Why is a dog-behaviour-inspired social robot not a doggy-robot?

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Introduction

Faragó et al (2014) suggested that certain aspects of dog-owner interactions (HDI) provide a new and fruitful inspiration for planning human-robot interaction (HRI) in general, for (1) putting the existence of social robots into a functional context, and (2) for constructing and designing the action space of the social robot (for a more extended and general overview of this idea see: (Miklósi & Gácsi, 2012)). Most commentaries on our work agreed, or at least recognised, some relevance of this new approach.

Bio-inspiration is not a new methodology in robot design. Humans have been obvious sources of such inspirations (e. g. Ishiguro & Nishio, 2007) but more generally many biological (including behavioural) systems have provided startling insights into solving engineering problems. Many such applications are concerned with movement over difficult terrain (Bar-Cohen, 2006). Importantly, most of these approaches are very focused on the technical aspects and do not endow the agent with a full-fledged behaviour system.

In contrast, the power of the ethological approach is that, by means of a detailed behaviour analysis of the biological system (e.g. HDI), it extracts a rule set of a behaviour system that provides the input for constructing an analogous system for artificial agents. Thus, etho-inspired research breaks down the behaviour of animals to basic elements and maps the (spatial and temporal) organization to a hierarchical representation (e. g. Botvinick, 2008; Canas & Matellan, 2007). We suggested that the ethological approach could clearly apply to robotics by using these basic elements as building blocks to create a behaviour system model for social robots.

More specifically, in our target study we addressed two main challenges in social robotics:

(1) How to construct socially acceptable robots relying on the present state of technology?

(2) How to handle the limitation and unsteadiness of state of art social robots with regard to functionality (practical application)?

In our response we aim to present complementing arguments as to why HDI offers the best potential model for ethologically inspired approaches in HRI studies and to provide solutions for many (but not necessarily all) problems.

The problem of resemblance

Marti, (2014) commented that "…*the resemblance between robots and humans or animals inevitably creates great expectations in the human interlocutor which are often let down during interaction*." We agree with this remark and we claim that this is a significant problem in the case of many robots used in HRI. All human users have prior expectations about robots in the form of preconceptions and first impressions, driven mainly by the appearance of the agent, which plays an inevitable role in their interaction. If the appearance and the behaviour or abilities of the robot do not match, or are contradictory to the function, then these expectations will be violated resulting in disappointment and aversion in the user. A robot having a human-like hand is convincing only if it is able to use the hand in a human-like way.

In parallel to this, Feil-Seifer (2014) misunderstands our arguments on using the dogs' social behaviour as a model in HRI. Importantly, we did not claim that the application of HDI to HRI necessitates that the robot should have a doglike appearance. On the contrary! We suggest that the relevant aspects of the diverse, multimodal social behaviours of dogs could be applied to *any* robot embodiment, and that the primary adjustment of the appearance and the behaviour of the robot should always depend on its primary function.

In a recent study, we successfully used the behaviour of specially trained hearing dogs as an inspiration for creating the algorithm for the leading behaviour of the Sunflower robot (Koay et al., 2013). In this scenario, the robot, which did not resemble a dog, had the task of leading the 'deafened' subjects (listening to loud music through earphones) to the door when someone rang the doorbell. In such situations, hearing dogs perform three distinct behaviours depending on the behaviour of the owner: (1) Dogs visually attract the attention of the deaf owners; (2) They lead them to the door by regularly looking back to check whether the owner is following or not; (3) The dog stops and waits if the owner is not following. These dog-like behaviours of the robot ('looking-back' and movement synchronisation) turned out to be the most salient features during the interaction and helped the robot to fulfil its task. In a follow-up study, we utilised robots with strikingly different embodiments in the same scenario with the same behaviour set borrowed from hearing dogs. We showed that the appearance of the robot has only minor effect on how humans recognize the goal directed behaviour ('intent') of these robots (Lakatos et al., 2013), supporting earlier results found by Fischer (2011). This also means that humans attribute goal directed behaviour independently from the embodiment if the agents' expressive actions share some resemblance with overlapping features of HRI and HDI.

Thus, we argue that the discrepancy between the appearance and behaviour causes ambiguity only if the behaviours are recognizably and irrelevantly dog specific. Using a dog-like robot in this case would be counterproductive because it increases the deaf owner's expectation toward the robot in an unpredictable way. This does not happen if one relies on the lower, less specific level of social interaction and extracts general patterns of HDI (like proximity regulation and looking behaviours) which can be applied regardless of the embodiment.

Is HDI limited only to some aspects of HRI?

Yes, it is. In some cases – depending on the function of the robot – humanlike social behaviours and abilities, such as verbal communication, could be both necessary and soluble. In line with this, Fischer (2014) argues very strongly against the utilisation of HDI and favours a more detailed study of human-human or human-robot interaction. However, considering the present state of the design of subtle communicational abilities or perception and expression of emotions, we claim that social robotics would achieve more believable social agents for most/many functions by using the dog model rather than a simplified mock human.

In addition, Koay et al.'s study demonstrates perfectly that we do not suggest slavishly copying the behaviour of dogs. Instead, we aim to identify socially important elements of the rich repertoire of HDI on which humans rely to recognize the intentions or communicative attempts of dogs. We claim however, that the subsequent application of these behaviours controlled by a specific algorithm makes the social robots more successful in the anthropogenic environment. Several authors commented that dogs can be used only as a model for companion robots (Feil-Seifer, 2014), or their application possibilities are very limited (Nicolescu, 2014), or questioning how the behaviour of such ‘subservient’ creatures can be applied in roles where the robot has to possess some authority over the human (such as coach or helper robots for elderly people (Dahl, 2014)). In contrast, we agree with Nicolescu (2014), who suggested that the modelling of the behaviour of working dogs might be the most relevant (e.g. Gácsi, Szakadát, & Miklósi, 2013) especially considering their excellent ability to cooperate and reach a specific goal during interactions with humans (but see a successful example with pet dogs: Kerepesi et al., 2005). For instance, an earlier study showed that guide-dogs and their blind owners, based on the circumstances and on who has the more relevant information for the successful navigation, switch back and forth between the role of decision maker while moving through a busy street (Naderi, Miklósi, Dóka, & Csányi, 2001). This means that in certain contexts these dogs can take over the leading from the human and are able to gain authority intermittently. Importantly, owners accept this situation with ease, thus navigation for a blind person is a team effort shared between cooperative partners, and not a question of dominance or submission (see also Bradshaw, Blackwell, & Casey, 2009).

A helper robot that has a task to remind the elderly user to take medication can properly fulfil its role even if in other social contexts its behaviour is regulated by an algorithm deduced on the basis of HDI, for example displaying a specific behavioural ritual for greeting the user upon arrival. Such behaviours provide an important enrichment of the social abilities of the robot and can also be used for a possible therapeutic aim. Besides its primary objectives (e.g, physical support, medication), the robot could provide playful interactions (e.g. like fetch or other simple games), or may have certain needs to be cared for and 'ask' for help from the owner (Marshall-Pescini, Colombo, Passalacqua, Merola, & Prato-Previde, 2013).

What aspects of dog behaviour could be translated to robots (and how)?

Dahl (2014) noted that dog behaviour is not universally understood. While this can be true for certain aspects and subtleties of behaviours where, for example, experience with dogs can have a strong effect on correct interpretation (Wan, Bolger, & Champagne, 2012), most humans show great skill in understanding the more general aspects of dog behaviour, which are based on biological rules. For example, humans who have little experience with dogs match the appropriate inner states with dog barks recorded in different social contexts (Pongrácz, Molnár, Miklósi, & Csányi, 2005). Humans and dogs share the same basic acoustic rules to assess the inner (emotional) state of each other's vocalizations (Faragó, Andics, et al., 2014). This ability could be capitalised for generating artificial emotion expressions for robots by synthetizing a specific vocal repertoire.

Novikova, Watts, & Bryson (2014) mention that emotion expressions should be multimodal using different channels that are relevant in human communication in a complementary way. We agree with this notion partly because such redundant emotional behaviour is typical across the animal kingdom, and follows from the evolution of communicative behaviour in general (Partan, 1999). Thus it is important that robots be endowed with the power of displaying their inner states ('emotions') by using multimodal channels. In addition, the dog model also provides the insight that the whole body could be used for signalling changes in inner states while approaches based on human behaviour focus on the face which relies on complex technology both with regard to signalling and perception.

However, one may ask if we use such general rules that are not dog specific in a strict sense, then why not use other species as a behavioural model? Grollman (2014) also noted that HRI could benefit from studying how humans interact with other domesticated animals or even members of wild species. Not excluding the possibility to refer to other species as a suitable model HRI, dogs have significant advantages in this regard making them the best candidate: (1) Dogs have a long shared evolutionary history with humans; (2) domestication certainly manifested selection for an animal which is able to collaborate with us under difficult conditions; (3) we engage in multifaceted and common social interactions with them in the anthropogenic environment; (4) intensive research has obtained extended empirical knowledge about dogs.

Ethical issues of believability

Dahl (2014) and Melson (2014) point to an interesting aspect of HRI by asking to what degree it is ethical to simulate social behaviours that can be so convincing for the user that s/he can perceive these robots as living creatures. Although this is an important question as it can have strong impact on how humans will perceive and accept social robots in the future, this issue has also emerged in the visual media where, for example, viewers of soap operas are made to believe that the characters are real people.

We fully agree with Matellán & Fernández's (2014) notion that "*the goal is not to recreate the internal operations, but the external functionality, that is, to simulate the mechanisms that make humans perceive their pets as social partners*," although at this point it may be confusing that one has to separate the appropriate reaction to a specific stimulus from the attribution of mental states. For the former case, the ethological notion of key stimuli provides some insight. Such a stimulus may have the potential to release a specific reaction from the partner, but this does not lead automatically to the attribution of a specific mental state. However, Dahl (2014) and Melson (2014) may be right in supposing that long-term interaction of a very skilful agent may indeed lead to incorrect attribution of mental state(s) to the other. For example, owners are inclined to attribute high-level, human-like inner states to dogs or other pets which they probably do not possess. Many owners believe their dogs feel guilt after disobeying a rule (e.g. taking a piece of food from the table). Controlled experimental observations provided evidence that many dogs display specific behaviours when confronting the owner after wrongdoing (Hecht, Miklósi, & Gácsi, 2012; Horowitz, 2009), however, it seems that dogs only learn how to behave to evoke or change the owner's behaviour for their advantage and they do not have a mental representation of guilt. We do not know whether the fact that owners do or do not attribute guilt to dogs reflects differences in their relationships. Further investigations should explore how increased believability (Rose, Scheutz, & Schermerhorn, 2010) increases humans' tendency of mental state attribution, and whether this interferes with the functionality of the robot. Parallel experiments in HDI and HRI could be very informative in this respect, and may actually influence the design and operation of social robots.

Concluding remarks

In most cases the dismissal of HDI as a model for HRI reflects a misunderstanding about the level of analogy. We never claimed that the behavioural observations of human-dog interaction or especially the actual behaviour of the dog should be applied directly to robots. In the end, robots are engineered creations that should comply with various other challenges, including the ability to safely handle sensitive information. However, HDI brings engineers closer to realising some very important issues of social robots that had not emerged before when they were designing traditional household appliances. Such neglected and not trivial engineering problems include the challenge given by the need for long-term interaction, which is impossible without solid functioning (e.g. battery life, physical endurance). Engineers could also harness the robots ability to interact socially to balance for their imperfectness.

In conclusion, the general acceptance of the commentaries of using dog behaviour as a model or inspiration for social robot behaviour design further convinces us that we are on the right path. Following the suggestions of our colleagues, in the future we plan to focus our studies (1) on dogs that live and work in conditions similar to those of future robots (assistant, guide, rescue, etc. dogs), (2) collect behavioural data under natural conditions (home or work settings) to get a more precise picture about the interaction and efficiency of dog-owner dyads, and (3) test these behaviours in robot-human interaction studies, especially in long term scenarios.

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