

c0012 Dogs' Sensitivity to Human Ostensive Cues: A Unique Adaptation?

József Topál,¹ Anna Kis^{1,2} and Katalin Oláh^{1,3}

¹*Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest, Hungary,* ²*Department of Ethology, Eötvös University, Budapest, Hungary,* ³*Department of Cognitive Psychology, Eötvös University, Budapest, Hungary*

s0010 12.1 INTRODUCTION

p0010 One of the most striking trends in the social cognition literature is the rapid growth in the number of dog cognition papers published in the past few decades (see [Bensky et al., 2013](#), for a comprehensive analysis). This can be interpreted as indicating that dogs have become, in a certain sense, the ‘new chimpanzees’ (c.f., [Bloom 2004](#)) for cognitive scientists, and raises a fundamental question: Why does this domestic species deserve such a privileged status in the study of social cognition?

p0015 The clue to the ‘dog paper boom’ lies in this species’ *social competence*, a concept considered central to our understanding of the evolution of cognitive abilities. In fact, social competence ([Oliveira 2009](#); [Taborsky & Oliveira 2012](#)), which is widely believed to be a key to answering the question ‘what makes us human’, has gained increasing attention in the past few years. Although social competence, by default, manifests itself in conspecific interactions in a wide range of species, dogs can be seen as a unique case of how this system can manifest itself in inter-specific (i.e., dog–human) interactions ([Miklósi & Topál, 2013](#)). It is increasingly assumed that dogs can be seen as animals displaying human competent social skills ([Hare & Tomasello, 2005](#); [Topál et al., 2009b](#)), because their particular domestication history, including adaptive specialisation of social skills in the human social environment, paved the way for the emergence of an evolutionary novel, inter-specific social competence. Humans are characterised by more pronounced collaborative (prosocial) attitudes than other apes ([Hare & Tomasello, 2004](#); [Rekers et al., 2011](#)), and it has been suggested that this cooperative, prosocial bias may have been one of the key factors that made it possible for humans to develop higher-level cognitive skills ([Richerson](#)

- & Boyd, 1998; Moll & Tomasello, 2007). An increasing body of evidence suggests a similar trend towards collaboration with people in dogs (Miklósi et al., 2003; Gácsi et al., 2005). The specific differences in the social competence of dogs and apes (Wobber & Hare 2009) raise the hypothesis that dogs have evolved interspecific social sensitivity (Bräuer et al., 2006), and domestication may have specifically enabled dogs to coordinate their own actions with humans in a collaborative manner (Horn et al. 2012; Ostojic & Clayton, 2013).
- p0020 The idea that domestication enhanced the social skills of dogs in cooperative–communicative tasks involving humans gained some further support from studies in which dogs and wolves have been shown to differ (e.g., Gácsi et al., 2009a), while dogs and human infants display similarities with respect to their ability to react to challenges of the human social environment (e.g., Lakatos et al., 2009). In fact, in spite of their phylogenetic distance, dogs and human children often show comparable performance at the behavioural level in cooperative–communicative tasks involving humans. Dogs possess a wide variety of social-communication skills, and these skills are often manifested in an infant-analogue, sophisticated manner in interspecific interactions (towards people). Although the conclusions of these experimental results have often been challenged (e.g., Udell et al., 2009), leading to contrasting theories of the origins of dog social cognition (see Miklósi & Topál, 2013, for a recent review), the vivid debate on the interpretation of findings has led to the emergence of a new research direction in comparative cognition.
- p0025 A core idea of this new wave of research is that in the course of domestication, human beings became an integral part of dogs’ world, and the selective force entailing this interspecific social environment was one of the main factors of the adaptive specialisation of dogs’ social cognition. In line with this assumption, Reid (2009) proposed that this social challenge could have been overcome by gaining skills that enable dogs to correctly interpret information provided by people, whereas others (Hare & Tomasello, 2005; Topál et al., 2009a) suggested functionally infant-analogue manifestations of social competence in dogs, including their responsiveness to human signals in social (learning) settings.
- p0030 It stands to reason that domestic dogs and human infants are in a similar situation because of the enormous variations of human social behaviour, and the diversity in human communication poses an everyday challenge not only for young infants but also for dogs. When communicating, humans can use a potentially infinite number of communicative signals, leastways in the visual and the acoustic modalities. In addition, they apply certain signals for *initialising and maintaining* communication (e.g., addressing, eye-contact) and rely on various behavioural cues to recognise human attention. It is also worth mentioning that people spontaneously interact with dogs in a very similar way to how they typically interact with infants (Mitchell, 2001), and they spontaneously use a specific intonation pattern both when they talk to infants (motherese) and dogs (doggerel) (Hirsh-Pasek & Treiman, 1982).
- p0035 In this chapter, we focus on a key feature of dogs’ interspecific social competence, the use of human ostensive referential communication as a source of

information, arguing that this is more flexible than was formerly thought and shows functional similarities to human infants' corresponding skills (see Miklósi & Topál, 2012, for a review). To highlight these similarities (and differences), in the first part of the chapter, we give a short introduction to what human-like social competence entails and how communication contributes to forming socially competent behaviours (section 12.2). We also highlight the inferential nature of the human communication system and the role ostensive signals play in making the act (interaction) truly communicative (section 12.2.1). Then we provide a description of a human-specific system for fast and efficient transfer of knowledge (natural pedagogy) as compared to the characteristics of non-human types of social learning (section 12.2.2) and show that even young preverbal infants are able to learn efficiently from communication-guided interaction (section 12.2.3). In the next part of the chapter, we describe the infant-analogue manifestations of social competence in dogs as a set of skills reflecting evolutionary adaptation to the cognitively challenging human social environment (section 12.3). We also provide evidence about dogs' sensitivity to different types of human ostensive signals including eye contact and verbal addressing (section 12.3.1) and further discuss potential similarities between dogs' and preverbal infants' communication skills (referential expectation, genericity assumption—section 12.3.2). Finally, in section 12.4, 'Summary and Conclusions', we give a short overview of the infant-like characteristics of dogs' communication skills and share some thoughts regarding the possible adaptive function and the putative cognitive mechanisms that underpin these skills in dogs.

s0015 12.2 HUMAN COMMUNICATION SYSTEM: A UNIQUELY POWERFUL WAY OF KNOWLEDGE TRANSMISSION

p0040 One of the wonders of human evolution is the significant gap between humans' cognitive skills and that of any other animal—even primate—species. These human-specific capacities have enabled us to create unprecedentedly complex and rich cultures (Richerson & Boyd, 1998) that are characterised by a vast amount of accumulated and shared knowledge preserved over a great span of time. The accumulation of knowledge—and thus the preservation of cultures—could not be realised without uniquely effective mechanisms for acquiring, storing, and transferring knowledge, which poses, both on evolutionary and developmental time scales, a great adaptation challenge on the human cognitive system.

p0045 Although there is debate about the point at which communication exerts its effects in human evolution, the fact that humans possess a communicational system that is unique among species can hardly be challenged. Human communication—that is designed for acquiring, storing, and transferring relevant knowledge content—is clearly distinguishable from other communicational forms in that it consists of a highly complex system of linguistic symbols and grammatical structure. However, arguably a more striking feature of human communicative interactions is the *mode* with which information can be conveyed between individuals by the combination of linguistic, non-verbal, and

meta-communicative cues. The content of the communicative intention is in great part conveyed by the social context, and a slight modification of one aspect may entirely change the meaning behind the message.

s0020 **12.2.1 Recognising Communicative Intentions as a Key to ‘Socially Competent’ Interactions**

p0050 The recognition that human communication is characterised by a number of factors that lie without the system of linguistic codes has prompted researchers to try to identify these additional aspects and preconditions for successful communication. Grice (1989), for example, argued that successful communication is dependent on the ability of perceiving others’ communicative intentions and on a will to express our own. Grice’s theory resonates with accounts that emphasise a role of cooperation in the evolutionary emergence of human cognitive skills, as his theory also claims that in inferring the meaning of an utterance, people rely on an expectation of the cooperative intent of the communicator (Co-operative Principle). Drawing on Grice’s account, Sperber and Wilson (1986) put forward a theory, termed Relevance Theory, to explain how people come to successfully decode the intended meaning of a communication. According to this view, the mere realisation that a communication is intended for oneself is crucial in this process. This recognition in the recipient of the message is achieved by the *production of ostensive signals* (Sperber & Wilson, 1986). Ostensive signals consist of a set of verbal and non-verbal cues providing evidence of the communicator’s intention to convey information.

p0055 Csibra (2010) further argues that—as he puts it—the *communicative intention* and the *informative intention* of a communication may be separated procedurally (but not conceptually), meaning that one might express or recognise one without the other (e.g., I may understand that someone is trying to say something to me without understanding what it is). In Csibra’s view, ostensive cues serve as a means to identify the *communicative intention*. However, he rejects the possibility that ostensive signals work this way merely due to their ability to grasp attention. If this were true, anything that has the power to evoke the orientation reflex (e.g., any loud noise) may serve the function just as well. Instead, he claims that ostensive cues have the power to grab our attention *because* the human mind is wired to interpret them as a precursor for communication addressed to oneself.

s0025 **12.2.2 Natural Pedagogy versus Social Learning: The Role of Communication in Humanly and Non-Humanly Acquired Knowledge**

p0060 Reflecting in some aspects Sperber and Wilson’s idea (1986), a recent theory, termed Natural Pedagogy (Csibra & Gergely 2006; 2009), also emphasises how the realisation that a communication is addressed to oneself changes the processing of the content of communication. However, while the scope of the

Relevance Theory is narrowed down, as it comes from the field of linguistics, Natural Pedagogy, putting the issue in a broader evolutionary perspective, builds on the literature on social learning.

p0065 **Csibra and Gergely (2006)** argue for a communicational system that allows the efficient transmission of generic knowledge from one individual to another. According to the theory, human cultural products have become so complex that simple observational learning could not serve as a mechanism by which the accumulated knowledge is sustained and transmitted through generations. A key adaptation challenge for hominisation is, therefore, the necessity of sharing generic knowledge among group-mates in a fast and efficient manner. They identify the emergence of recursive tool use (making tools in order to make other tools with them) as a turning point at which observational learning ceases to be an efficient mechanism for cultural transmission. During recursive tool making, the goal and the benefit of the performed action cannot simply be inferred from the observable context, which makes a great part of human cultural habits opaque to the observer. In such opaque situations, distinguishing the necessary (and invariant) elements of an action sequence from the incidental ones becomes extremely hard, if not impossible. Imagine observing a person turn on a TV with a remote control by lifting the remote, pointing it at the TV, shaking it a couple of times, and then pressing a button. If one does not possess any prior knowledge about the functioning of remote controls, it would be impossible to decide which step contributed to the achievement of the desired outcome (the appearance of the picture on the screen) and which step was irrelevant. Human cultures are filled with complex phenomena such as this, which poses a great challenge on our cognitive system.

p0070 **Csibra and Gergely (2009)** propose that human cultural transmission is made possible by a species-specific adaptation that is responsible for disambiguating such situations via teaching. Evidence from archaeological studies also support the idea that the evolution of our complex material culture would have been impossible without some forms of teaching (**Tehrani & Riede, 2008**), thereby strengthening the claims and evolutionary rationale of the Natural Pedagogy theory. With the help of this adaptation, people are able to (1) perceive others' communicative intentions and infer that the presented knowledge is relevant to them as well as to (2) express such communicative intentions by providing ostensive cues. This idea suggests that ostensive cues serve the function of calling the attention of the novice to the fact that the presented information is produced for their benefit and thus expresses the communicative intention. In other words, in addition to the addressing function (specifying the addressee), ostensive signals are indicators of the presence of a communicative intention, importantly however, without having the capacity to specify the knowledge to be transmitted. In such an ostensive setting, accompanying (or subsequently presented) referential signals direct the attention of the novice to the relevant aspects of a scenario, and this enables the addressee to decode the knowledge content of the communicative exchange.

- p0075 This specialised communication system is highly interactive, and it results in three key properties of human social transmission. First, it enables the fast and efficient transfer of cultural knowledge even if the knowledge to be acquired is cognitively opaque (regarding its aim and/or the cause-effect relationships); and second, it ensures that naïve social learners can acquire knowledge even after one or a few observations. A further important claim of the theory is that ostensive-referential signals induce an expectation that the validity of the presented knowledge is not constrained to the given context, but that it is generalizable to other situations as well (e.g., all remote controls work this way and not just the one being used at the moment). While this account provides an explanation of how children acquire a great amount of cultural knowledge in a relatively short period of time (thus deals with the ontogenetic aspect), it also offers an account of the phylogeny of human cultures. Natural pedagogy may be the mechanism by which cognitively opaque cultural knowledge is sustained over generations (Csibra & Gergely, 2009).
- p0080 In contrast, the non-human type of social/observational learning is a very slow and fortuitous process. The difficulties of observational learning lie in the fact that, without the guidance of ostensive signals, it cannot provide sufficient information regarding the following question: Who and when should be observed? How can the episodic and generalizable aspects of the presented knowledge content be separated? In the absence of natural pedagogy, these problems cannot be solved unless the naïve learner could gain (at least some) insight into the cause and effect relationships of an action.
- p0085 Moreover, observational learning cannot answer the challenges of the generalisation problem. The naïve learner becomes informed about objects and events that are relevant in the particular context of ‘here and now’, but this mechanism provides no cues as to which pieces of information can be transferred to other contexts as well. The acquisition of nut cracking in wild chimpanzees, for example, clearly demonstrates the low efficiency of non-human types of social learning (i.e., knowledge transfer without being supported by natural pedagogy). Nut cracking has been described as a socially transmitted tradition of wild chimpanzees living in West Africa (Boesch et al., 1994). This can be regarded as a relatively complex behaviour pattern because in order to split the nut without pulverising it, chimps need to use stone tools (hammer, anvil) and they have to strike at the nut very precisely (applying about 1 kg force). A practiced chimpanzee mother can break open more than 100 nuts per day, providing extensive opportunity for her child to observe and learn the technique. Importantly, however, studying the acquisition of nut cracking in wild chimpanzee populations takes about 3–7 years (Inoue-Nakamura & Matsuzawa, 1997). However, others reported that chimpanzees living in a captive environment, after having reached the age of 3, can acquire the technique of nut cracking after a relatively brief exposure to a demonstration by an experienced conspecific (Marshall-Pescini & Whiten, 2008).
- p0090 It seems that the learning process is time consuming and cognitively demanding because during the construction of generic knowledge, the naïve observer

could only rely on observation of individual events—namely, the episodic manifestation of a particular nut-cracking action of the chimpanzee mother (“this particular nut can be split using this particular stone, in this particular manner”), which is in itself not very helpful for the naïve observer. To master the nut-cracking technique, the infant chimp *needs to extract generic knowledge* (“any nut-like object can be cracked by any ‘hammer-shaped’ stone by implementing the observed motor pattern”) by keeping in mind the invariant (relevant) and omitting the incidental (variable) components of the repeated action demonstrations. Accordingly, in lack of natural pedagogy, the utilisation of knowledge flexibly across a wide range of contexts can be acquired only by extensive ‘trial-and-error’ experience or by observing the tutor’s behaviour many times under many different conditions.

p0095 In summary, it seems that introducing ostensive-referential guidance into social learning processes was a great invention of human evolution which allowed for more efficient transfer of knowledge. Qualitative and quantitative differences in the main characteristics of non-human and human social learning mechanisms are summarised in [Table 12-1](#).

t0010

TABLE 12-1 Main Characteristics of Non-Communicative Social-Observational Learning Mechanisms and Social Transmission of Knowledge Supported by Ostensive-Referential Signalling

	Non-Human Social-Observational Learning	Human Social Learning via Pedagogy
Novice’s role	passive (eavesdropper or passive recipient)	(inter)active
Focus of novice’s attention	uncontrolled	guided by referential signals
Source of information	inflexible (based on dominance, kinship, social affiliation)	flexible (based on the expression of communicative intent)
Validity of information	context-embedded	generalizable to other contexts
Number of presentations necessary for successful knowledge transfer	several	one or few
Timing of knowledge transfer	based on present needs	flexible
Imitation of opaque elements	rarely (if any)	frequently

s0030 12.2.3 Human Infants are Socially Competent Participants of Pedagogical Knowledge Transfer

p0100 A specific aspect of communication-guided knowledge transfer is that natural pedagogy makes it possible to learn efficiently from communicative interactions well before a novice can acquire complex (adult-like) cognitive skills. In the past few years, ample evidence has been accumulated to support the claim that even preverbal infants readily interpret ostensive signals (such as eye contact or infant-directed speech) as indicating communicative intentions and are competent receivers of pedagogical knowledge manifestations (see Csibra, 2010, for a review). Ostensive signals not only grab and direct attention in infants from very early on (Farroni et al., 2002) but have the potential to unambiguously specify the addressee and trigger some inferential processes. In other words, ostensive-referential communication changes how we process what we see. A body of evidence supports the notion that, in observational learning situations, introducing information in an ostensive-referential manner *can modify what a novice learns* from a demonstration (Butler & Markman, 2010; Southgate et al., 2009). For example, 14-month-old children imitate a suboptimal and opaque means to achieve a goal (turning on a lamp with their forehead) when it is presented in an ostensive setting, but choose the prepotent action (using their hands) when the pedagogical setting is eliminated (Király et al., 2013).

p0105 This example clearly shows that ostension has a specific impact on infants' information processing and provides effective guidance for young infants on the available information content (message). The effect can be conceptualised as 'assumptions' or 'cognitive biases' affecting the interpretation of communicative acts. Recent evidence suggests that there are at least two scaffolding cognitive processes called 'referential expectation' and 'assumption of genericity'. These 'automatic' information processing dispositions prepare human infants to efficiently learn when they are addressed by ostensive signals. For example, it has been shown that infants below the age of one expect the direction of gaze to signal a referent at a specific location (Csibra & Volein, 2008; Senju et al., 2008). Importantly, this *referential expectation* is formed only when it is preceded by communicative (ostensive) signals (Senju & Csibra, 2008). These results suggest that infants appreciate the interactive nature of human communication and are prepared to benefit specifically from communication addressed to them. The fact that referential gestures in themselves (without accompanying ostensive signals) do not elicit attention to the subject of the communication further supports the idea of the aforementioned *dual nature of communication* (see Senju & Csibra, 2008), i.e., the claim that for successfully decoding a message it is important to recognise both the communicative and the informative intention (Csibra, 2010).

p0110 It has also been shown that in communicative situations preverbal infants tend to grab generic information even from a single observation and ignore episodic elements of the context. That is, when infants are presented with an object in an ostensive-referential context, they tend to pay attention to its generic (i.e., visual feature) rather than transient (i.e., location) properties. However, they remember

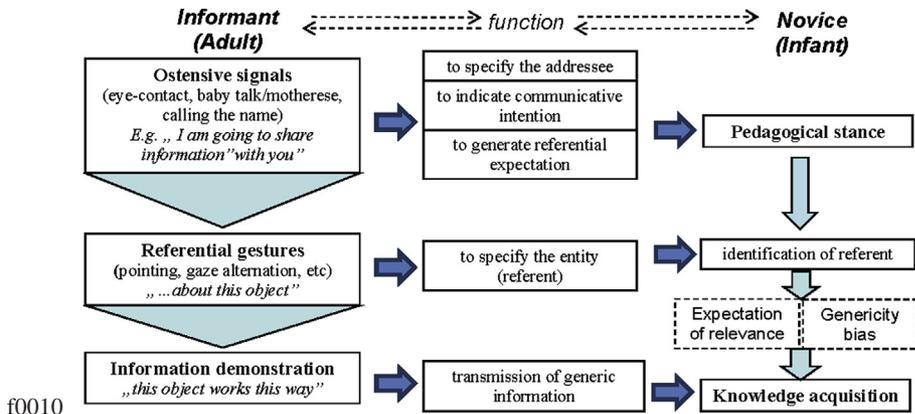


FIGURE 12-1 The interactional components of ‘natural pedagogy’ that serve for efficient knowledge transfer.

better the location information when the object is presented in non-communicative context (Yoon et al., 2008). This *genericity bias* makes it possible to learn not only about the present situation but to extend the acquired knowledge to other contexts as well. For example, if one tries to teach a novice how to use a fork, it is essentially important for the novice to understand that the conveyed information refers to a kind of artefact and not just that particular object. If the novice did not have this comprehension, it would be necessary to demonstrate the function of an artefact before each instance of usage, which would be extremely costly. This aspect of human pedagogy contributes to the accumulation of cultural knowledge (Csibra & Gergely, 2009) since the ability to learn generalizable knowledge of artefact functions saves us the trouble of having to invent everything ourselves.

On the basis of these findings, *natural pedagogy* can be conceptualised as a step-by-step social interaction process based on mutual skills in informant and recipient (Figure 12-1). An important feature of human communication that arguably cannot be found in any other animal species (Csibra, 2007) is that with its help, the information conveyed is not stalled between the boundaries of the current, but it endows the recipient with knowledge that can be efficiently used in other situations as well. As described previously, this is the crucial factor that arguably allowed for the evolvement of the complex cultural niche we live in today and the sophisticated cognitive architecture the human race is equipped with.

12.3 THE INTERACTIVE NATURE OF DOG–HUMAN COMMUNICATION AS A HALLMARK OF DOGS’ SOCIAL COMPETENCE

One of the important conclusions of the previous description of human-specific communication is that natural pedagogy opens the possibility for cognitively immature individuals (young infants) to profit from this highly

interactive system and to acquire new, relevant, and generalizable knowledge. This conclusion and recent theoretical and experimental works on dog domestication (e.g., Miklósi & Topál, 2013) raise an intriguing question: Do dogs demonstrate a human-tunedness in their communicative skills that would enable them to participate in ‘pedagogical’ knowledge transfer as recipients?

p0125 In the following sections, we focus on the notion of the existence of infant-like social competence in dogs, examining the ways in which a dog can engage in communicative interactions with humans. We argue that dogs’ interspecific social competence, which allows for the establishment of a wide range of social relationships with humans, can be characterised by some preverbal infant-like features, including the sensitivity to human eye contact and other ostensive signals as well as some understanding of the referential nature of human directional gestures.

s0040 12.3.1 Sensitivity to Human Ostensive Signals

p0130 A characteristic feature of human communication is that any action that gives evidence about the content of the corresponding informative intention of the communicator (in the form of referential gestures and the manifestation of specific knowledge with regard to the referred object/subject/event) can acquire communicative value if these behaviours are preceded or accompanied by ostensive signals. That is, ostensive signals are ‘designed’ to give evidence about the *communicative intention* of the communicator and are generally applied for initialising and maintaining communicative interactions.

s0045 12.3.1.1 Eye Contact

p0135 When communicating with a (preverbal) infant or a dog, face-to-face interactions in general and making eye contact in particular could potentially be communicatively meaningful signals. In fact, looking at each other’s eyes in a face-to-face setting triggers enhanced attention to the human’s face in infants and dogs alike. This is supported by recent investigations on ‘left gaze bias’ in dogs and human infants, which raised the possibility that the human face has a special importance for both (Guo et al., 2009). Left gaze bias, when the left hemiface is inspected first and/or for longer periods, is widely believed to be associated with the processing of facial-emotional information because this perceptual function is located in the right hemisphere, which receives visual input from the left visual field. Adult dogs demonstrate a significant left gaze bias only towards neutral human faces but not towards objects or other hetero-specific faces (Guo et al., 2009). Moreover, dogs, like humans, show a left gaze bias towards human faces expressing positive or negative emotions, but they show a similar gaze bias towards dog images only if such an image displays a threatening (negative) expression (Racca et al., 2012).

p0140 The eyes within the face are of great importance in human communication because one of the key 'ostensive' components of the signal patterns displayed during communicative interactions is eye contact. Eye contact specifically confirms for both the communicator and the recipient that the partner is 'on line' and, in addition, it is an obvious signal for the recipient that she/he is the intended addressee of the communication. The tendency to look into each other's eyes is based on face preference: ample evidence suggests that in human infants face and gaze perceptions are closely linked together from birth. Human infants innately detect eye contact (Bátki et al., 2000) and the fact that newborns show selective preference for upright faces looking at the baby (Farroni et al., 2002) suggests that eye contact has some communicative function for infants from very early on (Csibra, 2010). It is worth mentioning that in non-human primates eye contact seems to play a role in affiliative processes (social bond) and has no communicative significance. This is supported by the finding that although eye contact and face-to-face interaction can also be observed in the mother–infant interactions of rhesus macaques (Ferrari et al., 2009), these behaviour patterns gradually diminish a few weeks after birth.

p0145 Needless to say, staring at the eyes of another is a strong attention-getter for adult individuals in all (social) species (Emery, 2000) because it can signal either coercive (threatening) or prosocial (information sharing) attitudes towards the group mate. Concerning these two contradictory functions, we should note that the prosocial (information sharing) role of eye contact has become predominant during hominisation, whereas for the 'rest of the world', eye contact usually induces fear or aggression and this signal has little (if any) ostensive-communicative property. Recent evidence suggests that there is at least one notable exception to this: the domestic dog.

p0150 Interestingly, although dogs use eye contact in intraspecific situations in a wolf-like manner, this signal can carry different meaning for dogs and wolves when used in interspecific interactions (towards humans). That is, direct eye contact between dogs has little (if any) ostensive-communicative property. This signal is commonly used to indicate dominance (submissive wolves/dogs avoid eye contact with dominant members of the pack) and as a form of ritualised aggression (Schenkel, 1967). The same holds true, of course, for the use of eye contact between dogs and humans in many cases. Eye contact with an unfamiliar human in a 'threatening approach' task has the potential to evoke fear (Vas et al., 2005) and to increase heart rate (Gácsi et al., 2013) in dogs. Moreover, in a 'forced eye contact' task, dogs show less tolerance of eye contact with an unfamiliar than with a familiar human (Hernádi et al., 2012). Additionally, however, dogs often establish eye contact with humans for the same purpose people do: demanding attention, initialising communicative interaction, or just keeping in contact.

p0155 Findings from dog-wolf comparative research indicate an early emerging and permanent preference for face-to-face interactions and eye contact with humans in dogs, but not in hand-reared wolves, and support the idea that this

behaviour may reflect the dogs' adaptation to the human social environment. For example, in a reinforced eye-contact task, in which food reinforcement always followed the eye contact, dog puppies showed a significantly stronger tendency to look in the human's eye from 4 weeks of age onward (Gácsi et al., 2005). In a food search task, while the subject was waiting for a human's pointing signal, 8-week-old dogs showed significantly shorter latency to gaze at the human's face than wolves, and the difference still existed in juveniles and adults (Gácsi et al., 2009a). Moreover Gácsi et al. (2009a) found that willingness to form eye contact increases with age in dogs but not in hand-reared wolves. Virányi et al. (2008) also reported that 4-month-old dogs and wolves differ in their readiness to establish and maintain eye contact with a human while waiting to be informed in a food search task. They concluded that although wolves *can be trained* to prefer to make eye contact with a human (after extensive formal training; see Virányi et al., 2008), dogs have a *spontaneous tendency* to gaze at a human's face from very early on.

p0160 There is now ample evidence to show that dogs are willing to initiate eye contact with humans in a wide range of situations (e.g., begging: Gácsi et al., 2004; out-of-reach food task: Miklósi et al., 2000). This tendency is often studied in 'unsolvable task' paradigms, in which an experimenter baits a container with an unobtainable reward to prevent the dog from solving the task. In these conflict situations, human-directed gazing is a characteristic behavioural trait of dogs and is widely interpreted as 'requesting help' (Miklósi et al., 2000). Although the flexible use of human-directed gazing behaviour in such situations increases with age (Passalacqua et al., 2011; Hori et al. 2013) and learning experiences during ontogeny can evidently modulate communicative behaviour (Barrera et al., 2011), available results concerning the prominent role learning may play in dogs' looking at a human's face are not yet conclusive (Bentosela et al., 2008; Gaunet, 2008; Yamamoto et al., 2011). In addition to the striking individual variation (Marshall-Pescini et al., 2009; Jakovcevic et al., 2010), breed differences have also been shown to exist in dogs' tendency to make eye contact with humans in communicative situations. Interestingly, dog breeds selected for cooperative working roles (e.g., retrievers) and 'short nosed' dog breeds (in which the ganglion cells occur more centrally in the retina, enabling them to perform much more focused attention on the human, e.g., bulldogs) are better in visually guided cooperative interactions involving eye contact with humans (Passalacqua et al., 2011; Gácsi et al., 2009b). A more recent study further confirmed the role of innate factors in the individual differences in dogs' gazing to the human face. In an unsolvable task, the latency, frequency, and duration of human-directed gazing showed associations with dopamine receptor gene polymorphism (Hori et al., 2013), a gene that has been shown to be associated with different aspects of social behaviour in dogs (social impulsivity, aggressiveness: Héjjas et al., 2007; 2009) as well as in human infants (temperament, attachment: Lakatos et al., 2000; Holmboe et al., 2011).

p0165 In summary, converging evidence indicates that dogs' preference for human faces (eye contact) can be interpreted as an innate predisposition, an adaptive orientation mechanism which ensures that dogs will fixate on and learn about the most relevant social stimuli in their environment. This 'infant-like' mechanism of preferential orientation may help dogs overcome their 'wolf-like' predisposition to seeing face-to-face interactions with humans as an aversive/threatening situation. More importantly, this ensures comprehensive learning experience for young dogs about the communicative-collaborative nature of eye contact. If so, communicative skills may be a by-product of preferential attention to faces, and especially to the eye region, which may carry important communication signals (Miklósi et al., 2003).

s0050 12.3.1.2 Verbal Addressing in an Ostensive Manner

p0170 In addition to eye contact, verbal signals can also have an ostensive function because these cues, among others, can indicate that the communication is directed to a specific addressee. Importantly however, there is a difference between eye contact and verbal signals regarding their addressing function: without being able to decode the content of the speech, one cannot decide whether he is the one being addressed. Therefore, when someone initiates communicative interaction with a preverbal infant or a dog, the best way to reduce the inherent ambiguity of verbal addressing is to use a specific intonation pattern, 'motherese' (higher average pitch and exaggerated intonation contour).

p0175 In human communicative interactions, motherese is an efficient tool for disambiguating the addressee from very early on: the acoustic characteristics of infant-directed verbal signals effectively grab even few-day-old infants' attention (Cooper & Aslin, 1994). It has also been raised that the use of such characteristic intonation and rhythmic pattern has the potential to grab the dogs' attention while interacting with people (doggerel: Hirsh-Pasek & Treiman, 1982).

p0180 Empirical findings suggest that acoustic features of human verbal signals modulate dogs' responsiveness both when commanded to do an act (Fukuzawa et al., 2005) and when informed about the location of a reward (Pettersen et al., 2011; Scheider et al., 2011). In this latter study, dogs have been shown to be more responsive to human directional gestures when they were addressed in a high-pitched, 'informing' voice compared to addressing in a lower-pitch, imperative manner.

p0185 It is also worth mentioning that, as naming and eye contact are usually provided in a highly contingent manner, mentioning the name becomes 'decodable' for even preverbal infants (Newman, 2005) as a reliable signal assuring that the communicator is talking to the named subject. Although intuitively very reasonable, there is no solid evidence that the dog's own name would acquire an ostensive function via strong association with other potentially ostensive signals (eye contact, dog-directed speech). In a recent study, Kaminski et al. (2012) found that dogs react similarly to a human's directional gestures both when their name or an unfamiliar name was called in an ostensive-addressing manner.

These results suggest that for dogs, independently of the lexical meaning of the vocal communication, high-pitched dog-directed intonation pattern (like eye contact—see preceding text) is a reliable indicator of ostension. The finding that dogs do not recognise their names as specific signals indicating humans' communicative intention is further supported by [Virányi et al. \(2008\)](#), who reported that in an ambiguous situation, calling the dog's name in an imperative mode without accompanying eye contact is insufficient to evoke obedience.

p0190 Although these studies give some support for the conclusion that dog-directed verbal addressing attracts the dog's attention towards the speaker efficiently, current evidence is insufficient to assess the exact role specific intonation pattern and name calling play in making manifest the actor's communicative intention for the dog.

s0055 12.3.1.3 Combined Use of Verbal and Non-Verbal Ostensive Signals

p0195 Needless to say, verbal signals in human-to-dog communication are usually accompanied by further non-verbal signals (e.g., eye contact) that give evidence about the communicative intention of the communicator, and this can help to overcome the difficulties in interpreting the situation. In fact, in most studies of dogs' interspecific communication skills, the human communicator uses verbal addressing signals in combination with eye contact (e.g., [Ittyerah & Gaunet, 2009](#)). Dogs are highly sensitive to such combined signals, and these cues, in comparison with non-social attention-getters (e.g., sound signal or a visual marker), are not simply more salient than non-social cues, but ostensive signals are *more effective* in terms of signalling the location of a reward in an object choice context (e.g., [Agnetta et al., 2000](#); [Udell et al., 2008](#)) and can also be crucial for overcoming difficulties in observational learning tasks (e.g., [Pongrácz et al., 2004](#), but see [Range et al., 2009](#), for a more sophisticated picture).

p0200 Interestingly, dogs show a strong initial bias towards maladaptive response in object choice tasks if the inefficient or mistaken solution is cued ostensively by a human. Increasing evidence suggests that adult pet dogs readily follow deceptive pointing despite having been informed of the correct location of the reward ([Szetei et al., 2003](#)); they prefer to select an empty container despite having seen the correct one being baited ([Erdőhegyi et al., 2007](#); [Topál et al., 2009a](#)) and adopt inefficient responses in object manipulation tasks as a result of repeated observations of human action demonstrations ([Kupán et al., 2011](#)). In a quantity discrimination task, it has also been shown that after having seen a human's ostensively cued preference for a smaller amount of food, dogs change their 'natural' preference for the larger quantity and show a selection bias towards the smaller one ([Prato-Previde et al., 2008](#); [Marshall-Pescini et al., 2011](#)). Task performance in human children can also be biased by ostensive signals even when these cues serve to highlight an inefficient or mistaken solution ([Moriguchi & Itakura, 2005](#); [Topál et al., 2008](#)). It is also worth noting that in some cases learning experience can help dogs to overcome their tendency to rely 'blindly' on

ostensive-communicative signals because they are able to learn to stop responding to ostensively cued 'deceptive' pointing (e.g., [Elgier et al., 2009](#)).

p0205 More importantly, there are three experimental paradigms: the A-not-B error task ([Topál et al., 2009a; 2010; Marshall-Pescini et al., 2010; Kis et al., 2012; Sümegei et al., 2013](#)), the quantity discrimination task ([Marshall-Pescini et al., 2012](#)), and the two-way object choice task ([Kaminski et al., 2012](#)), in which the role different human ostensive signals and non-ostensive attention-getters play in dogs' communicative responsiveness was more or less systematically tested.

p0210 The findings from these experiments provide a somewhat coherent picture, and although the details are not fully understood, the main conclusions regarding how dogs perceive different manifestations of human communicative intentions can be summarised in a few points:

o0010 **1.** Dogs treat specific human behaviours not simply as discriminative cues: for dogs, human ostensive signals indicate that they are being instructed, and this is an important and often indispensable element of their readiness to respond to human referential gestures (pointing, gaze shift, etc.).

o0015 **2.** Eye contact is the 'strongest' human ostensive signal; it has a primary role in inducing specific responsiveness. High-pitched vocalisation has a secondary but still an important role in this respect, whereas calling the dog by its name is of minor importance.

o0020 **3.** Ostensively cued human behaviours can often act as imperatives for the dog, inducing a "ready-to-obey" attitude that may result from the domestication of dogs and/or from their extensive experience with humans. There is no solid evidence of a dog-like responsiveness to eye contact and verbal addressing in hand-reared wolves.

o0025 **4.** While interacting with humans, non-ostensive and/or non-social attention getting signals may also affect dogs' response; however, dogs' specific responsiveness to ostensive signals is based on the perception of the communicative intention behind the action.

s0060 **12.3.2 Interpretation Biases in Information Processing**

p0235 It is increasingly accepted that dogs can learn a lot by simply observing humans' actions, preferences, or object manipulations, especially if the human behaviour is embedded in an ostensive-communicative context. The results concerning dogs' sensitivity to ostensive signals (see preceding text) raise the possibility that they interpret these cues as indicating that further information is to be expected. Concerning the dogs' ability to profit from human communication, the intriguing question is whether they interpret and respond to human actions differently depending on whether these displays are preceded or accompanied by ostensive signals.

p0240 As pointed out previously, ostensive signals have an important modulatory role in human communicative interactions, as these signals can specifically change how (even a preverbal) human infant processes the communicator's actions (see

section 12.2.3). We also mentioned that the impact of ostensive signals on young infants' information processing can be conceptualised as two kinds of cognitive biases: *referential expectation* and *genericity assumption*. In the next section, we discuss whether dogs, in comparison with infants, show an ability to understand the referential character of human cuing and to learn something generic in an ostensive communicative context.

s0065 12.3.2.1 *Referential Expectation*

p0245 Understanding the designating function of directional gestures, or in other words, the referential interpretation of pointing or looking at an object or event is an inherent component of triadic communication (which includes the signaler, the recipient, and a target object). Such triadic or 'shared' engagement has been shown to occur in preverbal infant–adult as well as in adult dog–human interactions (e.g., [Parise et al., 2008](#); [Kaminski et al., 2009a](#); [2009b](#)).

p0250 Gaze following is one of the key indicators of a subject's involvement in triadic communication situations. Spontaneous gaze following into distant 'empty' space (i.e., even if the partner's attention is not guided by an external stimulus) has been shown to occur in young human infants as well as in many non-human species (for a review, see [Shepherd, 2010](#)). Gaze following may also occur in interspecific (human–animal) interactions: accumulating evidence suggests that corvids ([Schloegl et al., 2008](#)), great apes ([Bräuer et al., 2005](#)), and canids ([Range & Virányi 2011](#)) also show an ability to follow humans' gaze.

p0255 Gaze following in non-human subjects and preverbal infants is standardly interpreted either as a 'cognitively blind', socially facilitated orientation response that supports associative learning ([Povinelli & Eddy, 1996](#)) or as evidence of their understanding of perception and attention ([Baron-Cohen, 1991](#)). Moreover, the ability to follow the gaze of others to spaces behind barriers is often interpreted as an indicator of visual perspective taking (e.g., [Kaminski et al., 2009a](#)). All these explanations presume some understanding of the referential nature of looking; importantly however, according to these accounts, gaze following has no explicit communicative value because the response does not necessarily depend on whether or not the source of the gaze has a communicative intention.

p0260 If the communicative intention behind an object-directed gaze matters to the social partner, then gazing in a particular direction is more likely to be followed by the partner if the signal is presented in an ostensive context indicating the actor's addressee-directed communicative intention. It seems that human infants gradually acquire the ability to establish a link between referentiality and ostensive addressing: while 1–6 month-olds follow others' gaze 'reflexively' ([Hood et al., 1998](#)), older ones form strong referential expectations about the gazing behaviour of others only in ostensive-communicative contexts (e.g., [Okumura et al., 2013](#)). For preverbal infants, in addition to verbal addressing, eye contact has been shown to be a crucial factor in detecting the association between gaze direction and the target object ([Senju & Csibra, 2008](#)).

p0265 As mentioned previously, the preference to look at humans' face and to make eye contact with humans (see preceding text) might have led to enhanced skills in reading human visual attention in dogs in comparison with wolves. In fact, hand-reared wolves (who received intensive obedience training and eye contact on a daily basis), unlike pet dogs, follow a human's gaze shifts into distant space 'reflexively' (Agnetta et al., 2000; Range & Virányi, 2011).

p0270 Dogs, however, are very skillful in using human gaze in object choice situations in which they both follow and direct human gaze (for a review, see Kaminski, 2009). Ample evidence suggest that dogs are not only sensitive to whether or not a human is watching them (e.g., Kaminski et al., 2013) but are sensitive to the direction of human visual attention in various contexts; e.g., when they beg (Gácsi et al., 2004), perform forbidden actions (Call et al., 2003), or are asked to fetch an object (Kaminski et al., 2009a). Moreover, relying on the gaze direction of humans in an ostensive-addressing context, dogs are able infer who is commanded by the human experimenter (Virányi et al., 2008). These findings raise the possibility that, relying on the direction of a human's gaze, dogs generate expectations about the potential referents (i.e., who/what is the addressee/target object).

p0275 Dogs themselves also use eye contact and gazing as a component of communication in situations in which they have to direct the attention of someone to something. For example, in unsolvable problem-solving tasks, dogs, like toddlers, show an increased tendency to make eye contact and gaze alternation between the target object and the human participant (potential helper), and this supports the intentional and communicative-referential nature of gaze alternation in both dogs and children (Marshall-Pescini et al., 2013).

p0280 A few studies provide more direct evidence for the claim that dogs selectively shape referential expectations about human gaze cues. Soproni et al. (2001), for example, investigated the dog's behaviour in a two-way object choice task in which making eye contact with the dog (ostensive addressing) preceded shifts of a human's gaze either to the baited container (looking at target) or to the 'empty' space (looking above target). The finding that dogs reliably chose the baited container in the 'looking at target' condition but had difficulty doing so in the 'looking above target' condition supports the notion that in ostensive contexts they tend to interpret humans' gaze cues as referential signals. Others also concluded that the ostensive context specifically enhances the referential understanding of directional signals. Kaminski et al. (2012) reported that human gaze cues can acquire a communicative-referential meaning by preceding or accompanying ostensive signals. In another recent study using eye-tracking methods, Téglás et al. (2012) also found that dogs tend to follow a human's gaze towards a target object only if it is preceded by eye contact and high-pitched addressing. It is also noteworthy to mention that although a wide range of non-human animals (apes: Brauer et al., 2005; horses: McKinley & Sambrook, 2000; ravens: Schloegl et al., 2007) follow the gaze of humans, there is no evidence to support that any of these species (except the dog) would do this preferentially in ostensive-communicative situations.

p0285 In addition to gaze shift, human pointing gestures also seem to induce referential expectations in dogs. Ample evidence suggest that dogs, unlike wolves (Virányi et al., 2008) or apes (Povinelli et al., 1997), reliably utilise human pointing even from early puppyhood (Riedel et al., 2008), and like children, they show some capacity to generalise this knowledge to relatively unfamiliar directional gestures (Lakatos et al., 2009). Comparative evidence on the dogs' and children's performance in pointing tasks suggest that although there is considerable individual variation in both infants' and dogs' ability to understand the referential character of pointing gestures, adult pet dogs show a performance similar to 16–18-month-old toddlers (Lakatos et al., 2009; Pfandler et al., 2013).

p0290 Some have challenged these findings and propose that pointing following in dogs is based on associative learning mechanisms without any specific, 'infant-like' understanding of the human's communicative-referential intention (e.g., Wynne et al., 2008). Converging evidence, however, indicates that dogs are not simply skillful at using human pointing gestures (as a discriminative stimulus), but their response depends on contextual information including the human's communicative motive (e.g., Petterson et al., 2011; Scheider et al., 2011).

p0295 To date, there is no consensus regarding the question whether dogs perceive human pointing in an ostensive context as an informative gesture (e.g., informing them about the location of the reward) or as an imperative order (i.e., a strong command that has to be obeyed). There are indications that dogs often tend to interpret pointing and other referential gestures as more or less strong imperatives (Topál et al., 2009a; Kaminski et al., 2012; Kirchhofer et al., 2012; Kis et al., 2012), whereas others suggest that for dogs human pointing falls somewhere between informing signal and imperative command, a suggestion, which, in some situations, can be ignored (Scheider et al., 2013). The imperative-referential nature of pointing is also supported by the fact that human pointing can even outweigh dogs' spatial bias to search for an object where they saw it disappear (Plourde & Fiset, 2013). It is also worth mentioning that, unlike in human children, referential understanding of human directional signals in dogs seems to be limited to cooperative contexts (Wobber & Hare 2009; Petterson et al., 2011).

s0070 12.3.2.2 *Genericity Assumption*

p0300 As mentioned previously, even preverbal infants can acquire generalizable information by communication. This is so because in addition to referential expectation, there is another interpretation bias in social information processing: in ostensive contexts, infants tend to assume that "they are supposed to learn something generic" (Csibra, 2010). In contrast, dogs do not seem to show a similar bias to receive generic information about objects or events in ostensive contexts; they tend to pick up information from the communication that is restricted to the 'here and now'.

p0305 The difference between dogs and preverbal infants is clearly shown by those studies in which [Topál et al. \(2008; 2009b\)](#) investigated how ostensive communication affects the perseverative search error in the A-not-B object search tasks. These studies reported that the A-not-B search error—the phenomenon that subjects repeatedly look for a hidden object at an initial hiding place (A) even after the object has been displaced in full view of them—is strongly tied to the ostensive-communicative character of the object hiding action in both dogs and preverbal infants. These results raise the possibility that if one location is misleadingly indicated by the human's ostensive signals, this may be interpreted by the subject either as communicating information about some generalizable property of the referent kind (e.g., “this type of object is usually found in container A”) or as ‘imperatives’ with the function of performing the observed action (e.g., “produce search behaviour at location A”).

p0310 As one of the crucial components of the A-not-B task is the identity of the person that dogs/infants interact with, [Topál et al. \(2009b\)](#) also investigated how they react if, after the ‘A’ trials, the identity of the hiding person is changed and a new experimenter continues hiding the object at the new location. They hypothesised that if the ostensive hiding action were interpreted as an imperative order associated with a specific ‘instructor’, then the perseverative search bias might be expected to diminish during the ‘B’ trials. In contrast, if the ostensive hiding action is (mis-)interpreted as conveying some generalizable information about the type of the hidden object or the function of the hiding location that is not related to the identity of the particular demonstrator, switching the experimenter should not reduce the tendency to commit the A-not-B error.

p0315 The finding that dogs did not persevere after switching the experimenter confirms the hypothesis that they did not extend the scope of the learned imperative to the new context but anchored communication to the episodic situation and to the specific communicator. Infants, however, tended to generalise their erroneously learnt object-finding action to the new person context probably due to their bias to expect generic information that could lead to a misinterpretation of communication and to such characteristic errors ([Topál et al., 2009a](#)).

s0075 **12.4 SUMMARY AND CONCLUSIONS ON THE ‘INFANT-LIKENESS’ OF DOGS’ COMMUNICATION SKILLS**

p0320 The experimental findings presented in the preceding sections provide strong support for the idea that social competence in dogs has been affected by the challenges of the human social environment. We propose that as a consequence of these adaptation requirements (i) dogs have evolved some special skills for interacting and communicating with humans, (ii) these skills provide the basis for the emergence of a more ‘infant-like’ and less ‘wolf-like’ social competence in the dog, which (iii) makes this species remarkably adept at learning from humans in communicative contexts.

- p0325 More specifically, recent studies provide corroborating evidence that similarly to preverbal human infants, dogs fulfil at least two out of three operational criteria for being a recipient in ‘pedagogical’ knowledge transfer.
- p0330 First, dogs show special sensitivity to ostensive cues that signal the human’s communicative intention, and they also show some evidence of recognising the information transferring nature of communicative contexts. As in infants, ostensive-communicative cues have the potential to guide the dogs’ attention and influence their inferences and interpretations in human–dog interactions.
- p0335 Second, dogs seem to comprehend the referential character of human cuing in a way similar to human infants. Dogs show differential sensitivity to human directional signals (gaze-shift, pointing) in communicative contexts as compared to non-ostensive situations. The finding that ostensive-communicative addressing signals facilitate, for example, gaze-following behaviour in dogs suggests that for dogs human ostensive signals indicate that they are being instructed (i.e., the communicator has an informative intention).
- p0340 Importantly, however, human ostensive-communicative referential signals seem insufficient to create an ‘infant-like’ expectation to receive generic information about objects or events in dogs. That is, whereas in infants ostensive signals induce a specific receptive attitude towards learning something generic, it seems that in dogs, an ostensive context induces a ‘ready-to-learn’ or ‘ready-to-obey’ attitude that is largely tied to the here and now. However, regardless of its generic or episodic character, an important consequence of this receptive attitude is that both dogs and infants are willing to reproduce those cognitively ‘opaque’ actions that they have seen in a communicative referential context even if the action is unusual or represents a counterproductive solution to the problem. Thus, the adaptive function of dogs’ interspecific communicative skills can be conceptualised as not (only) knowledge acquisition from human partners but as facilitating behavioural synchronisation in order to avoid conflicts and/or to co-act in terms of common actions without necessarily comprehending the causal structure of the collaborative interaction. There is no denying that communication always involves some kind of coordination among partners. But it seems that in dog–human ostensive-communicative interactions the essential coordination is not about the interpretation of contextual cues (what is mutually assumed) but simply on the manner in which the recipient (dog) will respond to the human’s communicative act.
- p0345 Infants’ receptivity to ostensive signals may also have the social function of achieving a higher level of interactional synchrony. In fact, synchronising activities have a general facilitating effect on the interaction of human partners, and such activities are often guided by ostensive signals. Synchronisation is essential for group cohesion (Engel & Lamprecht, 1997), and in humans, it can be achieved by the employment of different means, such as the tendency to follow social rules (de Waal, 1996), the ability for emotional contagion (Hatfield et al., 1993) and imitative learning skills, assuring a high level of behavioural conformity between partners (Meltzoff, 1999).

p0350 Dogs are also equipped with abilities that are crucial in establishing behaviour synchrony, and these abilities are often tied to ostensive contexts (see Figure 12-2). For example, recent studies provide evidence of social referencing in dog-human interactions: dogs readily use the emotional information provided by a human about a novel object to guide their own behaviour towards it (Merola et al., 2012). There is also empirical evidence suggesting empathy-based emotionally connected yawn contagion in dogs (Silva et al., 2013). Moreover, dogs can efficiently use human behaviour as a cue for selecting functionally similar behaviour (Fugazza & Miklósi, 2013), and it has also been reported that dogs are inclined to follow social rules of the group in both the short (Topál et al., 2005) and the long term (Kubinyi et al., 2003).

p0355 It is also noteworthy to mention that dogs, like preverbal infants, are extremely proficient in using signals that reliably indicate human communicative or informative intentions, even if they cannot fully understand the 'message' (i.e., the content of this intention). Although ostensive-referential communicative interactions are often described as a process in which partners intentionally try to influence each other's mental state while viewing the partner's ostensive signals as the offering of evidence for communicative intentions (Sperber & Wilson, 1986), this is just one way in which more sophisticated agents may interact, and there are other, cognitively less demanding ways to interact communicatively. In fact, a basic act of communication involves one agent drawing another agent's attention to a situation. As the communicative situation is a shared situation, it is a potential source of shared knowledge and intentions. Importantly, however, an agent (dog or preverbal infant) can recognise the shared nature of the ostensively guided situation without being able to recognise that the content of the communication (the manifested knowledge) is also shared between the partners. That is, dogs as well as infants can grasp the explicit or overt dimension of

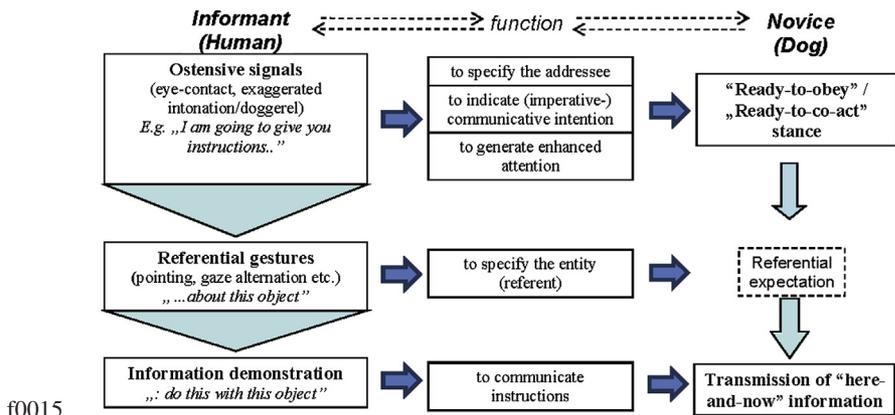


FIGURE 12-2 The interactional components of dog-human communicative interaction.

communication without any sophisticated mind-reading abilities or conceptual thinking skills.

p0360 Thus, we propose that those motivational processes and cognitive skills that enable dogs (and preverbal infants) to (1) monitor, (2) gain, (3) maintain, and (4) shift attention while interacting with humans and to (5) share a common focus on something with the human partner can be regarded as the ‘minimum requirements’ for socially competent responding in ostensive-communicative situations.

p0365 Accordingly, dogs’ and preverbal infants’ receptivity to ostensive-communicative signals are not necessarily tied to complex mental processing, and it is still unclear whether a particular type of self-knowing consciousness is involved in initiating communicative interactions and responding to the manifestation of communicative intention in others. Despite the fact that dogs’ reactions and expectations help them to act in line with the presumed content of the communicative interaction, we are not necessarily entitled to call this phenomenon ‘recognition’ of intention. Although dogs’ sensitivity to human communication is unprecedented among non-human animals, for them, human ostensive signals may simply act as reliable signs for anticipating further informative stimuli, and we have no reason to suppose a recognition of the ‘conceptual bond’ between the communicative and the informative intent of the human.

p0370 In summary, although we may say that recent research effort in the field of dogs’ social cognition raises more research questions than it answers, the generally consistent pattern of findings that emerged from the previously cited studies provide an increasingly firm basis for understanding what is ‘infant-like’ about dogs’ interspecific communication skills.

b0010 **Future Directions**

- Dogs seem to be especially attuned to human ostensive communication. The idea of infant likeness of dogs’ social competence, however, requires further systematic comparative investigations (between wolves, dogs, and children).
- There is also a compelling need for more systematic investigation of the relative importance of different types of human ostensive signals (e.g., eye contact, name calling, specific intonation) in dogs’ communicative responsiveness.
- It is also unknown whether or not dogs can recognise the ostensive nature of those turn-taking situations in which a human partner initiates contingent responding (an essential structural property of human communicative exchanges).
- The role of associative reinforcement learning in dogs’ communicative responsiveness is strongly debated. Results are still largely inconsistent due to a lack of systematic data collection and properly controlled experiments. Further comparative (and longitudinal) studies between dogs and human infants would be necessary to clarify the exact role of individual experience (associative learning) in both species.

ACKNOWLEDGEMENTS

p0375 This work was supported by the Hungarian Scientific Research Fund (OTKA K100695).

s0080 REFERENCES

- Agnetta, B., Hare, B.A., Tomasello, M., 2000. Cues to food location that domestic dogs (*Canis familiaris*) of different ages do and do not use. *Anim. Cogn.* 3, 107–112.
- Baron-Cohen, S., 1991. Precursors to a theory of mind: Understanding attention in others. In: Whiten, A. (Ed.), *Natural theories of mind. evolution, development, and simulation of everyday mindreading*. Blackwell, Oxford, pp. 39–50.
- Barrera, G., Mustaca, A., Bentosela, M., 2011. Communication between domestic dogs and humans: effects of shelter housing upon the gaze to the human. *Anim. Cogn.* 14, 727–734.
- Bátki, A., Baron-Cohen, S., Wheelwright, S., Connelan, J., Ahluwalia, J., 2000. Is there an innate gaze module? Evidence from human neonates. *Infant Behav. Dev.* 23, 223–229.
- Bensky, M.K., Gosling, S.D., Sinn, D.L., 2013. The world from a dog's point of view: a review and synthesis of dog cognition research. *Adv. S. Behav.* 45, 209–406.
- Bentosela, M., Barrera, G., Jakovcevic, A., Elgier, A.M., Mustaca, A.E., 2008. Effect of reinforcement, reinforcer omission and extinction on a communicative response in domestic dogs (*Canis familiaris*). *Behav. Proc.* 78, 464–469.
- Bloom, P., 2004. Can a dog learn a word? *Science* 304, 1605–1606.
- Boesch, C., Marchesi, P., Marchesi, N., Fruth, B., Joulain, F., 1994. Is nut cracking in wild chimpanzees a cultural behaviour? *J. Hum. Evol.* 26, 325–338.
- Bräuer, J., Call, J., Tomasello, M., 2005. All great ape species follow gaze to distant locations and around barriers. *J. Comp. Psychol.* 119, 145–154.
- Bräuer, J., Kaminsky, J., Riedel, J., Call, J., Tomasello, M., 2006. Making inferences about the location of hidden food: social dog, causal ape. *J. Comp. Psychol.* 120, 38–47.
- Butler, L.P., Markman, E.M., 2010. Pedagogical cues influence children's inductive inference and exploratory play. In: Ohlsson, S., Catrambone, R. (Eds.), *Proceedings of the 32nd annual meeting of the Cognitive Science Society*. Cognitive Science Society, Austin, TX, pp. 1417–1422.
- Call, J., Bräuer, J., Kaminsky, J., Tomasello, M., 2003. Domestic dogs are sensitive to the attentional state of humans. *J. Comp. Psychol.* 117, 257–263.
- Cooper, R.P., Aslin, R.N., 1994. Developmental differences in infant attention to the spectral properties of infant-directed speech. *Child Dev.* 65, 1663–1677.
- Csibra, G., 2007. Teachers in the wild. *Trends Cogn. Sci.* 11, 95–96.
- Csibra, G., 2010. Recognizing communicative intentions in infancy. *Mind Lang.* 25, 141–168.
- Csibra, G., Gergely, G., 2006. Social learning and social cognition: The case for pedagogy. *Processes of change in brain and cognitive development. Atten. and Perform.* XXI, 249–274.
- Csibra, G., Gergely, G., 2009. Natural pedagogy. *Trends Cogn. Sci.* 13, 148–153.
- Csibra, G., Volein, A., 2008. Infants can infer the presence of hidden objects from referential gaze information. *Br. J. Dev. Psychol.* 26, 1–11.
- Elgier, A.M., Jakovcevic, A., Barrera, G., Mustaca, A.E., Bentosela, M., 2009. Learning and owner-stranger effects on interspecific communication in domestic dogs (*Canis familiaris*). *Behav. Proc.* 81, 44–49.
- Emery, N.J., 2000. The eyes have it: the neuroethology, function and evolution of social gaze. *Neurosci. Biobehav. Rev.* 24, 581–604.
- Engel, J., Lamprecht, J., 1997. Doing what everybody does? A procedure for investigating behavioural synchronization. *J. Theor. Biol.* 185, 255–262.

- Erdőhegyi, Á., Topál, J., Virányi, Zs., Miklósi, Á., 2007. Dogs use inferential reasoning in a two-way choice task—only if they cannot choose on the basis of human-given cues. *Anim. Behav.* 74, 725–737.
- Farroni, T., Csibra, G., Simion, F., Johnson, M.H., 2002. Eye contact detection in humans from birth. *Proc. Natl. Acad. Sci. USA* 99, 9602–9605.
- Ferrari, P.F., Paukner, A., Ionica, C., Suomi, S.J., 2009. Reciprocal face-to-face communication between rhesus macaque mothers and their newborn infants. *Curr. Biol.* 19, 1768–1772.
- Fugazza, C., Miklósi, Á., 2013. Deferred imitation and declarative memory in domestic dogs. *Anim. Cogn.* <http://dx.doi.org/10.1007/s10071-013-0656-5>. in press.
- Fukuzawa, M., Mills, D.S., Cooper, J.J., 2005. More than just a word: non-semantic command variables affecting obedience in the domestic dog (*Canis familiaris*). *Appl. Anim. Behav. Sci.* 91, 129–141.
- Gácsi, M., Győri, B., Miklósi, Á., Virányi, Z.S., Kubinyi, E., Topál, J., Csányi, V., 2005. Species-specific differences and similarities in the behavior of hand raised dog and wolf puppies in social situations with humans. *Dev. Psychobiol.* 47, 111–122.
- Gácsi, M., Győri, B., Virányi, Z., Kubinyi, E., Range, F., Belényi, B., Miklósi, Á., 2009a. Explaining dog wolf differences in utilizing human pointing gestures: selection for synergistic shifts in the development of some social skills. *PLoS One* 4, e6584.
- Gácsi, M., Maros, K., Sernkvist, S., Faragó, T., Miklósi, Á., 2013. Human analogue safe haven effect of the owner: behavioural and heart rate response to stressful social stimuli in dogs. *PLoS One* 8, e58475.
- Gácsi, M., McGreevy, P., Kara, E., Miklósi, Á., 2009b. Effects of selection for cooperation and attention in dogs. *Behav. Brain Func.* 5, 31.
- Gácsi, M., Miklósi, Á., Varga, O., Topál, J., Csányi, V., 2004. Are readers of our face readers of our minds? Dogs (*Canis familiaris*) show situation-dependent recognition of human's attention. *Anim. Cogn.* 7, 144–153.
- Gaunet, F., 2008. How do guide dogs of blind owners and pet dogs of sighted owners (*Canis familiaris*) ask their owners for food? *Anim. Cogn.* 11, 475–483.
- Grice, H.P., 1989. *Studies in the Way of Words*. Harvard University Press, Cambridge, MA. p. 406.
- Guo, K., Meints, K., Hall, C., Hall, S., Mills, D., 2009. Left gaze bias in humans, rhesus monkeys and domestic dogs. *Anim. Cogn.* 12, 409–418.
- Hare, B., Tomasello, M., 2004. Chimpanzees are more skilful in competitive than in cooperative cognitive tasks. *Anim. Behav.* 68, 571–581.
- Hare, B., Tomasello, M., 2005. One way social intelligence can evolve: the case of domestic dogs. *Trends Cogn. Sci.* 9, 439–444.
- Hatfield, E., Cacioppo, J.T., Rapson, R.L., 1993. Emotional contagion. *Curr. Dir. Psychol. Sci.* 2, 96–99.
- Héjjas, K., Kubinyi, E., Rónai, Z., Székely, A., Vas, J., Miklósi, Á., Sasvári-Székely, M., Kereszturi, E., 2009. Molecular and behavioral analysis of the intron 2 repeat polymorphism in the canine dopamine D4 receptor gene. *Genes Brain Behav.* 8, 330–336.
- Héjjas, K., Vas, J., Topál, J., Szántai, E., Rónai, Z., Székely, A., Kubinyi, E., Horváth, Z., Sasvári-Székely, M., Miklósi, Á., 2007. Association of polymorphisms in the dopamine D4 receptor gene and the activity-impulsivity endophenotype in dogs. *Anim. Gen.* 38, 629–633.
- Hernádi, A., Kis, A., Turcsán, B., Topál, J., 2012. Man's underground best friend: domestic ferrets, unlike the wild forms, show evidence of dog-like social-cognitive skills. *PLoS One* 7, e73267.
- Hirsh-Pasek, K., Treiman, R., 1982. Doggerel: motherese in a new context. *J. Child Lang.* 9, 229–237.
- Holmboe, K., Nemoda, Z.S., Fearon, R.M.P., Sasvári-Székely, M., Johnson, M.H., 2011. Dopamine D4 receptor and serotonin transporter gene effects on the longitudinal development of infant temperament. *Genes Brain Behav.* 10, 513–522.

- Hood, B.M., Willen, J.D., Driver, J., 1998. Adult's eyes trigger shifts of visual attention in human infants. *Psychol. Sci.* 9, 131–134.
- Hori, Y., Kishi, H., Inoue-Murayama, M., Fujita, K., 2013. Dopamine receptor D4 gene (DRD4) is associated with gazing toward humans in domestic dogs (*Canis familiaris*). *Open J. Anim. Sci.* 3, 54–58.
- Horn, L., Virányi, Z., Miklósi, Á., Huber, L., Range, F., 2012. Domestic dogs (*Canis familiaris*) flexibly adjust their human-directed behavior to the actions of their human partners in a problem situation. *Anim. Cogn.* 15, 57–71.
- Inoue-Nakamura, N., Matsuzawa, T., 1997. Development of stone tool use by wild chimpanzees (*Pan troglodytes*). *J. Comp. Psychol.* 111 (2), 159.
- Ittyerah, M., Gaunet, F., 2009. The response of guide dogs and pet dogs (*Canis familiaris*) to cues of human referential communication (pointing and gaze). *Anim. Cogn.* 12, 257–265.
- Jakovcevic, A., Elgier, A.M., Mustaca, A.E., Bentosela, M., 2010. Breed differences in dogs' (*Canis familiaris*) gaze to the human face. *Behav. Proc.* 84, 602–607.
- Kaminski, J., 2009. Dogs (*Canis familiaris*) are adapted to receive human communication. In: Berthoz, A., Christen, Y. (Eds.), *Neurobiology of Umwelt: how living beings perceive the world*. Springer Verlag, Berlin, pp. 103–107.
- Kaminski, J., Bräuer, J., Call, J., Tomasello, M., 2009a. Domestic dogs are sensitive to a human's perspective. *Behaviour* 146, 979–998.
- Kaminski, J., Pitsch, A., Tomasello, M., 2013. Dogs steal in the dark. *Anim. Cogn.* <http://dx.doi.org/10.1007/s10071-012-0579-6>. in press.
- Kaminski, J., Schulz, L., Tomasello, M., 2012. How dogs know when communication is intended for them. *Dev. Sci.* 15, 222–232.
- Kaminski, J., Tempelmann, S., Call, J., Tomasello, M., 2009b. Domestic dogs comprehend human communication with iconic signs. *Dev. Sci.* 12, 831–837.
- Király, I., Csibra, G., Gergely, G., 2013. Beyond rational imitation: learning arbitrary means actions from communicative demonstrations. *J. Exp. Child Psychol.* in press. DOI 0.1016/j.jecp.2012.12.003.
- Kirchhofer, K.K.C., Zimmermann, F., Kaminski, J., Tomasello, M., 2012. Dogs (*Canis familiaris*), but not chimpanzees (*Pan troglodytes*), understand imperative pointing. *PLoS One* 7, e30913.
- Kis, A., Topál, J., Gácsi, M., Range, F., Huber, L., Miklósi, Á., Virányi, Z., 2012. Does the A-not-B error in adult pet dogs indicate sensitivity to human communication? *Anim. Cogn.* 15, 737–743.
- Kubinyi, E., Miklósi, Á., Topál, J., Csányi, V., 2003. Social mimetic behaviour and social anticipation in dogs: preliminary results. *Anim. Cogn.* 6, 57–63.
- Kupán, K., Miklósi, Á., Gergely, G., Topál, J., 2011. Why do dogs (*Canis familiaris*) select the empty container in an observational learning task? *Anim. Cogn.* 14, 259–268.
- Lakatos, G., Soproni, K., Dóka, A., Miklósi, Á., 2009. A comparative approach to dogs' (*Canis familiaris*) and human infants' comprehension of various forms of pointing gestures. *Anim. Cogn.* 12, 621–631.
- Lakatos, K., Tóth, I., Nemoda, Z., Ney, K., Sasváry-Székely, M., Gervai, J., 2000. Dopamine D4 receptor (DRD4) gene polymorphism is associated with attachment disorganization in infants. *Mol. Psychiatry* 5, 633–637.
- Marshall-Pescini, S., Colombo, E., Passalacqua, C., Merola, I., Prato-Previde, E., 2013. Gaze alternation in dogs and toddlers in an unsolvable task: evidence of an audience effect. *Anim. Cogn.* <http://dx.doi.org/10.1007/s10071-013-0627-x>. in press.
- Marshall-Pescini, S., Passalacqua, C., Barnard, S., Valsecchi, P., Prato-Previde, E., 2009. Agility and search and rescue training differently affects pet dogs' behaviour in socio-cognitive tasks. *Behav. Proc.* 81, 416–422.

- Marshall-Pescini, S., Passalacqua, C., Miletto Petrazzini, M.E., Valsecchi, P., Prato-Previde, E., 2012. Do dogs (*Canis lupus familiaris*) make counterproductive choices because they are sensitive to human ostensive cues? *PLoS One* 7, e35437.
- Marshall-Pescini, S., Passalacqua, C., Valsecchi, P., Prato-Previde, E., 2010. Comment on “Differential sensitivity to human communication in dogs”. *Science* 329, 142–c.
- Marshall-Pescini, S., Prato-Previde, E., Valsecchi, P., 2011. Are dogs (*Canis familiaris*) misled more by their owners than by strangers in a food choice task? *Anim. Cogn.* 14, 137–142.
- Marshall-Pescini, S., Whiten, A., 2008. Social learning of nut-cracking behavior in East African sanctuary-living chimpanzees (*Pan troglodytes schweinfurthii*). *J. Comp. Psychol.* 122, 186–194.
- McKinley, J., Sambrook, T.D., 2000. Use of human-given cues by domestic dogs (*Canis familiaris*) and horses (*Equus caballus*). *Anim. Cogn.* 3, 13–22.
- Meltzoff, A.N., 1999. Born to learn: what infants learn from watching us. In: Fox, N., Worhol, J.G. (Eds.), *The role of early experience in infant development*. Pediatric Institute Publications, Skillman, NJ.
- [AU1] Merola, I., Prato-Previde, E., Marshall-Pescini, M., 2012. Dogs’ social referencing towards owners and strangers. *PLoS One* 7 (10), e47653. <http://dx.doi.org/10.1371/journal.pone.0047653>.
- Miklósi, Á., Kubinyi, E., Topál, J., Gácsi, M., Virányi, Z., Csányi, V., 2003. A simple reason for a big difference: wolves do not look back at humans but dogs do. *Curr. Biol.* 13, 763–766.
- Miklósi, Á., Polgárdi, R., Topál, J., Csányi, V., 2000. Intentional behaviour in dog–human communication: an experimental analysis of ‘showing’ behaviour in the dog. *Anim. Cogn.* 3, 159–166.
- Miklósi, Á., Topál, J., 2012. The evolution of canine cognition. In: Vonk, J., Shackelford, T. (Eds.), *The Oxford handbook of comparative evolutionary psychology*. Oxford University Press, Oxford, pp. 513–568.
- Miklósi, Á., Topál, J., 2013. What does it take to become “best friends”? Evolutionary changes in canine social competence. *Trends Cogn. Sci.* 17, 287–294.
- Mitchell, R.W., 2001. Americans’ talk to dogs: similarities and differences with talk to infants. *Res. Lang. Soc. Int.* 34, 183–210.
- Moll, H., Tomasello, M., 2007. Cooperation and human cognition: the Vygotskian intelligence hypothesis. *Phil. Trans. Roy. Soc. B: Biol. Sci.* 362, 639–648.
- Moriguchi, Y., Itakura, S., 2005. Does pointing comprehension disturb controlling action? Evidence from 2-year-old children. *Proc. 4th IEEE Int. Conf. Dev. Learn.*, 102–105.
- Newman, R.S., 2005. The cocktail party effect in infants revisited: listening to one’s name in noise. *Dev. Psychol.* 41, 352–362.
- Okumura, Y., Kanakogi, Y., Kanda, T., Ishiguro, H., Itakura, S., 2013. Infants understand the referential nature of human gaze but not robot gaze. *J. Exp. Child Psychol.* 116, 86–95.
- Oliveira, R.F., 2009. Social behavior in context: hormonal modulation of behavioral plasticity and social competence. *Int. Comp. Biol.* 49, 423–440.
- Ostojic, L., Clayton, N.S., 2013. Behavioural coordination of dogs in a cooperative problem-solving task with a conspecific and a human partner. *Anim. Cogn.* <http://dx.doi.org/10.1007/s10071-013-0676-1>. in press.
- Passalacqua, C., Marshall-Pescini, S., Barnard, S., Lakatos, G., Valsecchi, P., Prato-Previde, E., 2011. Human-directed gazing behaviour in puppies and adult dogs, *Canis lupus familiaris*. *Anim. Behav.* 82, 1043–1050.
- Pettersson, H., Kaminski, J., Herrmann, E., Tomasello, M., Kaminski, J., 2011. Understanding of human communicative motives in domestic dogs. *Appl. Anim. Behav. Sci.* 133, 235–245.
- Pfandler, E., Lakatos, G., Miklósi, Á., 2013. Eighteen-month-old human infants show intensive development in comprehension of different types of pointing gestures. *Anim. Cogn.* <http://dx.doi.org/10.1007/s10071-013-0606-2>. in press.

- Pongrácz, P., Miklósi, Á., Timar-Geng, K., Csányi, V., 2004. Verbal attention getting as a key factor in social learning between dog (*Canis familiaris*) and human. *J. Comp. Psychol.* 118, 375–383.
- Povinelli, D.J., Reaux, J.E., Bierschwale, D.T., Allain, A.D., Simon, B.B., 1997. Exploitation of pointing as a referential gesture in young children, but not adolescent chimpanzees. *Cogn. Dev.* 12, 423–461.
- Povinelli, D.J., Eddy, T.J., 1996. Factors influencing young chimpanzees' (*Pan troglodytes*) recognition of attention. *J. Comp. Psychol.* 110, 336–345.
- Parise, E., Reid, V.M., Stets, M., Striano, T., 2008. Direct eye contact influences the neural processing of objects in 5-month-old infants. *Soc. Neurosci.* 3, 141–150.
- Plourde, V., Fiset, S., 2013. Pointing gestures modulate domestic dogs' search behavior for hidden objects in a spatial rotation problem. *Learning and Motivation*. <http://dx.doi.org/10.1016/j.lmot.2013.03.004>. in press.
- Prato-Previde, E., Marshall-Pescini, S., Valsecchi, P., 2008. Is your choice my choice? The owners' effect on pet dogs' (*Canis lupus familiaris*) performance in a food choice. *Anim. Cogn.* 11, 167–174.
- Racca, A., Guo, K., Meints, K., Mills, D.S., 2012. Reading faces: differential lateral gaze bias in processing canine and human facial expressions in dogs and 4-year-old children. *PLoS One* 7, e36076.
- Range, F., Virányi, Z., 2011. Development of gaze following abilities in wolves (*Canis lupus*). *PLoS One* 6, e16888.
- Range, F., Heucke, S.L., Gruber, C., Konz, A., Huber, L., Virányi, Z., 2009. The effect of ostensive cues on dogs' performance in a manipulative social learning task. *Appl. Anim. Behav. Sci.* 120, 170–178.
- Reid, P.J., 2009. Adapting to the human world: dogs' responsiveness to our social cues. *Behav. Proc.* 80, 325–333.
- Rekers, Y., Haunsend, D.B.M., Tomasello, M., 2011. Children, but not chimpanzees, prefer to collaborate. *Curr. Biol.* 21, 1756–1758.
- Richerson, P.J., Boyd, R., 1998. The evolution of human ultra-sociality. In: Eibl-Eibesfeldt, I., Salter, F. (Eds.), *Ideology, warfare, and indoctrinability*. Berghen Books, Oxford, New York, pp. 71–95.
- Riedel, J., Schumann, K., Kaminski, J., Call, J., Tomasello, M., 2008. The early ontogeny of human–dog communication. *Anim. Behav.* 73, 1003–1014.
- Scheider, L., Grassmann, S., Kaminski, J., Tomasello, M., 2011. Domestic dogs use contextual information and tone of voice when following a human pointing gesture. *PLoS One* 6, e21676.
- Scheider, L., Kaminski, J., Call, J., Tomasello, M., 2013. Do domestic dogs interpret pointing as a command? *Anim. Cogn.* 16, 361–372.
- Schenkel, R., 1967. Submission: Its features and function in wolf and dog. *Am. Zool.* 7, 319–329.
- Schloegl, C., Kotschal, K., Bugnyar, T., Lorenz, K., Gru, F., 2007. Gaze following in common ravens, *Corvus corax*: ontogeny and habituation. *Anim. Behav.* 74, 769–778.
- Schloegl, C., Schmidt, J., Scheid, C., Kotschal, K., Bugnyar, T., 2008. Gaze following in non-human animals: the corvid example. In: Columbus, F. (Ed.), *Animal behaviour: new research*. Nova Science Publishers, New York, pp. 73–92.
- Senju, A., Csibra, G., 2008. Gaze following in human infants depends on communicative signals. *Curr. Biol.* 18, 668–671.
- Senju, A., Csibra, G., Johnson, M.H., 2008. Understanding the referential nature of looking: infants' preference for object-directed gaze. *Cognition* 108, 303–319.
- Shepherd, S.V., 2010. Following gaze: gaze-following behavior as a window into social cognition. *Front. Integr. Neurosci.* 4 (5). <http://dx.doi.org/10.3389/fnint.2010.00005>.
- Silva, K., Bessa, J., Sousa, L., 2013. Familiarity-connected or stress-based contagious yawning in domestic dogs (*Canis familiaris*)? Some additional data. *Anim. Cogn.* <http://dx.doi.org/10.1007/s10071-013-0669-0>. in press.

- Soproni, K., Miklósi, Á., Topál, J., Csányi, V., 2001. Comprehension of human communicative signs in pet dogs. *J. Comp. Psychol.* 115, 122–126.
- Southgate, V., Chevallier, C., Csibra, G., 2009. Sensitivity to communicative relevance tells young children what to imitate. *Dev. Sci.* 12, 1013–1019.
- Sperber, D., Wilson, D., 1986. *Relevance: communication and cognition*. Harvard University Press, Cambridge, MA. 142.
- Sümegei, Z., Kis, A., Miklósi, Á., Topál, J., 2013. Why do adult dogs (*Canis familiaris*) commit the A-not-B search error? *J. Comp. Psychol.* in press.
- Szetei, V., Miklósi, Á., Topál, J., Csányi, V., 2003. When dogs seem to lose their nose: an investigation on the use of visual and olfactory cues in communicative context between dog and owner. *Appl. Anim. Behav. Sci.* 83, 141–152.
- Taborsky, B., Oliveira, R.F., 2012. Social competence: an evolutionary approach. *Trends Cogn. Sci.* 27, 679–688.
- Téglás, E., Gergely, A., Kupán, K., Miklósi, Á., Topál, J., 2012. Dogs' gaze following is tuned to human communicative signals. *Curr. Biol.* 22, 209–212.
- Tehrani, J.J., Riede, F., 2008. Towards an archaeology of pedagogy: learning, teaching and the generation of material culture traditions. *World Archaeology* 40 (3), 316–331.
- Topál, J., Gergely, G., Erdőhegyi, Á., Csibra, G., Miklósi, Á., 2009a. Differential sensitivity to human communication in dogs, wolves, and human infants. *Science* 325, 1269–1272.
- Topál, J., Gergely, G., Miklósi, Á., Erdőhegyi, Á., Csibra, G., 2008. Infants' perseverative search errors are induced by pragmatic misinterpretation. *Science* 321 (5897), 1831–1834.
- Topál, J., Kubinyi, E., Gácsi, M., Miklósi, Á., 2005. Obeying social rules: a comparative study on dogs and humans. *J. Cult. Evol. Psychol.* 3, 213–238.
- Topál, J., Miklósi, Á., Gácsi, M., Dóka, A., Pongrácz, P., Kubinyi, E., Virányi, Z., Miklósi, Á., Csányi, V., 2009b. The dog as a model for understanding human social behavior. *Adv. S. Behav.* 39, 71–116.
- Topál, J., Miklósi, Á., Sümegei, Z., Kis, A., 2010. Response to comments on "Differential sensitivity to human communication in dogs, wolves and human infants." *Science* 329, 142d, 1624.
- Udell, M.A.R., Dorey, N.R., Wynne, C.D.L., 2008. Wolves outperform dogs in following human social cues. *Anim. Behav.* 76, 1767–1773.
- Udell, M.A.R., Dorey, N.R., Wynne, C.D.L., 2009. What did domestication do to dogs? A new account of dogs' sensitivity to human actions. *Biol. Rev.* 85, 327–345.
- Vas, J., Topál, J., Gácsi, M., Miklósi, Á., Csányi, V., 2005. A friend or an enemy? Dogs' reaction to an unfamiliar person showing behavioural cues of threat and friendliness at different times. *Appl. Anim. Behav. Sci.* 94, 99–115.
- Virányi, Z., Gácsi, M., Kubinyi, E., Topál, J., Belényi, B., Ujfalussy, D., Miklósi, Á., 2008. Comprehension of human pointing gestures in young human-reared wolves and dogs. *Anim. Cogn.* 11, 373–387.
- de Waal, F.B.M., 1996. *Good natured: The origins of right and wrong in humans and other animals*. Harvard University Press, Cambridge, MA.
- Wobber, V., Hare, B., 2009. Testing the social dog hypothesis: are dogs also more skilled than chimpanzees in non-communicative social tasks? *Behav. Proc.* 81, 423–428.
- Wynne, C.D.L., Udell, M.A.R., Lord, K., 2008. Ontogeny's impacts on human–dog communication. *Anim. Behav.* 76, e1–e4.
- Yamamoto, M., Ohtani, N., Ohta, M., 2011. The response of dogs to attentional focus of human beings: a comparison between guide dog candidates and other dogs. *J. Vet. Behav. Clin. Appl. Res.* 6, 4–11.
- Yoon, J.M., Johnson, M.H., Csibra, G., 2008. Communication-induced memory biases in preverbal infants. *Proc. Natl. Acad. Sci. USA* 105, 13690–13695.

KAMINSKI: 12

Non-Print Items

Abstract

There is increasing scientific agreement that domestication has led to the adaptive specialisation of dogs in the human environment, and this evolutionary process has greatly impacted the behaviour of ‘man’s best friend’. There are, however, highly contrasting views on the question of how important a role domestication played in the formation of dogs’ responsiveness to human referential and ostensive cues. In this chapter, we argue that the evolutionary adaptation to the human social environment created an animal possessing functionally human infant-analogue skills with regard to communication abilities. We propose that, irrespective of its precise evolutionary origin and the underlying cognitive machinery, the dog–human communicative interaction can be described as a step-by-step constructive process based on a set of specific skills in both participants. This is a shared characteristic of dog–human and infant–adult interactions, and among others, this makes this animal—on an intuitive level—so childlike for us.

Keywords: cognition; referential cue; ostensive; cue; dog–human interaction; communicative intention; referential expectation; genericity assumption; pedagogical knowledge transfer.