunden. Tidligere forsøk gjort med UMO har hovedsakelig vært fokusert mot hundens responser til UMO'en sitt utsende. For å undersøke relevansen av UMO'en sin sosiale atferd i interaksjoner med hund, ble den tradisjonelle A-ikke-B feil testen til Piaget brukt for å sammenligne tre behandlingsgrupper, hver bestående av 16 hunder: en Menneske partner gruppe, en Sosial UMO partner gruppe og en Asosial UMO partner gruppe. De to UMO gruppene bestod av den samme UMO'en men den utviste forskjellige atferd i de to behandlingsgruppene. I den sosiale konteksten så løste UMO'en en problemløsings oppgave sammen med hunden som hunden ikke kan klare på egenhånd, som ledet til at UMO brakte belønning til hunden. Den Asosiale UMO'en hadde en behandlingsfase hvor den kjørte mekanisk rundt i en konstant sirkel uten å respondere på eller interagere med hunden. Menneske partner gruppen fungerte som en kontrollgruppe. Hundene i den Asosiale behandlingsgruppen, utførte A-ikke-B feil testen vel over sjanse nivå i den kritiske delen av testen, altså utførte ikke A-ikke-B feilen, hvilket indikerer at hunden ikke anser informasjonen som UMO'en gir i testen til å være betydningsfull. Hunder i den Sosiale UMO partner behandlingsgruppen derimot utviste et lignende mønster i den kritiske fasen av testen som den Menneske partner gruppen hadde, bare ikke ved samme nivåer. Disse resultatene indikerer at den sosiale atferden til en UMO i denne testen, fremmet forekomsten av A-ikke-B feil, hvilket antyder at hundene i den Sosiale gruppen anså informasjonen fra UMO'en til å ha noe relevans i denne situasjonen. Dette forsøket viste at type interaksjon (både i den Asosial og den Sosiale behandlingsgruppen) som hunden opplever med en UMO direkte før en A-ikke-B feil test , var en avgjørende faktor om UMO'en ville kunne fremkalle A-ikke-B feilen under den kritiske fasen av testen. Resultatene indikerer at hunder kanskje ikke bare er gode på interaksjoner med mennesker ("menneskets beste venn"), men muligens er generelt godt tilpasningsdyktig for interaksjoner og samarbeid med flere potensielle partnere og at i disse interaksjonene så er sosial atferd en avgjørende faktor.

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1 INTRODUCTION

1.1 SOCIAL BEHAVIOUR AND INTERACTION

Social behaviour is any behaviour caused by or affecting another individual. This is usually of the same species (intraspecific), but can also be with other species (interspecific) (MeSH, 1969). Social behaviour is the precursor of interaction, cohabitation and coexistence in social species. It allows for communication and consequently interaction and the possibility for cooperation. Humans (*Homo sapiens*) and domestic dogs (*Canis lupus familiaris*) are social species with a broad spectrum of social behaviour.

We already know that dogs have through domestication developed a skill set for communicating with humans. Research results indicate that dogs may not be just good at interacting with humans ("man's best friend"), but might in fact be very plastic for interaction with mutually inclined partners or agents. They are sensitive to human directions such as pointing and gazing (Miklósi et al., 1998), change their preferences based on human explicit preferences (Prato-Previde et al., 2008) and look to humans for help in tasks involving unobtainable resources (Miklósi et al., 2000).

1.2 THE A-NOT-B ERROR

1.2.1 PIAGET'S STAGES OF OBJECT PERMANENCE

The A-not-B error task is an interaction where dog choices are affected by human presence and interaction. The A-not-B error, first described in human children, is one of the most replicated findings in the developmental psychology field. It is a phenomenon discovered by Jean Piaget, a Swiss psychologist, biologist and philosopher born in 1896 (Vidal, 1994).

The phenomenon is an error made in a substage of the sensorimotor stage in Piaget's theory of cognitive development in children, more exactly stage 4, hence this is also referred to as "stage 4 error" or "perseverative error" (Piaget, 1969) (Table1; Table2). In the classical experiments for children's conceptual understanding of object permanence and the development of this skill, Piaget used a progressive series of tasks aimed at determining the child's capacity to understand object permanence. The experimenter sitting opposite the infant has two identical, available and visible hiding spots that the infant can reach. These two hiding spots are referred to as A (first hiding spot) and B (second hiding spot). The experimenter visibly hides a desirable object under spot A, and the infant is then given the opportunity to search for and retrieve the object. This is repeated a set number of times, before the critical repetition is executed. In the critical repetition, the experimenter hides (still visibly) the object under spot B, before again allowing the infant to search for and retrieve the object. The A-not-B error is when the child persistently searches in the wrong place (A), despite observing where the object was hidden (B) (Piaget, 1954). This perseverative error is found to be common in infants from approximately 8 – 10 months of age, whereas corresponding children 12 months of age and older seem not to be prone to the same error. Piaget's original explanation was that the error is the result of not fully developed object permanence comprehension, such that the child thought the object's appearance at the initial hiding spot was due to the act of searching for it. In other terms, searching under A would causally lead to the object being under A, independent of where it was hidden (Piaget, 1954).

TABLE 1 – PIAGET'S STAGES OF DEVELOPMENT, DERIVED FROM PIAGET (1954 & 1969)
THESE ARE FOUR STAGES OF PIAGET'S COGNITION DEVELOPMENT. SUBSTAGE IV (WHERE THE A-NOT-B ERROR OCCURS) IS DURING THE FIRST PERIOD – SENSORIMOTOR.

Age range	**Periods**	**Description**
0 – 2 years	1. Sensorimotor	Development of object permanence. Understands, learns and experiences through trial and error via senses (taste, vision, smell, hearing and touch) and action (motor responses). Rapid cognitive growth. Developing the relationship between sensation and motor responses.
2 – 6 years	2. Preoperational	Egocentrism Views world through speech and imagination. Semiotic function; mental representation of objects and events (symbolic thinking). Strong imagination and animism (believe that inanimate objects have feelings. Lacking logic reasoning.
7 – 11 years	3. Concrete (pre-) operational	Conservation Beginning of logical thought and rules, understands through categories and logical deduction. Logic only applies to concrete physical objects.
12 - onwards	4. Formal operations	Abstract reasoning Strategy and planning, as well as theoretical, hypothetical and scientific thinking develops. Concepts become context transferable.

TABLE 2 - PIAGET'S SUBSTAGES OF THE SENSORIMOTOR PERIOD (PIAGET 1954 & 1969)
SUBSTAGE IV IS WHERE THE A-NOT-B ERROR IS PERFORMED, WHEN THE CHILD HAS DEVELOPED THE SKILL TO LOOK FOR SOMETHING THAT IS HIDDEN (START OF OBJECT PERMANENCE).

Age range	Substage	Description
0 – 1 month	**I.** Reflexes	New-born reflexes
1 – 4 months	**II.** Primary circular reactions	Sensation affects the reflexes and causes changed behaviours. Limited anticipation.
4 – 8 months	**III.** Secondary circular reactions	Purposely uses behaviour for its effects, e.g. imitation
8 – 12months	**IV.** Coordination of reactions	Intentions emerge, imitation expands and object permanence develops (searches for hidden objects). Makes perseverative error in the A-not-B task from about 8-10months.
12–18months	**V.** Tertiary circular reactions	Exploration of object properties, trial and error. Performs successful A-not-B task (i.e. not performing perseverative error).
18 – 24 months	**VI.** Mental representation	Mental operations become part of the child's understanding. Development of semiotic function.

1.2.2 ALTERNATE EXPLANATIONS FOR THE A-NOT-B ERROR

During decades of research on the A-not-B error test, multiple explanations have been proposed to explain the error. One of the more recent suggested explanations is a lack of ability to inhibit previously rewarded motor-responses in the child (immature prefrontal cortex). The claim is that the child remembers where the object is hidden and will search correctly if allowed to search instantaneously. When there is a delay between the hiding and the search the habitual response evidently is stronger than the memory of the hiding, triggering the erroneous search (Diamond, 1985). Bjork & Cummings (1984), claim the error can be explained by not yet fully developed working memory, specifically short-term memory in the child's development. Acredolo (1979) focused on the child's development of special orientation and the effects of novel (e.g. a laboratory) compared to familiar test locations (e.g. the child's home). Accountability has also been accredited to developing of latent and active memory traces (Munakata, 1998). Ruffman & Langman (2002) explain it as underdeveloped executive functioning in the prefrontal cortex leading to lack of ability to switch attention from A to B (perservation in attention, not search behaviour). The mirror neuron explanation is that a neurophysiological mechanism (mimicry), affects both understanding of action and imitation, and has been suggested as an explanation for the A-not-B error (Longo & Bertenthal, 2006). There is accredited work and findings in these researches, but none of them can fully explain the complex aspects of the A-not-B error (Smith & Thelen, 2003). Interestingly in the numerous replications done on this test, despite many inconsistencies in methods and protocols, the results still seem to be quite consistent.

1.2.3 Ostensive referential communication in humans, towards infants and dogs

Definition of social behaviour by Aldrich & Zimmer (1986): *"Social behaviour is defined as the way in which action is constrained or facilitated because of its social context".* Communication is a set of signals between a minimum of two parties, whereby the sender affects the receiver's behaviour. Csibra and Gergely (2009) propose a communication system in humans that they call *Natural Pedagogy*. This system proclaims that humans are adapted to effectively acquire generalizable information through social learning in context of referential value. Additionally infants are especially inclined to be receptive to this natural pedagogy, through *ostensive referential* cues. Csibra & Gergely explain ostensive referential communication as consisting of cues that indicate one is being addressed by communication of generalizable value.

Most of these explanations of the A-not-B error focus on the repetitiveness of the A hiding. In contrast to this Topál et al. (2008) found that ostensive referential cues could be the common denominator in these A-not-B error tests, thereby being an important part of the explanation of the phenomenon. They approached the A-not-B error task, with a different angle on the interpretation of the test; trying to find if there was a way the infants would reliably pass the test. Infant-directed-speech (ostensive/referential cues, what one may call "baby-talk" in everyday speech) was the focus of the research where they compared three treatments: one where they did the classical treatment with the ostensive referential communication (SocCom), one with a non-communicative neutral body language (NonCom) and the third one with no visible experimenter, who was hidden behind a curtain (NonSoc). In the ostensive referential condition the experimenter used eye contact, addressed the baby by name, spoke in a tone of infant-directed speech and performed gaze alterations between the hiding spot and the baby. In the second, non-communicative, condition, the cues used in the ostensive-referential condition were omitted. All movements were visible but without any social interactions, such as eye contact, speech, body posture and body gestures. The third condition had the same procedure, but with everything being conducted from behind a sheet so only the object being hidden and the hiding spots were visible as shown in Figure 1.

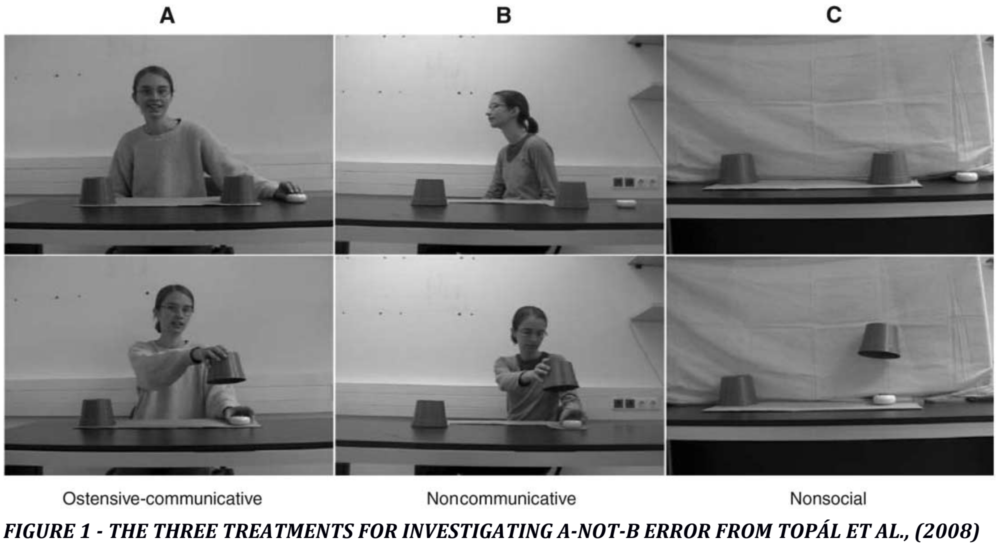

FIGURE 1 - THE THREE TREATMENTS FOR INVESTIGATING A-NOT-B ERROR FROM TOPÁL ET AL., (2008)
A: THE OSTENSIVE-COMMUNICATIVE HIDING; THE EXPERIMENTER USES GAZE ALTERATIONS, "BABY-TALK" AND POSTURE
B: THE NONCOMMUNICATIVE HIDING; THE EXPERIMENTER DOES NOT SHOW ANY OSTENSIVE REFERENTIAL SIGNALLING
C: NONSOCIAL HIDING; WHERE THE HIDING IS DONE WITH INVISIBLE STRING TO PULL UP, AND POLES TO PUSH UNDER CURTAIN. TREATMENT A PRODUCED THE MOST A-NOT-B ERRORS.

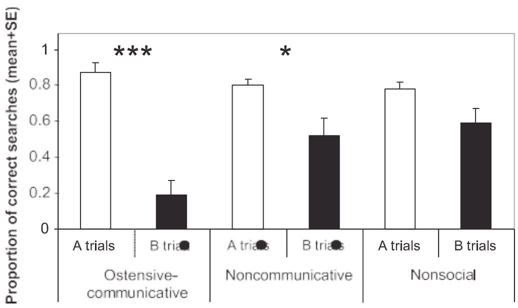

FIGURE 2 – PROPORTION OF CORRECT CHOICES (TOPÁL ET AL., 2008)
RESULTS SHOWING DIFFERENCES IN THE THREE TREATMENT GROUPS SHOWN IN FIGURE 1.

The results (Figure 2) showed that infants in the ostensive-communicative group were the ones performing the most errors (Ostensive-communicative versus Noncommunicative, P < 0.05; Ostensive Communicative versus Nonsocial, P < 0.01). Of the infants in the ostensive communicative group, 86% performed the error during the B-hiding, while fewer in the Noncommunicative (43%) and the Nonsocial (36%) groups performed with errors on the B hidings (Topál et al., 2008). So infant-directed-speech during the test can prompt the perseverative error. Correspondingly removing this contextual information leads to the errors being reduced significantly. These results are not consistent with earlier commonly accepted explanations for the error and therefore Csibra & Gergely (2009) and Topál et al. (2008) have proposed that, instead of being episodic information like "this object is hidden under A or under B", the infants, in fact, comprehend the hiding behaviour as a generalizable learning context in the form of "objects like this can be found under A". If this proposal is correct, then the perseverative error is not an error but a fundamental adaptation of the cognitive system to gain rapid learning of generalizable information (Topál et al., 2008).

Csibra & Gergely (2009) proposed that the context of the ostensive communication set the child in a receptive state for generalizable learning, meaning that the child becomes more receptive for a type of information that can be generalized to other settings, e.g. "Child points to light and parent points to light, while saying the word light." The parent probably speaks in an infant-directed-speech manner with gaze alterations from the baby to the light, while encouraging the child. The interaction conveys to the child that objects like this are called light, and this information is later generalized to other lights. Csibra & Gergely (2009) suggest that it is triggered by means of an innate bias to generalizing information conveyed in an ostensive communicative manner.

1.2.4 Previous A-not-B error - Research done with Domestic Dogs

Expanding on their previous (2008) research, Topál et al. (2009) have indicated similar for the ostensive referential communication in dogs using three treatment groups; a Social Communicative (SocCom), a Non Communicative (NonCom) and a Non Social group (NonSoc). The SocCom consisted of ostensive referential signalling (vocal communication, referring to dog by name and gaze alterations from dog to hiding place). The NonCom had no ostensive referential cues; the experimenter simply conducted the test without eye contact or vocally addressing the dog. The NonSoc group had no experimenter present. They used an "invisible" (clear see-through) string attached to the ball they were hiding, so the experimenter who was outside the room could pull it, thereby omitting the ostensive referential cues completely from the equation. They found significant differences between the groups in the B trials (P< 0.001). SocCom searched the least often at the correct (B) screen (P < 0.05) compared to NonCom, and then the NonSoc (P < 0.001). Additionally their NonSoc group showed the effects of removing the experimenter. Because no social cues were present, the errors ceased to occur. The NonSoc performed significantly over chance level in the B trials (P = 0.003). This showed that when no cues are present the ”error” disappears, strengthening the theory of ostensive referential cues importance in eliciting the A-not-B error.

Prior research performed by Sümegi et al. (2014) replicated Piagetian A-not-B error task (referred to as invisible displacement tasks in that research) with dogs. They systematically examined potential explanations, manipulations and variations to the A-not-B error task. The three major findings were firstly the importance of the dogs' motivation to fetch the hidden object, as under-motivated dogs did not perform the task while over-motivated dogs seemed to ignore all ostensive cueing and mostly chose the right spot.

Secondly, human signals when given in a communicative or a non-communicative manner influence the occurrence of the error (Sümegi et al. 2014). The communicative manner induced more errors (25% correct in the B trials) than the non-communicative (68% correct) and produced a higher number of correct choices (p = 0.001).

The third element pointed out in this research was the crucial role of what Sümegi et al. (2014) refer to as *Sham-baiting*, in inducing the error. *Sham-baiting* is where during the B-trials the experimenter performs the ostensive referential communication at hiding spot A, before moving to hiding spot B, and repeating the cueing while hiding the object. Sümegi et al. (2014) explain this sham-baiting as eliciting a form of obedience, where the dog searches at the first place cued. Being so cued in on human communication and willingness to cooperate with us, it seems the dogs override the role of determining where the object is and instead trust that the information the experimenter is cueing must be of importance and correspondingly base their choices on that.

This sham-baiting effect is similar to effects found in previous research, amongst others the classical *pointing test* in a two-choice food test. The dog is presented with two bowls (one containing food) and then the human experimenter points to the baited (containing food) bowl before the dog is released and given the option of choosing between the two bowls. The test has been performed in many different manners, including showing the dog which bowl the food is hidden in (Szetei et al., 2013), not showing (Szetei et al., 2013), pointing with different body-parts (Miklósi et al., 1998; Lakatos et al., 2008), comparison of wolves and dogs (Virányi et al., 2008) and comparison between cats and dogs (Miklósi et al., 2005). In the research performed by Szetei et al. (2003), they found that when there was no pointing, the dogs chose the bowl with the food. However, the dogs chose the empty food bowl when pointed at by the experimenter, even though they saw the food being hidden in the other bowl.

1.2.5 Studying interactions

Social behaviour is difficult to study due to the lack of full control over the interaction. This is true even when studying human-animal interactions. We tend to think it is easier when one of the partners of the interaction is human, since we assume we can control our own or other humans' behaviour more easily than that of animals. However, there are many components of human behaviour that can potentially affect a dyadic interaction, including those below conscious awareness that may act as a source of bias in behavioural studies (Krause et al., 2011). Therefore, the use of robots has become popular as a tool for teasing out the effects of different components of social interactions (Matarić, 1998).

1.3 Unidentified Moving Object (UMO) in Canine Research

Robots have recently been introduced into canine research as a tool to investigate dog social behaviour. The method of using an unidentified moving object (UMO) increases controllability and reproducibility of experimental techniques, as well as allowing for the separation between appearance and behaviour. To use this tool correctly we must know its limitations and strengths (Gergely et al., 2013). In an early study on robots and dog interaction, Kubinyi et al. (2004) compared four agents varying in degree of 'sociability'; one remote controlled car, one doglike robot (AIBO brand from SONY), one AIBO with a fake fur that had puppy-smell on it and one live puppy of Vizsla breed. They found that the dogs' age, the context of the experimental setup and the agents' physical features all affected the dogs' behaviour towards the agents. The dogs seemed to show little social behaviour towards the AIBO despite resembling a dog in embodiment. The three robots in that study did not show any responsiveness to the dogs' behaviour, which might be an important part of eliciting dogs' social behaviour to an unknown agent.

The effect of interaction with the dog was investigated by Gergely et al. (2013), who had dogs performing a problem-solving task with one of three different partners; a Social UMO, a Mechanical UMO and a Mechanical Human. The task consisted of one of the agents hiding a visible but unobtainable food source for the dogs. The box used for hiding the food had an entrance so the agent could hide and get a hold of the food, and after each repetition give it to the dog. The two mechanical partners were only differentiated by their visual appearance; they acted in a similar nonresponsive manner to the dog. The Social UMO on the other hand was responsive and interactive with the dogs. The combination of their varied embodiment and interaction led to dogs spending increased time looking at the two mechanical agents during the repetitions in the test. They spent more time looking at the Mechanical UMO than to the Mechanical Human. Additionally they had an overall increase over repetitions, in gaze alternations between unobtainable food and both the mechanical agents. Comparing the Mechanical and Social UMO, the dogs showed more and longer gaze alterations between the unobtainable resource and the Social UMO, than to the Mechanical UMO. The results from these tests were the first to suggest that: "the interactive behaviour of a robot is important for evoking dogs' social responsiveness" (Gergely et al., 2013).

1.3.1 SWARMIX

The research within UMO agents in interaction with dogs is still a young topic. Sound preliminary research has been done, but to effectively introduce the use of UMO in real interactions with dogs more research is needed. Especially on what behaviours are crucial for the dogs to seek the interaction. One of the planned areas of this use was the SWARMIX project (http://www.swarmix.org) that was funded by the Swiss National Science Foundation, Sinergia Programme in cooperation with the *Department of Ethology, Eötvös Loránd University, Budapest, Hungary*, and ran from 2011-2014. Swarmix stands for *Synergistic Interactions in Swarms of Heterogeneous Agents*. It is a heterogeneous multi-agent system that consists of humans, animals and robots, working in cooperation to solve tasks e.g. Search and Rescue (SAR) operations. These systems are referred to as mixed swarms.

In the SAR scenarios drones are used to search areas and interact with SAR dogs. The dogs are attached to harnesses that can communicate with the Swarmix network including the drone. If the dog is to follow the drone (i.e. respond to its "commands"), the dog will necessarily have to consider the information conveyed by the drone as of importance.

UMO's are relevant land driving artificial agents that can be researched in the place of a drone. The previous research done with UMO mostly focuses on appearances of the UMO. With the statement Gergely et al. (2013) proposed about the importance of interactive behaviour in the robot, the importance of further research within the robots perceived behaviour becomes eminent. By knowing what the dog finds crucial in interaction with the UMO's behaviour, this can be implemented in the drones and other UMO agents behaviour coding. It might also generate a better understanding of dogs' communication and interaction across species.

1.4 CURRENT STUDY

1.4.1 A COMPARATIVE A-NOT-B TEST IN DOMESTIC DOGS, OF UMO AND HUMAN AGENT

The quality and quantity of interaction and the degree of sociality in the interaction are important parameters to know when creating a dog UMO dyad. This experiment looks further into what role social responsiveness and reaction might play in the role of the UMO, for the dog to consider its actions as containing important information; the way dogs consider human actions.

With the current study I focused on the quality and quantity of social interaction needed for the dogs to recognise aspects of an artificial agents' (UMO) behaviour in a guiding context. The previous A-not-B research done with dogs made it a good template for this research. I could compare the results with that of Social and Non Social contexts with humans, and with contexts without any agent present. The goal was to assess the role of social interaction with the UMO in producing A-not-B error, with three treatments varying in level of interactivity with the dog. The three groups were The Human group that was the control group, where a human experimenter conducted the A-not-B error test in a traditionally ostensive referential communicative manner. The two next groups had a UMO conducting the test. The Social UMO (Soc.) treatment had a socially interactive session with the UMO prior to the actual test, while the Non Social UMO (NonSoc.) treatment had a non-interactive session with the UMO prior to the test. Through the use of A-not-B-error tests, we sought to assess the importance of interactivity of social agents in interaction with dogs.

The hypothesis and predictions explored in this thesis were as follows:
Hypothesis: An agent's sociality plays a major role in producing errors by dogs in the A-not-B test. *Prediction 1:* Dogs perform more A-not-B errors when offered a social interaction, when compared to a non-social UMO interaction prior to the testing. *Prediction 2:* Dogs exposed to a UMO that shows no social responses to the dog's behaviour perform similarly to dogs in previous studies (Topál et al., 2009) that were exposed to an invisible partner (object was pulled by a string), in which significantly more successful than chance during the B trials (P = 0.003). *Prediction 3:* Based on earlier research (Topál et al., 2008; Ostensive communicative group had 81% error in the B trials), I predict approximately 80% of dogs in the human group to perform at least one A-not-B error, but somewhat different percentages (± 10%) could be found than in previous experiments because of adaptations to the test design that were needed to accommodate the use of UMO's in this study.

2 MATERIALS AND METHODS

2.1 SUBJECTS

In this study, there were 62 adult (>1 year) domestic dogs in total; all breeds and sizes were recruited through the database for volunteers to the Family Dog Project at Eötvös University in Budapest, Hungary.

Because the A-not-B test would involve finding a hidden tennis ball, all the test dogs were required to have an interest in tennis balls. Under-motivated test subjects would not be reliable test participants. However, based on the findings of Sümegi et al. (2014), highly ball-motivated dogs are less likely to consider human ostensive-communicative cues as relevant. We therefore performed a pre-test to judge and exclude both over and under-motivated test-subjects, using the scoring system of Sümegi et al. (2013; Table 3). In total, 14 dogs had to be excluded due to motivation, 7 under-motivated and 7 over-motivated. The remaining 48 dogs were 32 purebred dogs from 20 different breeds, and 16 dogs of mixed breed (Table 4). They ranged from 1 -11 years of age, with a mean age of 5.5 years (S.E. ± 2.5 years).

The owners filled out a form with basic information on the dog, including whether the dog had previous experience with A-not-B error tasks (only dogs without A-not-B experience were included in the experiment) and with the UMO (previous social experience test performed at the Ethology dept. at ELTE was coded as experience, while dogs with previous non social experience were excluded to avoid unclear results. Prior experience was also checked against a database containing records on previous experiments.

TABLE 3 - ETHOGRAM PRETEST FOR MOTIVATION

SÜMEGI ET AL. (2014) SHOWED THAT THE DOGS MOTIVATION FOR RETRIEVING THE OBJECT HAD AN EFFECT ON THE RESULTS. OVER-MOTIVATION DECREASES THE VALUE OF THE OSTENSIVE REFERENTIAL CUES, WHILE UNDER-MOTIVATION LEADS TO THE DOG NOT PERFORMING THE TEST. THEREFORE DOGS WITH SCORE 0 AND 4 WERE REMOVED FROM THE EXPERIMENT.

Score	Description
0	Not motivated. No interest in the ball or in searching for it
1	Low motivation. Might take the ball in its mouth, but then drops it again, does go and look for the ball when it is hidden, but might not pick it up
2	Motivated. Waits calmly while ball is being hidden, approaches the screen immediately and retrieves the object
3	Highly motivated. The dog tries to release itself, but accepts being held back. Dog runs for the ball every time, but might not be very willing to release the ball
4	Over motivated. The dog repeatedly lunges for the ball, when experimenter or owner is holding it. Tries to break loose to get the ball. Avoids releasing the ball

TABLE 4 - NUMBER AND NAME OF BREEDS REPRESENTED IN THE EXPERIMENT
32 PUREBRED DOGS (FROM 20 DIFFERENT BREEDS) AND 16 MIXED BREED DOGS. BREED NAMES FROM FCI (FÉDÉRATION CYNOLOGIQUE INTERNATIONALE) INTERNATIONAL BREED REGISTER.

Breed names	n
Australian Sheepdog	2
Bichon Frisé	1
Border Collie	1
Boucheron	1
Boxer	2
Bullmastiff	1
Cavalier King Charles Spaniel	1
Croatian Sheepdog	1
Doberman	1
Foxterrier	2
German Shepherd	3
Golden Retriever	1
Howavart	3
Mixed	16
Mudi	2
Pumi	1
Shetland Sheepdog	2
Staffordshire Bullterrier	1
Tervueren	1
Nova Scotia Duck Tolling Retriever	1
Vizsla	4
Total	**48**

2.1.1 Ethic Statement

This experiment was conducted in Budapest, Hungary and therefore does not fall in under any Norwegian requirements. The experiment is non-invasive and thereby not considered an animal experiment by the Hungarian law "1998. évi XXVIII. Törvény" - the Animal Protection Act – that defines experiments on animals in the 9th point of its 3rd paragraph (3. 1/9.). Hence it is exempted from any need for permission from the University Institutional Animal Care and Use Committee (UIACUC, Eötvös Loránd University, Hungary). All owners volunteered to participate.

2.2 Treatments

Dogs were assigned to three different treatment groups. Group 1 was the Human treatment, Group 2 was the Social (Soc.) UMO treatment, and Group 3 was the Non-social (NonSoc.) UMO treatment. In the Human (control) treatment, a human social partner gave ostensive social cues and hid the tennis ball for the dog. In the Social UMO treatment, the UMO was the social partner. It was a remote-controlled car (Ford Mustang Boss #302, measurements: 37x19x12cm) adapted so that it could carry and hide a tennis ball (Figure 4). The UMO had a device fitted under its cover that produced a beep sound when a remote control was activated. This was used to mimic the human's ostensive communicative cues during communication with the dog, i.e. was an attraction caller. In the Non-social UMO treatment, the same UMO was used for carrying and hiding the ball but no social interaction was performed during the treatment phase (Table 5).

The dogs were pseudo-randomly assigned to the three treatment groups, with sex counterbalanced across treatment. The UMO treatment groups had an even distribution of UMO Experienced (Exp.) and UMO novice (NonExp.) dogs in each treatment. UMO experienced were dogs that previously had attended one of the Social UMO test performed at *Department of Ethology, Eötvös Loránd University, Budapest, Hungary*. UMO Non Experienced were dogs that had no previous experience with a UMO.

TABLE 5 - GROUPS, TREATMENTS, PHASES & TRIALS
THERE WERE THREE TREATMENT GROUPS IN THE EXPERIMENT, WITH THREE PHASES IN EACH TREATMENT GROUP.
GROUP 1 – HUMAN TREATMENT. A HUMAN AGENT PERFORMS THE HIDING IN PHASE 3 (A-NOT-B ERROR TASK) AND INTERACTS SOCIALLY WITH THE DOG IN THE TREATMENT PHASE (PHASE 2).
GROUP 2 – UMO SOCIAL TREATMENT. A UMO (UNIDENTIFIED MOVING OBJECT) AGENT PERFORMS THE HIDING IN THE A-NOT-B ERROR TASK, AND HAS A SOCIAL INTERACTIVE SESSION SOLVING A TASK WITH THE DOG IN THE TREATMENT PHASE (PHASE2).
GROUP 3 – UMO NON SOCIAL TREATMENT. SAME UMO PERFORMS THE HIDING IN PHASE 3, BUT HAS A NON SOCIALLY INTERACTIVE SESSION IN THE TREATMENT PHASE, I.E. IGNORING AND BEING NON RESPONSIVE TOWARDS THE DOGS BEHAVIOUR.
PHASES:
*PHASE1 WAS THE PRETEST FOR BALL-MOTIVATION (AS DESCRIBED IN **TABLE 3**).*
PHASE2 WAS THE TREATMENT PHASE WHERE THEY RECEIVED INTERACTION: SOCIAL OR NON SOCIAL WITH THE PARTNER FOR THE TEST.
PHASE3 WAS THE ACTUAL EXPERIMENT. THERE WERE TWO – 2 REPETITIONS IN EACH PHASE1 AND FIVE - 5 TRIALS IN EACH PHASE3. THE SEQUENCE OF THE REPETITIONS IN PHASE3 WAS PERFORMED AS A,A,B,B,A. THE BALL WAS HIDDEN TWICE BEHIND OCCLUDER A, AND THEN TWICE BEHIND OCCLUDER B AND THEN ONCE BEHIND OCCLUDER A AGAIN. THE TRIALS WERE NAMED A1, A2, B1, B2, A3.

Group no.	Treatment	Phase	N dogs	Trials, rep., min.	Signal
1	Human	1. Pretest	16	2min. (2 rep.)	”Dogs name + look”
		2. Treatment 1		2min.	-
		3. Trials		5trials: 1A, 2A, 1B, 2B, 3A	”Dogs name + look”
2	UMO Social (Soc.)	1. Pretest	16	2min. (2 rep.)	”Dogs name + look”
		2. Treatment 2		6 rep.	2 beeps
		3. Trials		5trials: 1A, 2A, 1B, 2B, 3A	2 beeps
3	UMO Non Social (NonSoc.)	1. Pretest	16	2min. (2 rep.)	”Dogs name + look”
		2. Treatment 3		2min.	-
		3. Trials		5trials: 1A, 2A, 1B, 2B, 3A	2 beeps

2.3 EXPERIMENTERS

Experimenter1 (E1) was Anna Bjurgård Compton, whilst Experimenter2 (E2) was Anna Gergely PhD student from *Department of Ethology, Eötvös Loránd University, Budapest, Hungary*.

2.4 Apparatus

The experiment was conducted in a laboratory (5m x 2.5m) at the *Department of Ethology, Eötvös Loránd University, Budapest, Hungary.* The room was fitted with four video cameras mounted one on each wall, and a computer setup with a recording program outside the room. Tape was used to mark locations on the floor where equipment was placed to keep the setup standardized, since the room had to be changed between phases of the experiment. At the back of the room a chair was placed for the owner to sit on during the test (Figure 3).

A regular yellow tennis ball was the object to be hidden. The hiding spots for the ball were two occluders made of 4 identical white plastic sheets with dimensions: 25x40x0.2cm, glued to two brick blocks with dimensions: 13x17x18cm. The white wall facing the dog during the hiding was set upright, so it was 40cm from the ground up and 25cm wide. The inside of the occluder - the part facing the opposite occluder -was set on its side so measuring 40cm long and 25cm high. This was to block the dog's view if it chose to come up in between the occluders, so its choice would not be affected by the visibility of the ball (Figure 4). The occluders were placed equally far from the sidewalls 50cm, and 100cm apart from each other (Figure 3).

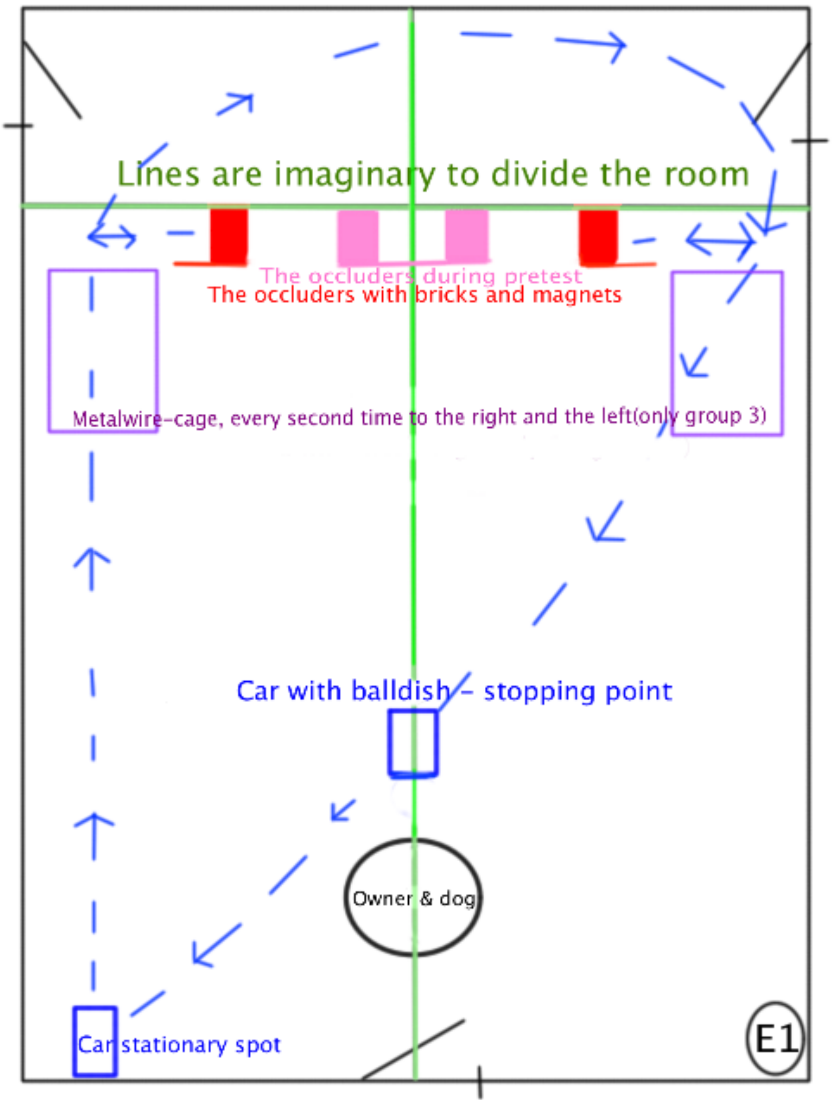

Figure 3 - Experimental setup in treatment
The room was 5 x 2.5meters. The occluders are 100cm apart from each other and 50 cm from each side wall. This was where both the human and UMO agent hid the ball. The metalwire-cage was used as the hiding place for the ball during the social UMO treatment phase (phase 2) (only present in social UMO treatment). It had an opening in the front where the UMO could drive in and retrieve the ball for the dog. Both human and UMO agent followed the blue arrows during the hiding sequences in phase 3 (A-not-B error test). The owner of the dog sits on a chair, with their dog between their legs, where the circle is marked. Experimenter 1 (E1) is at the rear right corner of the room and the agent has their stationary spot at the left rear corner of the room.

The UMO was fitted with a square plastic tray 6.5x6.5x2cm with magnets attached to each side, which was used to transport the ball in front of the UMO and detach it behind the occluder. The brick blocks attached to the occluder were fitted with magnets on the backside so the UMO could drive up and attach the tray with the ball to the occluder. Therefore, the magnets on the brick block had to be stronger than the magnets on the UMO, so that it could pull the tray loose from the magnets on the UMO.

In the social UMO interaction treatment the ball was hidden in a wire mesh cage with dimensions: 61x46x54cm. There was an opening in front of the cage big enough for a UMO to get through but not the dogs. Also here were magnets used in the cage, but these were weaker than the magnets on the UMO so the UMO could pull the tray loose from the cage.

FIGURE 4 – THE UMO USED IN THE EXPERIMENT
A – UMO (REMOTE CAR) WITH BALL IN TRAY BETWEEN THE TWO OCCLUDERS
B – UMO DELIVERING BALL IN TRAY BEHIND OCCLUDER A, SEEN FROM THE SIDE
C – UMO DELIVERING BALL IN TRAY BEHIND OCCLUDER A. VIEW FROM ABOVE

2.5 PHASES

Each dog was exposed to three experimental phases. Phase 1 was identical for all three treatment groups. Phase 2 was the treatment phase, which differed between the three groups. Phase 3, the actual test, was composed of five trials.

The human treatment was the control group of the experiment; therefore there was a human hiding the ball instead of the UMO. This was in order to have a baseline to compare with previous studies. In all three groups' treatment phase (Phase2) the dog was given two - 2 min acquaintance time with the experimenters, and ball play between dog, owner and experimenters. E2 executed the hiding in the test phase (Phase3). The UMO Social treatment of dogs had an interactive training time with the UMO in the treatment phase (Phase2) before the A-not-B test. They had 6 repetitions of interaction retrieving the ball from a metal cage with the UMO. The UMO executed the hiding of the ball in the testing phase (Phase3). In the UMO Non Social treatment the dogs had a non-interactive experience with the UMO in the two - 2 minutes treatment phase (Phase2). The UMO drove around in a constant circle without reacting to the dog. The UMO executed the hiding in the testing phase (Phase3).

2.6 PROCEDURE

Each experiment was recorded with four cameras in the test room and the phases were executed consecutively. Dogs were allowed to take short breaks between the phases if needed to get some water. For Phase 1 & 2 a stopwatch was used to standardise the time used.

In the Human treatment, E2 was the social partner who hid the ball for the dog during the test. E1 was a neutral person standing in the same spot as in the other treatments to keep the test standardised. In the Social UMO treatment, the UMO was the social partner remotely controlled by E1 standing in the right back corner of the test room. E2 attached the ball to the car and executed the beeps for the car by the remote control during the test. E1 and E2 played the same roles in the Non-social UMO treatment tests, excluding operation of the 'beeper'.

Before the owner and dog entered the room, E1 set up the occluders, the UMO (not for the human-control group) and the chair at their predetermined spots. When entering the room, the dog was free to explore the room and play with the tennis ball with its owner. E2 informed and explained to the owner about the test. The owner sat down at the predetermined location and held the dog in front of themselves or between their legs. If the dog was too big for this, the chair was moved a little to the right side (for the person sitting) of the room and the dog could sit on the owners left side, still then in the middle of the room.

2.6.1 PHASE 1 (PRETEST) - ALL TREATMENT GROUPS

The pre-test was done with the two occluders put together in the middle of the room, creating one hiding spot. (1) E2 took the ball, showed it to the dog and walked behind the occluders. (2) Here E2 attracted the dog's attention in the same way as in the experiment, by calling the dog's name and saying, "look here". E2 left the ball behind the occluders, walked back to the dog, showed the dog her empty hands and went to the stationary spot. (3) The dog was encouraged to find the ball and retrieve if possible. The owner was allowed to motivate the dog as much as needed during this pre-test. (4) This was repeated one more time. When the two repetitions were over, the experimenters moved the occluders to their test positions.

2.6.2 PHASE 2 (TREATMENT PHASE) - HUMAN TREATMENT GROUP

(5) The experimenters walked around in the room playing with the ball and talking to the dog for two min. (6) After 2 min. the owner sat down at the predetermined location and held the dog in front of him/her. E2 stood in the stationary spot for the UMO.

2.6.3 PHASE 2 (TREATMENT PHASE) - SOCIAL UMO TREATMENT

(5) After the pre-test, E2 brought in the cage to the room, put the tennis ball in the cage and left the room. The ball was now inaccessible for the test dog, but it could still be seen and smelled. (6) The owner released the dog and it was free to try to get hold of the ball. (7) As soon as the dog showed any interest towards the UMO (looking at it etc.), E1 drove the UMO into the cage, beeped two times before pulling the tray and ball out so the dog could get the ball. If the dog did not look at the UMO within 15 s, E1 beeped two times with the UMO to get the dog's attention before proceeding to drive to the cage. (8) The owner was permitted to quickly play, praise or treat the dog for getting the ball. E2 entered the room and put the ball in the cage again, such that it was ready for repetition. This sequence was repeated six times, the cage was placed on the right and on the left side of the room alternately for a total of three times on each side of the room. (10) After the interaction was over, the owner sat down at his/her predetermined location again and held the dog in front of him/her. E1 drove the UMO back to its stationary place. E2 entered the room, took the cage out of the room, then put the ball in the tray in front of the UMO and stood at the exit, facing the door holding the beeper.

2.6.4 PHASE 2 (TREATMENT PHASE) - NON SOCIAL UMO TREATMENT

(5) E2 left the room, E1 walked to her predetermined spot at the right rear corner of the room and the owner sat down at his/her predetermined location and held the dog in front of him/her. (6) E1 started the UMO and steered it around the room in a circle for two - 2 min. On its first time past the dog, the UMO stopped allowing the dog to smell it if it wished to. If the dog was worried about the UMO, it kept more distance to the dog as needed. (7) After the 2 min. period, E1 drove the UMO back to its stationary place. E2 entered the room, put the ball in the tray in front of the UMO and stood at the exit facing the door holding the beeper.

2.6.5 PHASE 3 (A-NOT-B TEST) - HUMAN TREATMENT GROUP

(7) E2 walked on the left side of the room, towards occluder A, while allowing the dog to see the ball and calling its attention by saying the dogs' name + "look here". (8) E2 then walked on the outside of occluder A, stopping right behind it. (9) Here E2 held the ball in the air so the dog could see it, while saying "Look Doggy". (10) She then left the ball and tray behind the occluder, before walking back to the dog. (11) E2 stopped, allowing the dog to see that her hands were empty, before walking to the stationary spot. (12) After 3 s., the owner released the dog which then was permitted to search for the ball. Neither the experimenters nor the owner were to give any signals to the dog about which side the ball was hidden. The dog was allowed to keep searching until it found the ball, (13) then the owner called the dog and got the ball back while praising him/her. (14) E2 got the tray from behind the occluder and got the ball from the owner, before putting the ball in the tray while walking back to the stationary spot, ready for next repetition. (15) This was repeated one more time for occluder A. (16) For the B-repetitions, the same steps were followed, but E2 now after saying "Look Doggy" at the same spot behind occluder A, lowering her hand with the ball behind the occluder, then raised her hand again, visible for the dog. (17) E2 then walked to and stopped behind occluder B. (18) Here she repeated the attention calling "Look Doggy" before putting the ball and tray down behind the occluder. E2 then walked back to the dog and it was permitted to

search for the ball. This was repeated once more for occluder B, before repeating, one last time, hiding the ball behind occluder A. So the sequence was A, A, B, B, A.

2.6.6 Phase 3 (A-not-B test) - Social & Non Social UMO Groups

(11) The owner sat on the chair with the dog between his/her legs facing towards the occluders. E2 put the ball in the tray in front of the UMO and stood at the back of the room facing the door. E1 stood at the predetermined spot. (12) E2 beeped the UMO two times before E1 started driving the UMO to occluder A. If the dog tried to take the ball, the owner was to hold the dog back and praise it. If the dog managed to take the ball, E2 put the ball back in the tray in front of the UMO while the owner still praised the dog. After the beeps, the UMO drove on the outside of occluder A before driving in behind the first (A) occluder. Right before the tray was hidden behind the occluder, E2 beeped two times, before the UMO left the ball and tray behind the occluder. The UMO then drove behind occluder B, before returning back to the dog. The UMO stopped at the predetermined stopping spot, allowing the dog to see that it was empty, before it drove to its stationary place. After 3 s. the owner released the dog, which was then permitted to search for the ball. Neither the experimenters, nor the owner were allowed to give any signs to the dog about which side the ball was hidden. The dog was allowed to keep searching until it found the ball, then the owner called the dog and got the ball back while praising him/her. The owner could quickly play, praise or treat the dog for getting the ball. E2 got the tray from behind the occluder and the ball from the owner, before putting the ball in the tray in front of the UMO and standing face towards the door again. This was now repeated one time for occluder A. For the B-repetitions, the same steps were followed, but the UMO now beeped two times at the same spot at occluder A, before driving on to occluder B and in behind it. Right before the tray was hidden behind the occluder, E2 beeped two times before the UMO left the ball and tray behind the occluder. The UMO then drove back to the dog. This was repeated once more for occluder B, before repeating one last time for occluder A again. So the sequence was A,A,B,B,A.

2.7 Data Collection

All phases were videotaped continuously, and the videos saved on servers as well as backups. They were marked with subject's name and date.

In the A-not-B test (Phase 3), the dog's behaviour was considered as a choice when they bent their head behind the occluder. It was not required for the dog to pick up the ball, since certain dogs were only interested in finding it but not playing with it when it was motionless, and others were reluctant to put their head all the way behind the occluder. A correct choice was noted when the dog chose the occluder where the ball was hidden (score 1), and as a wrong choice (score 0) when the dog chose the occluder where there was no ball (Table 6). The choices made by the dogs during each trial were noted by E1 and were later double-checked with video-analysis. Inter-rater agreement between two coders was obtained for 10% of the videos, randomly picked. The treatment phase of the video was removed so the coder was blind to the treatment. The index of concordance (Martin & Bateson, 1986) was over 0.90.

TABLE 6 – SCORING SYSTEM FOR CHOICE IN TEST PHASE

Trial	Score	Description
A1	1	Put head behind occluder A
	0	Put head behind occluder B
A2	0	Put head behind occluder A
	1	Put head behind occluder B
B1	0	Put head behind occluder B
	1	Put head behind occluder A
B2	0	Put head behind occluder B
	1	Put head behind occluder A
A3	0	Put head behind occluder A
	1	Put head behind occluder B

2.8 Statistical analysis

Analyses were conducted using the Generalized Linear Mixed Model (GLIMMIX) procedure in SAS/STAT software 13.2 (SAS Institute Inc., Cary NC, USA). The effects of treatment (3 groups), trial (A1, A2, B1, B2, A3) and their interaction on choice (correct versus error) in the A-not-B error test were investigated using a binomial response distribution and logit link function. Trial was a random factor, and dog was the unit of replication. The same model was run after combining trials to examine effects of A trials versus B trials. Effects of experience, and its interactions with treatment and trial, were also modelled. Pairwise comparisons were based on differences in least squares means, adjusted for multiple comparisons using the Tukey-Kramer method. For all tests, the level of statistical significance was set at $P < 0.05$.

3 RESULTS

3.1 TREATMENT ACROSS ALL TRIALS

3.1.1 FIRST AND SECOND A-TRIAL

As seen in Figure 5 all three groups performed well above what would be expected in random search (50%) in the first and second A-trials, with 84.5% average (81% A1, 88% A2) in the Non-Social UMO, 91% (94% A1, 88% A2) in the Social UMO, and 100% (A1, A2) in the Human group.

3.1.2 FIRST AND SECOND B-TRIALS

The magnitude of errors performed during the B trials (the A-not-B error) was considerably smaller in the Non Social UMO treatment group than in both the Social UMO treatment group and Human treatment group (Figure 6).

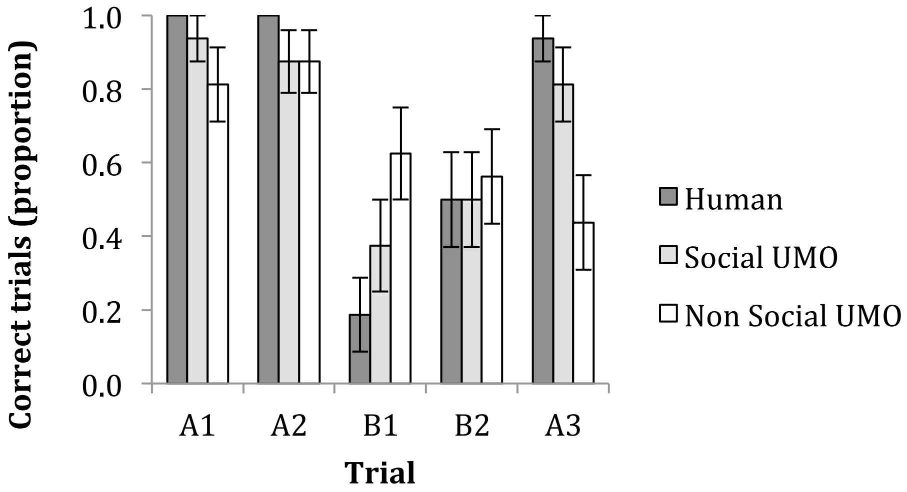

FIGURE 5 - TREATMENT BY TRIAL INTERACTION
*THIS GRAPH SHOWS THE SIGNIFICANT TREATMENT BY TRIAL INTERACTION, WHEREBY THE TREATMENT RESPONSES IN THE B1 TRIALS HAVE AN OPPOSITE PATTERN TO THOSE IN THE A3 TRIALS. A1 = 1 TRIAL, A2 = 2 TRIAL, B1 = 3 TRIAL, B2 = 4 TRIAL AND A3 = 5 TRIAL. THE THREE TREATMENT GROUPS HUMAN, SOCIAL AND NON SOCIAL UMO ARE ACCORDING TO PREVIOUS EXPLANATION (**TABLE 5**).*

3.2 TREATMENT EFFECTS ACROSS A AND B TRIALS

There was no significant main effect of treatment on choices in the A-not-B error test (GLIMMIX: $F_{2, 225}$=0.36, P=0.701). There were significant differences in error rate across trials ($F_{4, 225}$=2.94, P=0.021), with the most errors occurring in B1. However, the main focus of the research was whether the treatment in Phase2 would have an effect on the number of errors performed in the B-repetitions of Phase 3. The results show that responses in the five different trials did indeed vary according to treatment ($F_{8, 225}$=2.09, P=0.038). Comparing the two UMO treatments, where one was socially interactive and responsive, and the other was a Non Social UMO that ignored the dog and just drove in a circle, it was found that dogs in both the Human group and in the Social UMO group could not reliably find the object during the B trials.

Results of the pairwise comparisons show that overall success differed significantly between trial B1 and trial A3 (Tukey-Kramer: t_{225}=-3.43, P=0.006). When comparing treatment by trial interactions, pairwise comparisons indicated that success in Human group, trial B1 was significantly different (P<0.05) from success in each of the following: Human trial A3, Social UMO trial A1, Social UMO trial A2, and Non-social UMO trial A2.

Figure 5 shows that the treatment by trial interaction is mainly due to a difference in how dogs respond in the B1 and A3 treatments.

Dogs in the Human group had an overall success rate of 73% despite having the lowest success rate in the first B trial 19% and a difference of 81% from their first A trial to their first B trial. At the opposite end of the scale, the Non Social treatment group had a similar score overall and in the first B trial 69% and a difference from the A1 to the B1 trial of only 12%. There was a 50% difference in success in the first B trial between the Non Social UMO group and the Human group (Table 7; Appendix).

When the A trials were combined for comparison with the B trials, the treatment by trial interaction was strongly significant ($F_{2, 90}$=6.59, P=0.002), with errors in B trials being most common in the Human group and least common in the Non Social UMO group (Figure 6).

TABLE 7 - SUCCESS-RATE DIVIDED BY PARAMETER
TOTAL, B1 & DIFFERENCE BETWEEN A1 AND B1. ORDERED DECREASINGLY BY %

Treatment	Overall success (%)	B1 success (%)	Difference A1B1 (%)
Human	73	19	81
Social	71	38	56
Non Social	69	69	12

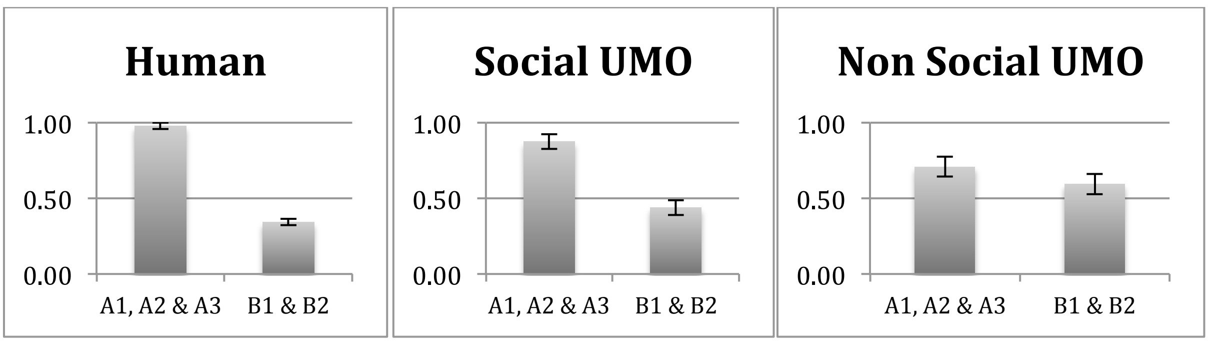

FIGURE 6 - MEAN AND STANDARD ERROR FOR A TRIALS (POOLED) VS. B TRIALS (POOLED).

3.3 Responses to previous Social UMO experience

When previous experience with UMO's was taken into account, no significant effects of experience or its interactions with treatment and trial were detected (GLIMMIX; P>0.70, Figure 7).

Looking at experience by treatment group we see that Non Experienced – Non Social UMO has the overall highest success rate of 80% and on the first B 88%, and the second smallest difference between A1 and B1 at 13%. (Table 8).

Previous experience of a social UMO, and its interactions with treatment or trial did not significantly affect on dog choices in the test. However, there appears to be a numerical drop in correct responses among social-UMO-experienced dogs that were assigned to the Non-social UMO condition in the current study (Figure 7).

TABLE 8 - SUCCESS RATE DEPENDING ON PREVIOUS EXPERIENCE WITH A SOCIAL UMO VS NO PREVIOUS EXPERIENCE WITH UMO'S.

Experience	Treatment	Overall success (%)	B1 success (%)	Difference A1B1 (%)
Experienced	Social	68	50	50
Experienced	Non Social	58	50	13
Non Experienced	Social	70	25	63
Non Experienced	Non Social	80	88	13

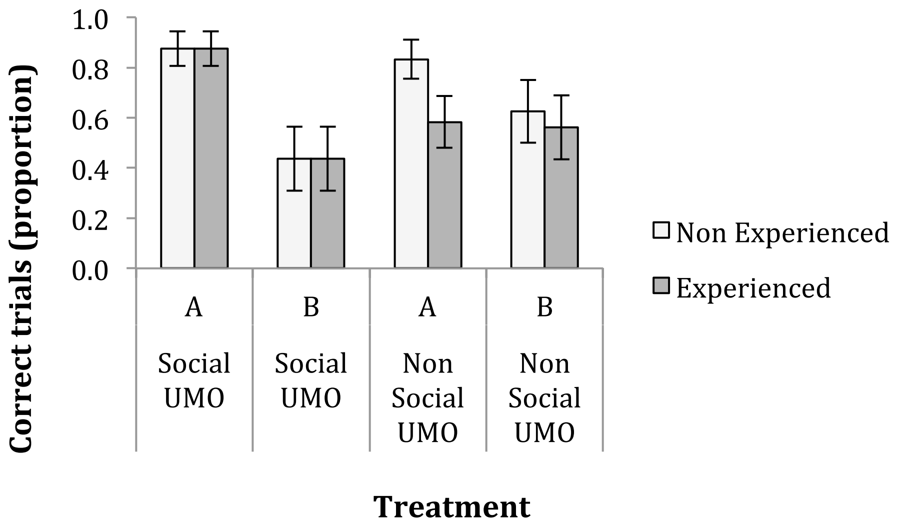

FIGURE 7 - EFFECTS OF PREVIOUS EXPERIENCE ON CHOICES
*CORRECT CHOICES IN % ON A TRIALS POOLED VERSUS B TRIALS POOLED, SHOWING THE EFFECT OF PREVIOUS EXPERIENCE WITH A SOCIAL UMO ON THE CHOICES IN THE TWO UMO TREATMENT GROUPS, RESPECTIVELY SOCIAL- AND NON SOCIAL UMO (AS DESCRIBED IN **TABLE 5**). NON EXPERIENCED ARE CATEGORIZED AS DOGS WHO HAVE NOT MET OR INTERACTED WITH THE UMO OR SIMILAR AGENTS BEFORE. EXPERIENCED ARE DOGS WHO HAVE PARTICIPATED IN PREVIOUS UMO RESEARCH AT ETHOLOGY DEPARTMENT, ELTE, BUDAPEST.*

4 Discussion

The goal of my research was to investigate what quality and quantity of experience is needed for a dog to recognise aspects of an artificial agent's behaviour as being of relevance. This A-not-B error study was designed to test three groups consisting of one group with a Human agent, one with a Social UMO agent and one with a Non Social UMO agent. The point of this being to elicit different quantum of errors in the groups where the dog considers the agents to be portraying information of importance and those that were not. The basis for this is previous research (Topál et al., 2009) done on A-not-B error with dogs where human agents using ostensive referential communication elicit the error, while non-socially communicative human agents do not - prompting the idea of the importance of social behaviour in human dog dyads. Building on this Gergely et al., (2013) found that also in Dog UMO dyads the behaviour of the UMO seemed to be of importance for the interaction to interest the dog.

I hypothesized on the basis of two theories, firstly on the theory of convergent social evolution between man and dog, leading to dogs having an increased sensitivity to human ostensive-communicative signals. Secondly a dog's expectations to unfamiliar moving objects and the importance of its interactive behaviour to elicit dog's social responsiveness. If the hypothesis is correct then there should be fewer dogs performing the error in the UMO Non Social treatment than in the UMO Social treatment. And there should be more errors performed overall in the Human treatment group than in both the UMO treatment groups.

The Non Social UMO treatment group scored overall highest in the first B trial, which fits both with previous UMO studies and with my prediction. Supporting the proposed idea, that dogs do not consider the information portrayed by the UMO as of significance when no social behaviour is produced - highlighting the importance of the socially interactive part of a UMO - dog dyad.

Dogs exposed to a UMO that shows no social responses to the dog's behaviour perform well above chance in comparison to dogs in previous studies with NonCommunicative humans (Topál et al., 2009). The UMO Non Social group that had 0.81 success rate in A1, interestingly had 0.88 in A2, so dogs that searched in the wrong spot during the first trial searched in the right spot during the second trial. There seemed to be no pattern in choices in the UMO NonSoc group. It was as if the UMO was creating an uncertainty in the entire test, as if the UMO confused the dogs.

There were certain indecisive choices from three of the dogs during the tests. With that I mean there wasn't one clear choice (A or B). The dog might have started towards one occluder and then changed direction, or gone past the occluder they headed towards without actually looking behind it and then choosing the other occluder. I set as a requirement for choice that the dog turned its head in behind the occluder. Therefor, because these dogs performed this behaviour, they were included in the analysis. There can be many reasons for why dogs would do this unclear choice, so to get clearer or more explanatory results one could have divided the scores into one more group, three in total. 1 for correct, 0 for wrong and 0.5 for indecisive choice, this was done in Topál et al. (2009). An analysis run excluding these three dogs made little difference to the overall results.

The results indicate that interaction recently is of more importance than previous experience. Even though certain individuals seemed to have a strong memory of the UMO and started interacting quicker with it, they still performed similarly to the dogs, which had no previous experience.

This study followed the tendencies of previous research (Topál et al., 2008) of the human ostensive referential group triggering high numbers of errors in the B trials. My prediction was approximately 80% of dogs in the Human treatment group would perform at least one error; the results showed that 81 % of the dogs in the Human treatment performed an error in the first B trial. The results replicated precisely the UMO Ostensive communicative B trial results in children from Topál et al. (2009). Hence the human treatment group was a sound control group to compare the two UMO groups to confirming my prediction.

These results give indications that dogs interpret certain of the UMO's behaviours and signals as important information and furthermore integrate this in their subsequent interactions. This shows that dogs within short time periods establish expectations about the behaviour of the UMO and use this information and expectation about social interaction with this relatively novice partner. Dogs are known or thought to be mans best friend, often considered to be caused by the convergent social evolution of man and dog during domestication (Topál et al., 2009). These latest findings of dogs' tendency to adopt to novice partners may indicate that dogs are not only man's best friend but in general a very adaptive species for interaction and cooperation with all other interested parties. This is a very adaptive development - by being able to cooperate with other species, dogs can quickly adapt to new situations and benefit from broader spectres than their own niche.

Previous experience with a social UMO did not significantly affect choices in the UMO trials in the current study. There was a non-significant numerical drop in correct trials among the experienced dogs that were assigned to the Non-social UMO treatment. A larger sample of experienced and non-experienced dogs would be needed to detect whether or not there is any significant effect of social UMO experience when exposed again to a UMO, but now behaving differently and not interacting with and helping the dog.

Three findings have been shown in this study:
Social behaviour of the agent interacting is of importance to elicit the A-not-B error, which fits with previous A-not-B error studies done. With decreasing communication and visible social cues the number of errors decrease correspondingly, indicating the eminent importance of social behaviour in interactions. Secondly the Non Social UMO

treatment group somewhat performed as expected but with an unforeseen element of what seems to be confusion on the dog's part. The communicative attempts from the UMO (beeps when starting to drive and while hiding) might be causing a sense of disturbance or insecurity in the task for the dog. Thirdly we found that experience seems to be of less importance, than the social and interactive behaviour in the interaction. One can however, argue that the treatment phase can also be considered as experience of interaction, but since both UMO groups received this interaction, the variable left is the social behaviour that seems likely to be the reason for the differences in the subsequent A-not-B test. If experience does play a role, the recent experience seems to play a greater role.

5 CONCLUSIONS

Gergely et al. (2013) were the first to present evidence of the importance of interactive behaviour of a robot to evoke dogs' social responsiveness. This study strengthens their conclusion that dogs can form expectations about a robotic agent's (in this case a UMO) behaviour in a short period of time and utilize this in subsequent interactions

This experiment showed that the type of interaction the dog had with the UMO immediately prior to the test (in the Social or Non Social treatment phase) was an important factor in whether or not the UMO would elicit the A-not-B error.

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5.2 AUTHOR CONTRIBUTIONS

Development of idea and planning for testing, Anna Bjurgård Compton, Anna Gergely, Ruth Newberry and Ádam Míklosi. Testing of dogs, Anna Bjurgård Compton, Anna Gergely, Judit Abdai and Eszter Petró. Translation Hungarian – English and communication with subjects owners, Anna Gergely. Statistical Analysis, Anna Bjurgård Compton and Ruth Newberry. Thesis writing, Anna Bjurgård Compton.

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7 APPENDIX

Human partner										
	A1		A2		B1		B2		A3	
	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong
	16	0	16	0	3	13	8	8	14	1
ERROR %	0%		0%		81%		50%		7%	
UMO Social (Soc.)										
	A1		A2		B1		B2		A3	
	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong
	15	1	14	2	6	10	8	8	11	2
ERROR %	6%		13%		63%		50%		15%	
UMO Non Social (Soc.)										
	A1		A2		B1		B2		A3	
	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong
	13	3	14	2	11	5	10	6	7	9
ERROR %	19%		13%		31%		38%		56%	

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