

Social-cognition and dog-human interactions: Is there potential for therapeutic-interventions for the disability sector?

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Abstract

The notion that dog-human interactions have the potential to mitigate impacts concerning the delay of typical development of social skills in humans is a novel concept. Research evidence concerning three aspects of social-cognition: sensory perception of social-cues, theory of mind and learning social-schemas, were reviewed with the scope to explore this notion. Literature from two different fields of research inquiry: animal-behaviour and neuroscience, was evaluated. Emerging from the animal-behavioural studies' review was that aspects of dog behaviour could be a functional analogue of human behaviour (e.g. perception of social-cues). Neuroscience research theories concerning the functional role of the mirror neuron system in social-cognition in humans were evaluated against evidence from animal-behavioural studies investigating the relationship between dogs and children with socio-communicative developmental delays (e.g. vision impairment, Autism). It emerged that both fields of research suggested that through "embodied simulations" an alternative (e.g. to language and/or vision) approach to acquiring knowledge concerning the world of social interactions may be possible for individuals who present with developmental delays of social-competence. Within this context it is suggested that dog-human interactions may provide learning opportunities for development of social-competence in individuals with vision impairment. Implications for practice for the disability sector and specific examples for professionals who work with individuals who have vision impairment and assistance/therapy dogs are discussed.

Keywords

Social-cognition, Socio-communicative development, Autism, Vision impairment, Companion-dogs, Therapy-dogs, Mirror neurons

Introduction

The ability of social-living animals to understand social relations, such as social ranks and intention of conspecifics, carries evolutionary advantages (Ghazanfar & Santos, 2004; Teufel et al., 2010). From understanding warning signals of immediate danger (e.g. predators) (Emery, 2000) to facilitating the communication of positive intent and cooperation among conspecifics (Kleinke, 1986), the development of social-skills is critical for social-animals survival (Ghazanfar & Santos, 2004; Shepherd, 2010).

Social-skills are developed throughout life through social-interactions (Hogg & Vaughan, 2014), to acquire what has been called by Adolphs (1999; 2001; 2003) a “social brain”. Developing a “social brain” requires understanding the actions of others, predicting their intentions, known as Theory of Mind (ToM), and as a consequence, learning the socially acceptable/unacceptable rules (Csibra & Gergely, 2006). A lack or delay in the development of social skills is associated with a number of mental illnesses, disorders, and long term disabilities such as Autism and Schizophrenia (Dickerson et al., 1996; Zilbovicius et al., 2006). Further, individuals with vision impairment may exhibit delay in typical social skills development, and/or need specific support during childhood and adolescence (Celeste, 2006; D’Allura, 2002; Duvdevany et al., 2007). Thus, understanding the mechanisms underpinning social-skill development holds relevance for individuals and society at large.

Social-cognition research, concerned with understanding the cognitive processes that influence and are influenced by the behaviours of social-living animals (Hogg & Vaughan, 2014), has traditionally investigated these mechanisms among conspecifics, or between evolutionarily close species (e.g. for humans with other primates) (Gomez, 1990; Povinelli et al., 1997; 1999). More recently a paradigm shift has occurred in comparative social-cognition research field, broadening the spectrum of species under investigation (Herman et al., 1999; McKinley & Sambrook, 2000; Miklósi et al., 2004). For example, social cognition research in dogs has provided evidence that domestic dogs, (*Canis familiaris*, Linnaeus, 1758), have a remarkable ability to respond to, and to establish forms of communication with humans such as understanding human communicative intent (Povinelli et al., 1997; So-

proni et al., 2001) and human emotional expressions (Albuquerque et al., 2016). This evidence is particularly compelling, as it occurs between species that are evolutionarily very distant, but, as some authors have argued, have potentially co-evolved (see dog-domestication: Paxton, 2000; Vilá, 1997) equivalent functional social-behaviours (Miklósi et al., 2004).

The canine ability to understand the social organisation and communication system of humans makes dogs a widespread choice for interventions that aim to increase social interactions opportunities such as Animal Assisted Interventions (AAI) (Grandin et al., 2019) For example, dogs can act as social catalysts for individuals who suffer from loneliness and depression (McConnell et al., 2011) and/or have long term disabilities: schizophrenia (Barak et al., 2001), Autism (Sams et al., 2006), Down syndrome (Esteves & Stokes, 2008).

Mechanisms underpinning such observed benefits remain unresolved and are the focus of much social-cognition research (Amodio & Frith, 2006; Miklósi & Szabó, 2012).

Some authors (Miklósi et al., 2004) have argued that by comparing the mechanisms underpinning social-cognition in dogs, those features that regulate social cognition in humans would be better understood. Others have argued that dogs could potentially mitigate the impact of delayed social competence development in humans and perhaps support the acquisition of social-skills (Solomon, 2012). Further investigating the potential of dog-human relationships could hold important implications for those professionals (e.g. Orientation and Mobility specialist, Guide-dogs mobility instructors and trainers) that use dogs to provide support, for example to adults and children with vision impairment for their mobility, or for therapeutic roles (e.g. Post Traumatic Stress Disorder) (O’Haire & Rodriguez, 2018; Stern et al., 2013).

This literature review will use contemporary research from two fields of research enquiry; animal-behaviour and neuroscience, to explore the notion that dog-human interactions have the potential to support the acquisition of social skills in humans. The review is organized around three aspects of the social human brain: a) sensory perception of social-cues, b) ToM and c) learning social-schemas. Each aspect concludes with practice im-

plications for the disability sector with a particular focus on vision impairment, and/or comorbid disabilities (e.g. Autism).

Sensory perception of social-cues

Eye-gaze is defined as the direction of one's gaze at another individual's eyes (Kleinke, 1986). In human social transactions, eye gaze conveys important information concerning what others attend to, their mental states, emotion, and intentions (Frischen et al., 2007; Schilbach, 2015). Humans respond to gaze-cueing stimuli from birth even though the human neonatal visual system is underdeveloped (Batkai et al., 2000; Haith et al., 1977). As such, the brain mechanisms underpinning gaze-behaviour have received great research attention (see for reviews: Emery, 2000; Frischen et al., 2007).

Early research studies (Baron-Cohen, 1994; Driver et al. 1999) suggested that the ability of humans and other animals to follow the gaze-direction of conspecifics is an innate and reflexive mechanism of adaptive importance. For example, an animal being aware that it is the focus of attention of another animal may signal that a predator is attending; this holds obvious survival advantages (Emery, 2000; Schilbach, 2015).

Experimental studies in humans have shown that faces displaying direct-gaze are attended to faster (von Grünau & Anston, 1995) and are better remembered than faces with averted-gaze (Mason et al., 2004). Babies as young as 3-6 months of age are able to discriminate between direct and averted gaze (Vecera & Johnson, 1995), and are able to respond with a shift in visual spatial-attention to a combination of head and eye-cues sent from their mother (Butterworth & Jarrett, 1991; Hood et al., 1998;). However, social interactions in humans are strongly driven by the ability to understand intentional behaviour of others, defined as purpose-guiding/showing behaviour (Ferrari et al., 2008). Such behaviour requires both attention and a referential understanding of the message. Thus, although humans are sensitive to following eye-gaze from an early age, a mere reflexive attentional orienting mechanism does not imply that there is a referential understanding that guarantees the gazer understands the intent of the sender (Doherty & Anderson, 1999).

Recent evidence from neurophysiological and neuropsychological studies conducted on monkeys (Perrett et al., 1992; Perrett & Emery, 1994; Ferrari et al., 2008) and humans (Kingstone et al., 2000; Langton, 2000) showed that complex neuronal mechanisms

regulate the referential understanding of social directional cues, rather than simple reflexive mechanisms as posited by earlier authors (Baron-Cohen, 1994). For example, by using single-cell responses of neurons in the superior temporal sulcus (STS) of a macaque brain, a cortical area sensitive to the processing of biologically important stimuli from eyes and faces, Perrett et al. (1992), showed that gaze-direction is analysed by a network of neurons. These neurons are highly specialised with a modular anatomical organisation, meaning one population of cells that fire with maximum frequency in response to one direction (e.g. a picture of a downward-gaze), and another population of cells that fire in response to a different direction (e.g. an upward-gaze). Perrett et al. (1992) posited that this cell network computed referential understanding by extracting information from eyes, head, and body posture-cues in a hierarchical way, with the eye-gaze stimulus having precedence over the information acquired from the other body parts-cues (e.g. head and body posture).

More recent experimental studies (Langton, 2000; Langton et al., 1996; 2000; Langton & Bruce, 2000), however showed findings contrary to this hierarchical model. A study by Langton et al. (2000) revealed that information extracted from all body parts (eye, head, hands, body posture) was processed concurrently and in parallel. Another study by Langton et al. (1996) showed that in addition to visual cues, other sensory modalities (e.g. auditory: spoken directional words) can equally contribute to the computation of referential understanding of social-cues. The results of these studies therefore, appear to suggest that humans use a combination of cues to draw the attention of conspecifics, and that complex multimodal (e.g. from different domains: visual, auditory) neuronal resources are employed for interpretation (Farroni et al., 2003; Ghazanfar & Santos, 2004; Langton et al., 2000).

The ability to referentially extract information from multiple stimuli is considered a higher-order cognitive skill that contributes to associative learning in humans (Gallese et al., 2002). This is an important precursor for the development of sophisticated social skills such as ToM, and for social learning (Schilbach, 2015; Schilbach et al., 2010; Shepherd, 2010). Yet, whether this skill is a human species-specific trait or shared with other non-human species is still the focus of much research debate (Horowitz, 2011; McKinley & Sambrook, 2000; Miklósi & Szabó, 2012).

In non-human primates (e.g. apes and monkeys) signals and communication intent can assume a complex structure. For example, there is evidence that some monkey species use gaze-alteration to recruit allies to fend against predators, suggesting advanced communi-

cation skills for establishing collaborative social-bonds (Gouzoules et al., 1984; Noe, 1992). However, it has been argued that, while non-human primates show forms of advanced communicative skills, their referential understanding of the signal is still context-specific (e.g. within conspecifics) (Owren & Rendall, 1997), with limited flexibility in its interpretation (Povinelli et al., 1997; Miklósi et al., 2004). For example, there is evidence that chimpanzee and marmosets use pointing gestures to draw the attention of others to external events, and are able to follow the gaze direction of conspecifics in much the same way as human infants (e.g. geometrically) (Burkart & Heschl, 2006; Tomasello et al., 1999). Yet, when these abilities were tested using differing forms of communicative signals provided by a human experimenter (e.g. the experimenter was pointing and standing near versus away from a food container), the chimpanzees failed to interpret the referential character of the human-signal (Povinelli et al., 1997; Itakura et al., 1999). These studies seem to suggest that the generalisation to other species of certain communicative cues may not always be possible.

In contrast, when similar forms of experimental “pointing-gesture” paradigms were used in dogs, it was shown that dogs were able to interpret the referential nature of humans given communicative signals in remarkable ways (Soproni et al., 2001; 2002). For example complex variants of the “pointing-gesture” were used in a series of experiments by Soproni et al. (2001, 2002). Variants of the pointing cues included: glancing (only with the eyes), head pointing, head nodding, and pointing and gazing (Soproni et al., 2001); and pointing-gestures with reversed direction of movement, distance of arm extension (far and near), cross-pointing using hands, elbows and a stick as variants of pointing objects (Soproni et al., 2002). In all studies, dogs interpreted all variants of the pointing-gestures above chance level, but most importantly, they were able to do so even when the direction of the hand was reversed and the whole body was positioned asymmetrically. The authors concluded that the reliable responses to these smaller components and variants of the pointing-gesture indicated that dogs were able to flexibly generalise their response to the human communicative signal to novel situations (Soproni et al., 2002; Miklósi et al., 2004).

Implication for the disability sector

The ability of dogs to flexibly interpret and adapt their mode of referential communication, or “showing behaviour” with humans holds important impli-

cations for those who works with individuals with vision impairment. For example, Gaunet (2008) compared the ability of guide-dogs of blind owners and pet-dogs of sighted owners to ask for food, and demonstrated that guide-dogs were able to develop novel audible behaviours (e.g. licking their mouth sonorously) to attract the attention of their non-sighted owners. The authors concluded that the guide-dogs, in contrast to pet dogs, supplemented visual attention-getting behaviour with sound attention-getting behaviour, to adjust and trigger a response reaction from the non-sighted owners. The use of these supplemental forms of communication would suggest that dogs can, similarly to humans, process and use information from different sensory stimuli in a referential way (Albuquerque et al., 2016; Gaunet, 2008; Miklósi et al., 2000, 2004). Professionals who train dogs to assist individuals with vision impairment may capitalise on the dog’s response to different sensory stimuli, and during training, reinforce those conditioned responses better suited to the dogs’ future non-sighted owners.

Humans follow the gaze direction of conspecifics to access spatial information that lies outside of their own field of view and awareness, and to acquire information about the mental state of the person whose gaze they observe. This ability to reason about what others think, know or believe, or ToM (Gallese & Goldman, 1998), is considered a milestone of social-skills development in children (Grossmann & Johnson, 2007), and a crucial component of successful social interactions (Amodio & Frith, 2006). The capacity of dogs to display ToM such as humans, and whether this ability can provide opportunities for interventions to support humans in their development of the “social brain” will be explored in the review of the next topic.

Theory of Mind (ToM)

It has been suggested that for many herd and pack animals like dogs, interpreting the behaviour of conspecifics at least, has adaptive relevance (Allen, 1998). For example, coordinating actions by interpreting the intentions of others serves for hunting or avoiding predators (Emery, 2000).

Perspective-taking paradigms have been used to investigate ToM and related forms of social cognition in animals (Heyes, 1998). The “knower-guesser” paradigm (Povinelli et al., 1990), where the goal of the test task is to investigate the ability to distinguish between a social-cue provided by a “knower” from a so-

cial cue provided by a “guesser”, has been used to demonstrate whether animals have the ability to interpret the world from the perspective of others. For example Cooper et al. (2003) tested whether dogs would solicit food from an experimenter (the knower), who was in the room when a food container was baited, or from someone who entered the room later and did not know where the food was originally placed (the guesser). Dogs begged for food more frequently, and above chance level, from the knower. Cooper et al. (2003) proposed that dogs could mentalise, defined as picture in the mind (Oxford Lexico, 2020), that “the knower” had more reliable information than “the guesser” regarding the food location. Similar results were obtained in a study conducted by Gácsi et al. (2004) where dogs were less likely to beg food from a person facing away from them or a blindfolded person. Similarly, in a study by Schwab and Huber (2006) dogs behaved differently (e.g. ate or not a treat on the floor that they were told not to take) depending on the type of experimenter’s attention to them (watching, turning the body, reading).

Conversely, other authors (Penn & Povinelli, 2007; Udell et al., 2011) have argued that the behaviours displayed by dogs in these studies do not require anything as remotely sophisticated as ToM. Rather, they suggested that such behaviours were the product of general learning mechanisms regulated by operant conditioning (Skinner, 1978), reflecting the dogs’ sensitivity to the contextual environment and discriminative cues associated with reward or no reward. While these criticisms may be valid, it should be noted that in the Cooper et al. (2003) study, dogs displayed those behaviours at a first trial, ruling out the possibility of a conditioned response over successive trials.

Other research studies have provided evidence of a dog’s ability to produce complex and organised patterns of “showing” behaviour towards their owners, such as engaging in a sequence of alternative gazing and vocalisations (Miklósi et al., 2000). Also, dogs were able to solicit assistance from their owners for problem solving, instead of just reacting to their attention (Miklósi et al., 2003; Topál et al., 1997). The complexity of these human-dog interactions cannot be explained as simple behavioural sequences that have been rewarded in the past, but rather suggests more advanced social cognitive skills (Kubinyi et al., 2009; Miklósi et al., 2000; Topál et al., 2006).

Implication for the disability sector

Overall it may be challenging to empirically demonstrate that in a species with non-verbal expression, there exists an awareness of another individual’s mental state. This perhaps accounts for the inconsistencies produced by these reviewed studies (Cooper et al., 2003; Heyes, 1998; Penn & Povinelli, 2007; Udell et al., 2011). However, rather than focussing on providing evidence for the existence of a full human-like ToM in dogs, it perhaps is more relevant to refer to degrees of or rudimentary ToM, as speculated by some authors (Allen, 1998; Horowitz, 2011).

Several authors (Dobbs-Gross, 2006; Martin & Farnum, 2002; Solomon, 2010; 2012), have suggested that, within these degrees of ToM and the ability that dogs have for reading human-social communicative signals, lies opportunities for training dogs to support the acquisition of social- skills concepts in individuals who struggle with social competence (e.g. Autism, Asperger’s Syndrome, and Pervasive Developmental Disorders Not Otherwise Specified: American Psychiatric Association, 2000).

For example, there is evidence (Dobbs-Gross, 2006; Solomon, 2010; 2012) that through the relationship with their companion dog, children with Autism may learn that certain behaviours lead to particular behavioural outcomes in others. Dobbs-Gross (2006) provides examples of children with Autism who learnt the concept of “happy state” by playing with their therapy-dogs. For these children, understanding their dog’s perspective and emotional state is easier than understanding human perspectives (Dobbs-Gross, 2006). It is, indeed, easier to comprehend a dog’s wagging tail, during a play-game of fetch and throw for example, as reflecting an happy state, rather than to interpret the state of mind of another human through the complexity of facial expressions (Dobbs-Gross, 2006). Interacting with their dogs may lead these children to begin to see the world from the perspective of another’s mind and support developing ToM. Perhaps through such dog-child interactions, dogs can become mediators for teaching children with Autism concepts that they can eventually, if properly guided, transfer to a human-interaction context (Dobbs-Gross, 2006; Solomon, 2010, 2012).

Further, using dogs as mediators to support the development of ToM holds also potential for individuals who are blind or have vision impairment. Indeed, the accounts by the work of Dobbs-Gross

(2006) and Solomon (2012) concern interactions of assistance and therapy dogs with children whose preferred mode of communication with the external world is based on touch (touching a dog wagging tail) or auditory (respond to a dog-vocalisation) rather than visual (e.g. looking at a dog tail) stimuli.

Research in social-cognitive neuroscience has also provided evidence for the notion that a visual experience is not necessary to develop ToM (Bedny et al., 2009; Kampe et al., 2003). For example, in a study comparing the neural bases that regulate ToM in congenitally blind and sighted individuals, Bedny et al. (2009) demonstrated when reasoning about the mental states of others, the same network of brain regions was activated in sighted and congenitally blind individuals. Yet, for the latter, this activation was triggered by a hearing experience rather than a visual experience. Such findings suggest that the development of ToM in humans can be achieved through different sensory modalities.

Recent neuroimaging research also suggests that this development occurs early in life (Grossmann, 2013; Grossmann & Johnson, 2007). A network of brain regions including: the medial prefrontal cortex (mPFC), the bilateral tempoparietal junction (TPj), the anterior temporal sulci (aSTS), precuneus (PC), are all known to support skilled social functioning in humans (Gallagher et al., 2000; Saxe & Kanwisher, 2003; Saxe et al., 2004). Within this network, the mPFC appears to play a special role in social-cognition and in ToM in particular (Amodio & Frith, 2006). There is evidence that lesions to the mPFC predict antisocial behaviour including: impairment of social and moral reasoning, violence against persons and objects, and insensitivity to consequences of own actions (e.g. stealing) (Anderson et al., 1999). Further, the earlier the acquired damage, the more severe the impact is on social functioning, suggesting a critical role that this brain region plays early in ontogeny for the development of social skills (Grossmann & Johnson, 2007; Grossmann, 2013).

Unlike other brain regions where damage early in ontogeny can be compensated (Thomas & Johnson, 2008), there seems to be a sensitive period for the mPFC development. This and the behavioural evidence mentioned earlier (Dobbs-Gross, 2006; Solomon 2010; 2012) suggests that when potential developmental delays for social skills are suspected/diagnosed, early interventions are beneficial in mitigating these delays, to en-

hance the likelihood of improved outcomes.

Yet, outstanding questions remain such as: what kind of early experiences are critical for the development of appropriate social competence (Bedny et al., 2009); and given that dogs can form unique bonding relationships with humans with disabilities (Fine, 2019) can the impact of developmental social delays be mitigated/supported through this relationship? Reviewing literature on learning social-schemas may provide insights and potential future research to explore these questions.

Learning Social-Schemas

Social-schemas are defined as a set of interrelated cognitions (e.g. thoughts, belief, and attitudes) that allow sense to be made of events and situations, when limited information is available (Hogg & Vaughan, 2014). There are many types of schemas including: role schemas that could represent the type of function or expected behaviour of an individual in a group (e.g. we expect a doctor to behave in a certain way); script schemas concerning events (e.g. eating out at a restaurant, going to the cinema); and self-schemas concerning people's concept of who they are (Hogg & Vaughan, 2014). Regardless of the type, all schemas are common in that they are learned through social interactions and allow humans to elaborate simplified and shared understanding of their social world (Moscovici, 1983). Observing and imitating actions of others plays a critical role in learning the rules and appropriate behaviours of a social world (Iacoboni et al., 1999; Rizzolati et al., 2014; Southgate & de Hamilton, 2008). For example, being able to imitate the body language and actions of others can influence personal relationships and dynamics of social interactions (Chartrand & Bargh, 1999).

It has been postulated that in the human brain a system of neurons, called the mirror neuron system (MNS) (Gallese et al., 1996; Iacoboni et al., 1999) responds to motor-actions that are self-executed or observed in others, and that this system is activated during action imitation (Gallese, 2005; Iacoboni et al., 1999; Rizzolati et al., 2001).

The MNS was initially identified as a visual-motor system (Gallese et al., 1996; Iacoboni et al., 1999), however, recent neuroscience research supports the notion that it can develop in the absence of sight, and it can process information that is not visual (Ricciardi et al., 2009). For example, in an inves-

tigation of brain activity in sighted and congenitally blind individuals, Ricciardi et al. (2009) demonstrated that the sound of a hand-executed action (e.g. using scissors or an hammer), activated cortical areas of the mirror system for action schemas in blind individuals, that were equivalent to those activated in sighted individuals when the stimuli were presented visually. This suggested that action representations in mirror neurons were induced through supra-modal sensory mechanisms, tactile (Keysers et al., 2003) and auditory experiences (Kohler et al., 2002; Ricciardi et al., 2009), that did not require a visual experience. This finding is perhaps evident in the ability of infants to imitate their mother's facial expression, despite never having seen their own face, and in the presence of a developing cortical visual system (Kidwell & Zimmermann, 2006; 2007; Meltzoff, 2007).

It is, however, recognised that interpersonal relations are more complex than simply being able to imitate gestures or expressions of others through body movement. Interpersonal relations require higher-order cognitive functions for representation and understanding of action goals (Csibra, 2007; Rizzolati et al., 2001), as well as selection of what and when to imitate (Southgate & de Hamilton, 2008).

Several authors have argued that such higher order cognitive functions related to interpersonal relations, share a common basic neuronal mechanism in the MNS (see the "manifold shared" hypothesis, Gallese 2003a and "the like me" hypothesis Meltzoff, 2005; 2007). According to these hypotheses, an internal embodied representation of other minds is first processed at a basic level through a sensory motor experience (Ferrari & Gallese, 2006; Gallese, 2005). Thus, as Gallese (2003a; 2005) posited, it is in the MNS, where the discrimination of when "I" act as opposed to when "others" act starts, and where the recognition of the "otherness of others" is first processed. Gallese (2005) commented "... this body-related experiential knowledge allows us to understand the actions of others and decode the emotions and sensations they experience" (p23.).

It has also been theorised that the MNS does not function in isolation, but it is part of a multi-layer neuronal network (Khalil et al., 2018; Southgate & de Hamilton, 2008), that supports and acts as the precursor (see "the neural exploitation hypothesis: Gallese, 2008) of more com-

plex and sophisticated forms of social cognition such as ToM (Gallese & Goldman, 1998), language and empathy (de Vignemont & Singer, 2006; Gallese, 2003 a, b). For example, manual gestures anticipate early development of speech in children (Gallese, 2008), and neuroimaging studies have provided evidence that motor regions contribute to the semantic representation of action-related words (Kellenbach et al., 2002).

As suggested by these theories and studies, the notion that neuronal mechanisms for key aspects of human social cognition, (such as reasoning about others' actions, thoughts, and language), can be linked to brain mechanisms originally evolved for sensorimotor integration (Gallese, 2005; 2008) is appealing. Agreeing with this notion, some authors have argued that socially relevant information can be acquired and learnt through sensorimotor experiences, as long as these experiences evoke some kind of social meaning (Maynard, 2005; Solomon, 2012).

Evidence from behavioural and ethological studies has shown that interactions between dogs and humans (e.g. play-games, walking and grooming a dog) (Table 1) encompass many of the elements and forms of behaviours that are similar to those that characterise successful human social interactions (Horowitz & Bekhoff, 2007; Solomon, 2012). For example, a typical ball-game of throw and fetch requires coordinated motor acts between the participants; an understanding of when the game starts or ends; the ability to maintain focus during a shared activity; and turn-taking. Horowitz and Bekhoff (2007) suggested that these patterns of behaviours were equivalent to following human behaviours in a social context, such as: directed response to others; communication of intent; mutuality and shared engagement; and contingent activity. In these behaviours each individual's action is based on and relate to what the other individual has just done.

Recent functional-magnetic resonance imaging (fMRI) studies have also demonstrated that the activation of the MNS and cortical areas involved in mentalising the intentions and behaviours of others occurred in humans when interpreting and observing dogs' behaviour (Buccino et al., 2004). This activation occurred both when humans were asked to observe the behaviour, or to infer reasons for the behaviour of the dogs in a similar fashion when they observed and interpreted actions of humans (Buccino et al., 2004).

Implication for the disability sector

The learning opportunities that structured dog-human interactions may provide for teaching social skills and social schemas to individuals who experience delayed (e.g. vision impairment) or atypical (e.g. Autism) socio-communicative developments, is worthy of speculation. There is indeed existing behavioural evidence that supports the assumption that dogs may be used as mediators for the concept development of what “being social” means to children with Autism (Dobbs-Gross, 2006; Hall et al., 2016; Solomon, 2010; 2012). The ability to imitate is maintained in children with Autism if instructions are provided (de Hamilton et al., 2007). A dog-human play interaction represents the ideal avenue for delivering these instructions in ways that do not require speech, and are usually highly repeatable and practicable (Solomon, 2010). For example, Dobbs-Gross (2006) suggested that when children with Autism respond to the harmonic barks that are used by a dog as a signal for social play, they started to learn about the necessary turn-taking required with pragmatic language. Similarly, Solomon (2012) suggested that the experience of walking a dog on a leash may translate into an embodied representation of what it meant to maintain appropriate social distance

and boundaries. It is worth noting that Solomon (2012) used the same term “embodied representation”, similar to neuroscientists who have described the function of the MNS for action imitation and understanding: “... a common functional mechanism is at the basis of both body awareness and basic forms of social understanding: embodied simulation” (Gallese, 2005, p24).

Thus, the “like me” hypothesis of Meltzoff (2005) has found a “like my dog” equivalent in the dog-human behavioural studies of Solomon (2010; 2012), Horowitz and Bekhoff (2007) and Dobbs-Gross (2006). While the potential of the “like my dog” hypothesis remains to be tested, Table 1 outlines practical suggestions for activities/learning opportunities for supporting individuals who have a vision impairment, or associated comorbidities (e.g. Autism, cognitive impairment), with the acquisition of social-skills.

Conclusion

The scope of this review was to explore the notion that dog-human interactions have the potential to support the development of social skills in humans when this development may be delayed or has not

Table 1. Activities for practice, drawn from the work of Dobbs-Gross (2006) and Solomon (2010; 2012): the “Like my dog” hypothesis and opportunities to teach children, through dog-human interactions, concepts concerning social-competence.

Activity- learning opportunity	Sensory modality	Dog communicative cue	Lesson to be learnt	Social behaviour
Object retrieval: ball-game (fetch and throw)	Tactile & Auditory	Vocalise/body-touch/nose nudge	Ball not thrown back when retrieved, play stops	Reciprocity, direct response
Object possession: toy belongs to child/tug of war	Tactile & Auditory	Vocalise	Pat dog when dog leaves the toy	Self-concept, mutual respect
Chase or wrestling	Tactile & Auditory	Vocalise/body touch	Play kindly	Contingent activity, ToM
Run/walk with dog on leash	Tactile	Body touch	No parallel walking, dog stops and pulls on leash	Boundaries, social distance
Grooming	Tactile	Relaxed body	Mutual care	Mutual Alliance, reciprocity of taking care of each other
Sleeping time: put on pyjamas while dog goes to its bed	Tactile	Vocalise/body touch	We do it together	Social bonds/collaboration

reached full potential. Theories and research evidence from two fields of research inquiry - animal-behaviour and neuroscience - were evaluated, to identify common ground between dogs and humans behaviour, and the potential for real-life applications of such therapeutic-interventions. Evaluation of the literature concerning behavioural studies that investigated the ability of dogs to communicate with humans, showed that aspects of dog behaviour could be a functional analogue of human behaviours (e.g. perception of social-cues). This outcome agreed with previous comparative reviews of social cognition in dogs and humans (Miklósi et al., 2004).

In this review, however, the functional analogy concept was escalated. Neuroscience research theories concerning the functional role of the MNS in social-cognition in humans, were evaluated against evidence from animal-behavioural studies that investigated the relationship between dogs and children with socio-communicative developmental delays. It emerged that both fields of research suggested that through “embodied simulations”, humans can learn to attune to others, and generate a representation of behaviours of others (Gallese, 2005; Solomon, 2012). When translated to individuals with socio-communicative delays, perhaps an alternative approach (e.g. to language and vision) to acquiring knowledge concerning the world of social interactions exists. Much work remains to be done to investigate the potential for dog-human interactions to mediate and facilitate social-skills learning (Solomon, 2012), and to influence the neurophysiological interactions between pathways of the MNS and other high order social cognitive functions.

Being outside the scope of this review, aspects concerning the welfare of dogs (Winkle & Jackson, 2012) and personality attributes of dogs (e.g. temperament, dependable nature, obedience) that must be considered for successful therapeutic interventions (McConnell & Fine, 2019; Parenti et al., 2015) have not been included. Despite this, and that several theories explored in this review require further research, an argument integrating the two lines of research from different fields of enquiry has been possible. This approach has begun to disentangle the bottom-up and top-down processes that may regulate the unique relationship of dog-human interactions. It is likely that the relationship among these processes is not one of linear nature. Perhaps this novel approach supports rethinking the fascinating relationship between humans and their

most unique companions and will fuel more behavioural studies and new practices within the field of animal-assisted therapy, to better meet the needs of people with disability.

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