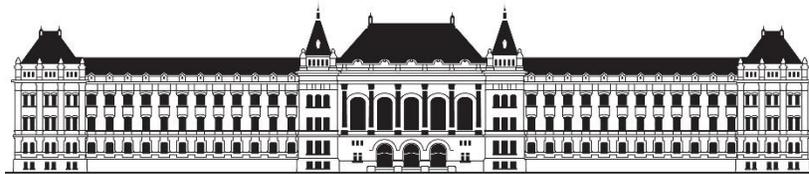


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**RESPONSIVENESS TO SOCIAL-AFFECTIVE SIGNALS IN DOGS
AND HUMANS: NEUROCOGNITIVE AND COMPARATIVE
PERSPECTIVES**

PhD Thesis Booklet

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Introduction and main objectives

The present PhD thesis aims to get a better insight of social susceptibility and the social cognition within the context of the Autism Spectrum Disorder from both comparative and developmental perspective, focusing on the functional similarities between dogs' and human children social signalling and attention modulation in social context. We combine behavioral and neurophysiological results with the neuro-hormonal aspects of social sensitivity.

The scientific research of the dog's behaviour from the very beginning started with the investigation of the domestic dogs' (*Canis familiaris*) exceptional social sensitivity, and the role of communication signals in learning (Miklósi & Topál, 2013). Both canine and developmental literature (Tauzin, Csík, Kis, & Topál, 2015; Topál, Gergely, Miklósi, Erdohegyi, & Csibra, 2008; Topál, Kis, & Oláh, 2014) proved that the ostensive-communicative signals (e.g., eye-contact) have a key role in attention modulation in social learning situations. In pedagogic context enable subjects to focus their attention more to the stable, intrinsic features (e.g. color) in contrast to the transient object properties (e.g. location) (Csibra & Gergely, 2011; Topál et al., 2008). In order to assess the priming effect of social stimulation (e.g. sustained eye-contact) in human problem solving, in Study 1 we adapted the change detection task of Marno (2014) to explore whether the human cognitive system can be primed to the a biased mode of information processing. In Study 2 study we investigated whether pretreatment with positive and negative social stimulation would affect subsequent behaviour of dogs in an instrumental helping situation in which an unfamiliar human request an out-of-reach object by extending her arm and gazing toward it.

Familiar behavioral characteristics (such as language, accent and other learned behaviors) also play a crucial role in learning from others and indirectly influences the relevance of information and the use of resources in the learning processes. The social preference for ingroup members is one of the central aspects of human behavior. Due to its close connection with social skills, social categorization is one of the main research areas of my dissertation. The categorization abilities of people with autism are characterized by a kind of context dependence (Brown & Bebko, 2012; Radenovic, 2010; Vandenbroucke, Steven Scholte, Engeland, Lamme, & Kemner, 2009). According to Brown and Bebko (2012), this is caused by increased discrimination and low

generalization abilities in ASD. With the greater attention to detail, it is difficult to eliminate similarities. The question arises as to whether the domestic dog has developed some sort of social categorization skills, which may provide an opportunity for further investigation.

The empirical studies presented in Study 3 aims 1.) to investigate from developmental perspective the importance of different category markers (transient vs. permanent visual markers) representing visual features of either humans or dogs, and 2.) to explore whether children with autism have different category learning performance or different criteria when forming social categories to age matched neurotypical controls. In Study 4 we investigated whether dogs also show tendency to interact differently with adult humans in an unsolvable problem (inaccessible toy) situation based on different types of similarities between their owners and unfamiliar human partners. More specifically we explore dogs' capacity for social categorization, which can promote the choice of an appropriate human partner to engage in successful cooperation.

One of the interesting socio-cognitive symptoms that characterize autism is the audience effect. The audience effect has been shown to play an important role in the differential diagnosis of autism, as children diagnosed with autism react differently to the observation than typically developing children (Chevallier et al., 2014; Izuma, Matsumoto, Camerer, & Adolphs, 2011). Increasing evidence indicates that domestic dogs (*Canis familiaris*) attend to a human's attentional state, and thus fulfil one of the core requirements for audience effect. In Study 5 and Study 6 we examined whether dogs show a tendency to change their behaviour according to the visual attention of humans. In Study 5 dogs participated in two types of observational conditions in presence of familiar and unfamiliar human (Attentive Owner & Attentive Experimenter) and a control condition in which both human participants turned their back and engaged in distracting activity (No Audience condition). The human partners disallowed the dog from eating a piece of food. Our results confirmed that dogs perform different visual monitoring strategies in the presence of their caregiver and an unfamiliar observer and point to the context-dependent nature of audience effect in dogs. Study 6 aims to investigate the impact of the owner's visual attention on dogs' tendency to bring back an object to an unfamiliar experimenter and to investigate the potential associations among owner-dog relationship, dogs' task performance and spectral EEG sleep profile. Analyzing the relationship between dogs' sleep EEG spectrum and fetching task behavior

is a novel approach to investigate the neuro-cognitive link between dogs' personality traits and their susceptibility to audience effect.

New scientific results

THESIS 1. SOCIAL PRIMING

1.1. THE EFFECTS OF SOCIAL PRIMING IN THE HUMAN ATTENTIONAL PROCESSES

Although ample evidence supports the existence of a genericity bias following communicative demonstrations, the underlying mechanism is not yet fully understood. Marno et al. (2014) suggest that the observed attention modulation effect can possibly be made up of two partly distinct processes. First – at the higher level –, communicative cues may directly alter the interpretation of the observed scenario, which leads to selectively encoding information that is relevant within the framework of the specific interpretation. Second, communicative cues may also exert their effects at a lower level by modulating the functioning of certain neural pathways and thus attuning the nervous system to a specific mode of information processing. Ostensive-communicative cues trigger a “pedagogical stance” in humans that is characterized by a specific mode of information processing (e.g. Marno et al., 2014). In our study (*Study 1*), we aimed to gain more information about the nature of this pedagogical stance by testing whether it can be elicited and sustained over a longer period of time by engaging participants in social interactions that are separated in time from stimulus presentation.

The main results of Study 1 are the following: offline social cues invite a similar bias in information processing as on- line communicative signals do and intensive social stimulation (pre-treatment) influences the allocation of attention between transient and stable object properties to facilitate the encoding of stable, generalizable properties. The results show that participants were significantly better at correctly identifying the change if it happened in the location of the object rather than in its identity. However, the difference between the proportions of correct responses was smaller after participating in a socially intense pre-treatment.

1.2. AFFECT MATTERS: POSITIVE AND NEGATIVE SOCIAL STIMULATION INFLUENCES DOGS' BEHAVIOUR IN AN INSTRUMENTAL HELPING SITUATION

Study 2 aims to investigate how the perceived affective quality of a social interaction with an unfamiliar experimenter affects dogs' behaviour in a cooperative situation in which another experimenter requests an out-of-reach object cued by approaching it, crouching down next to it, and indicating attempts to retrieve it.

We found that positive social pretreatment has a facilitatory effect on some aspects of dogs behaviour in an instrumental helping situation (longer duration of looking time at the experimenter; shorter latency of moving upon release and approaching the experimenter) while as a results of the priming with negative social interaction dogs became more hesitant.

To sum up, our empirical results provide evidence for how social experiences influence both humans' and dogs' behaviour and its underlying mechanisms in a variety of ways. Furthermore, it raises the possibility that exposure to differently valanced interactions with social partners would not only have an impact on physiological variables but may have long term effects on behaviour.

Related articles:

1. Oláh K, Elekes F, Turcsán B, Kiss O, Topál J. (2016). Social Pre-treatment Modulates Attention Allocation to Transient and Stable Object Properties FRONTIERS IN PSYCHOLOGY 7: Paper 1619. <https://doi.org/10.3389/fpsyg.2016.01619>
2. Galambos, Á., Gergely, A., Kovács A. B., Kiss, O. and Topál, J. (2020). Affect matters: positive and negative social stimulation influences dogs' behaviour in an instrumental helping situation, Applied ANIMAL BEHAVIOUR SCIENCE. Submitted manuscript.

Thesis 2.: SOCIAL CATEGORIZATION

2.1. SOCIAL CATEGORIZATION BASED ON PERMANENT VS TRANSIENT VISUAL TRAITS IN NEUROTYPICAL CHILDREN AND CHILDREN WITH AUTISM SPECTRUM DISORDER

In Study 3 we had two experiments. The goal of Experiment 1 was to investigate from developmental perspective the importance of different category markers representing visual

features of either humans or dogs. We expected younger children to rely more on personal (animal dependent) permanent markers, such as skin tone, or breed when contrasted with less personal markers (t-shirt colour, collar colour), in contrast with older children, who could benefit from their deeper social experiences, social knowledge and focus more to the more arbitrary but culturally relevant grouping factors, such as shirt colour.

Experiment 2 aimed to discover whether children with autism have different category learning performance of different criteria when forming categories to those of (mental-) age matched neurotypical controls when presented with the option to categorize images of humans and dogs based on permanent (hair or skin tone, dog breed or fur colour) or transient markers (shirt colour, fur colour).

Furthermore, we also investigated what affects categorization in both groups (ASD and control), whether humans and dogs are categorised differently and if skin tone/breed of dog or hair colour/fur colour will bring about different categorizing strategies.

The results of Study 3 show that children categorize humans and dogs differently, having a bias towards transient cues when the target is an image of a human, and towards permanent cues, when the target is an image of a dog. Our results suggest that children are able to flexibly switch between potential ways of categorizing fellow humans from very early on (at the age of 4 years) and they prioritize cues that are socially constructed. Although the same pattern of results was found with children diagnosed with Autism Spectrum Disorder, there were some minor differences in the strategies that we observed. While neurotypical children were more likely to rely on skin tone than hair, the opposite pattern was observed in children with autism.

2.2. SIMILARITY BETWEEN AN UNFAMILIAR HUMAN AND THE OWNER AFFECTS DOGS' PREFERENCE FOR HUMAN PARTNER WHEN RESPONDING TO AN UNSOLVABLE PROBLEM

Recognition of group membership is widely observed within the animal kingdom including humans. Although there is ample evidence to suggest that social preference for ingroup members is one of the central aspects of human behaviour from very early on (Fiske & Macrae, 2012), it is still unclear whether dogs are able (and willing) to categorise people into ingroups and outgroups. Furthermore, there is currently no consensus as to whether dogs can discriminate between humans

based on personal features of their potential cooperative partner, as well as based on earlier observation of human behaviour.

The aim of this study was to investigate whether dogs are able to differentiate between unfamiliar humans according to whether they show or do not show similarities to their owners. We hypothesized that dogs would show a preference for the ‘similar’ partner when interacting in order to ask for help.

In Study 4 dogs exhibited a visual attention preference for the human whose motion pattern and language usage were similar to their owner’s in the inaccessible-toy task, and only weak evidence of discrimination based on the arbitrary group marker (clothing).

Based on these studies we suggest that human infant-analogue forms of social categorization may have emerged in dogs. Moreover, our results suggest that the use of arbitrary categorization markers is highly associated with social categorization and might have the roots in out species tendency to use culturally relevant knowledge to ease the orientation in complex human-specific social systems and also avoid the overload of the cognitive system.

Related articles:

3. Kiss, O., Oláh, K., Fehér, L. J., Topál, J. (2020). Social categorization based on permanent vs transient visual traits in neurotypical children and children with autism spectrum disorder. SCIENTIFIC REPORTS. Submitted manuscript.
4. Kiss O, Kovács K, Szánthó F, Topál J. (2018). Similarity between an unfamiliar human and the owner affects dogs’ preference for human partner when responding to an unsolvable problem. LEARNING & BEHAVIOR , 46, 430-441. <https://doi.org/10.3758/s13420-018-0337-y>

THESIS 3. AUDIENCE EFFECT

3.1. HOW DO DOGS MONITOR THE HUMAN’S ATTENTIONAL STATE AFTER CHALLENGED BY THE PRESENCE OF FORBIDDEN FOOD?

We explored the combined effects of familiarity and the attentional stance of human participants on dogs' behaviour in a 'forbidden food' situation. That is, dogs' willingness to obey the command 'refrain from eating' the otherwise obtainable food was investigated in three different audience conditions in which the different human participants (the owner and an unfamiliar experimenter) either paid attention to the dog or engaged in distracting activity.

Our main findings in Study 5 about canine audience effect are the followings: the audience effect in dogs is context dependent and the individual differences in dogs' tendency to conform to the situational rules is of great importance.

Dogs that were motivated and tried to obey the rules were sensitive to the owner's attentional state, while those dogs who ate the food immediately after placing it on the table not only totally ignored humans' command but they were completely insensitive to the presence of familiar and unfamiliar humans showing different visual attention.

3.1. BEHAVIORAL AND NEUROPHYSIOLOGICAL CORRELATES OF DOGS' INDIVIDUAL SENSITIVITY TO BEING OBSERVED BY THEIR OWNERS WHILE PERFORMING A REPETITIVE FETCHING TASK

We investigated the effects of human audience on dogs' performance during a repetitive (relatively monotonous) fetching task. More specifically we aimed to examine the impact of the owner's visual attention on dogs' tendency to bring back an object to an unfamiliar experimenter and to investigate the potential associations among owner-dog relationship, dogs' task performance and spectral EEG sleep profile. We predicted that a dog's willingness to perform a relatively monotonous fetching task would change in response to the changing attentional state of its owner who is passively watching his/her dog. We expected dogs to perform better in a monotonous task when they are being watched than when being ignored by their owners. We also expected associations between the different aspects of the owners' relationships with their dogs (pet-related anxiety and avoidance) and dogs' sensitivity to their owners' visual attention.

Study 6 shows that dogs have a somewhat human-like susceptibility to the audience effect. Dogs were faster to approach the toy object in the presence of an attentive Owner, and were more willing to offer the toy to their owners when she/he was paying attention. Dogs of owners with higher relationship anxiety tended to approach the toy object less frequently and were more

hesitant to approach the toy object. We found that that a dog's individual susceptibility to the audience effect is a trait-like characteristic reflected in the EEG spectral power in all sleep stages. We may assume that the increased high frequency EEG activity in dogs that tended to show a greater change in following the experimenter's instructions and in gazing towards their owners can be interpreted as a sign of poorer sleep quality.

Related articles:

5. Kiss, O., Topál, J (2019). How do dogs monitor the human's attentional state after challenged by the presence of forbidden food? *BIOLOGICA FUTURA* 70, 103-111.

<https://doi.org/10.1556/019.70.2019.13>

6. Kiss, O., Kis, A., Topál, J. (2020) Behavioral and neurophysiological correlates of dogs' individual sensitivity to being observed by their owners while performing a repetitive fetching task. *FRONTIERS IN PSYCHOLOGY*, 11:1461.

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