

Human-animal relationships: from daily life to animal-assisted therapies

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Summary. Humans have a long history of relationship with domestic animals and nowadays pets often act as “social substitutes” through bonding. There is some evidence that pet presence at home may induce well being in people and the development of social skills in children. Animal assisted therapies aim at developing these skills in patients on the basis of human animal interactions. Experimental data obtained on animal models suggest that this is indeed a promising line. There is however a lack of clear scientific data that would help defines what the most appropriate procedures or species may be. Improvements are observed, but again sound scientific data are mostly missing. Attention must be given to the welfare of the animals being used.

Key words: human-animal relationship, ethology, bonding, animal-assisted therapies, pets.

Riassunto (*Relazione uomo-animale: dall'interazione quotidiana alle terapie assistite*). Gli uomini hanno una lunga storia di relazione con gli animali domestici a tal punto che gli animali da compagnia possono rappresentare dei validi surrogati di rapporti sociali. Alcuni dati mostrano che la presenza di animali da compagnia in casa può indurre un generale stato di benessere nelle persone nonché stimolare lo sviluppo di legami sociali nei bambini. Utilizzando la capacità degli animali di interagire con gli esseri umani, in molti casi le terapie assistite da animali mirano proprio all'arricchimento dei legami sociali in diversi tipi di pazienti. Dati sperimentali ottenuti su modelli animali rendono tale campo di indagine sempre più promettente. Tuttavia ulteriori evidenze scientifiche sono necessarie in particolare per la standardizzazione delle procedure di intervento e per definire quali specie siano più appropriate. Un'attenzione particolare deve poi essere posta a garantire il benessere degli animali utilizzati.

Parole chiave: legame uomo-animale, etologia, legami sociali, terapie assistite dagli animali, animali da compagnia.

INTRODUCTION

The term domestication comes from “*domus*”, the home, meaning that humans have brought some animal species close to their home. Although this domestication has had mostly utilitarian goals, the daily contact has necessarily induced the establishment of a relationship. One considers that a relationship is established once each interlocutor has expectations on the behaviour of the other: at each interaction, each partner has more knowledge about how the other will react, the outcome of the interactions and what the next encounter will induce [1]. The succession of interactions, and their outcomes, will determine the quality of the relationship, a core basis of the social intraspecific bonds but also of the interspecific exchanges (here human-animal) on a daily basis.

Species-specific characteristics, whether morphological or behavioural, lead to different modalities of interaction. An obvious aspect is size, limiting the possibility for humans of having the animal within the home site and obliging to develop ways of controlling a very powerful animal. Other aspect is the

species way of interacting: while dogs have many tactile contacts, horses express their affinities more by spatial proximity for example [2, 3].

Because most domesticated animals are social species, it has been proposed that humans were successful in keeping them. Indeed these species had “social competencies and needs” that could be used for establishing human-animal bonding. Domestication of solitary species (*e.g.* cats) or keeping of animals (*e.g.* genets or snakes in some countries) have been attributed to commensalism, where both species (human and animal) have mutual benefits (*e.g.* eradication of rodents for the former, heat or additional food for the latter) without a need for particular bonding. These general trends can be found in our current occidental societies where cattle or sheep are mostly kept in farms, with a human contact that tends to concentrate on work tasks, while dogs and cats are kept by millions in occidental human homes [3, 4]. Horses have an interesting particular status. As other ungulates, they tend to be kept either in distant stables or, when possible, in pastures

located close to the house. But human expectations are closer to those towards pets (*i.e.* companionship, specific bond).

Beyond these general trends, humans have probably realized very early a behavioural selection by choosing as breeders animals the ones they had particularly appreciated qualities. Although this was probably unconscious, the effects on a succession of generations have certainly been major, leading to our current behavioural and morphological types of dogs or cats. Studies performed in the last decades have demonstrated that it was possible, using a divergent selection, to favour some behavioural types. The pioneering study of Belyaev and Trut [5] on silver foxes is remarkable in this sense. By choosing within broods the young animals that were either the most or the least aggressive towards an experimenter and crossing them within each category, these scientists obtained, after a few generations, foxes that were either extremely aggressive or extremely familiar, with behaviours reminding of dog pups (*e.g.* tail wagging, licking). Interestingly, this procedure was also associated with the development of dog type morphological characteristics: tail, fur and ears were closer to those of dogs rather than foxes.

Therefore, our current pets are the results of both their phylogenetic history and their long history with humans. Both aspects may be involved in the finding that dogs are particularly efficient in the perception – and use – of human cues such as the attentional state (through the direction of body and gaze) that they can use, for example, in order to locate a food source [6-8].

HUMAN-ANIMAL RELATIONSHIP FROM THE DOUBLE POINT OF VIEW

Human and pets: why do humans wish an interspecific relation?

Although there are some examples of interspecific relationships between animal species in the wild (*e.g.* clown fishes and anemones, ants and aphids, mixed species groups of primates) where both species have benefits from the association, the human-pet relationship is rather unique in its current form. Pets are not necessarily expected to work and humans just enjoy having them at home. Companionship with pets has, in many cases, long lost its initial utilitarian form and one can wonder what humans expect from these animals. Could it be that pets fulfil some biological need, such as a need for bonding, even with another species?

According to Melson and Peet [9], attachment to pet is related to positive emotional functioning. A strong attachment may have a positive impact on anxiety [10]. Pets might increase the survival rate of people who had experienced coronary artery diseases [11]. But to date evidence for a direct beneficial effect of pet ownership on human health is inconclusive and data would need further replication. Overall, dog owners tend to present less minor health problems than non owners. It may be because

they do more recreational walks, which might be the cause [12]. However, cat owners tend also to have less of these problems despite of the fact that cat presence is not associated with increased walking [10]. Animals may act as “social lubricant” as their presence (*e.g.* during walks) increases the chances of social contacts with other people [13-15].

According to Paul [16, 17], dog ownership would be associated with greater family cohesion. Shared attention between adults and children may create increased communication and exchanges [18]. Parents often obtain a pet because they consider it to be good for their children [19]. Children’s self esteem scores tend to increase after 9 months of having kept a pet in the school classroom [20]. As the animals are entirely dependent upon their owner, children may learn to understand feelings and needs [17]. Pets are supposed to be a source of popularity and to help children develop empathy [21]. Children may feel responsible and competent if they take care of the pet [19]. Thus, pets may bring “social support”: children can go to them if they have a problem [22] without feeling “threatened” as it is a non judgemental affection. Children who owned a pet during childhood have more chances to acquire a pet when adult [23]. Only children or children without younger siblings tend to be more pet oriented [19], reinforcing the idea that animals may constitute “social substitutes” especially in case of restricted social situations.

Nevertheless causal relationships are difficult to prove while proper developmental studies would need longitudinal approaches that are time consuming. Many of these assertions remain therefore to be studied again at the light of current research standards. In any case, animals are a source of multimodal stimulation and attention that can certainly trigger the development of cognitive abilities. Although limited to clinical cases at first, Levinson’s pioneering work on dogs [24] suggested that the presence of such an animal near an autistic child may stimulate language production.

Animals and humans: the animal side

Domestic animals, as said before, develop real abilities to perceive and interpret human signals. Farm animals are able to discriminate familiar and unfamiliar humans [*e.g.* 25, 26] and to give a valence to the relationship [27] as do horses [28]. This valence is extended from the familiar caretaker to unknown humans, showing that animals may generalize [29, 30]. Each interaction is a source of positive or negative memory and the resulting relationship from a succession of interactions will depend on the relative weight of these memories. Human actions may have long term impact, resulting in avoidance of contact (if human actions are inappropriate, *e.g.* [31]) or proximity seeking (if appropriate, [32, 33]), even several months after loss of contact. Because different species may have different expectations and needs, there may be “misunderstandings”: for example, horses seek mere proximity where humans

seek tactile contact [34, 35]. Inappropriate life conditions and types of interactions may lead to negative reactions from animals [36], “depressive” states (Fureix *et al.* submitted) or the development of behavioural disorders (*e.g.* [37]). Horses deprived from contact with conspecifics paradoxically may behave more aggressively towards humans [38]. Overall, it seems that animals develop a better relationship to humans if, above the quality of interactions, their life conditions are appropriate. However, humans do not always recognize the signs of discomfort, which may lead to chronic problems with consequences on the relationship [39].

The human environment is often – for pets – a very unusual situation. Social animals like dogs are often kept single in home from an early age while more solitary species like cats tend to be more easily kept in groups. This may explain some of the problems observed such as the abnormal behaviours of dogs when faced with conspecifics in outdoor encounters, difficulties to respect “rules” and/or excessive bonding to humans. Adults are an important part for the development of appropriate social competencies in young animals [40] and lack of intraspecific experience may disturb the interspecific relationship as well [38].

However, keeping animals single ensures that a specific bond may be developed between this individual and the human(s) present in the house. In captive birds, such as starlings, it has been shown that a special bond can be established only if the bird has no opportunity of bonding with other birds [41]. Parrots are typically hand raised and kept singly in order to ensure that humans will be their only reference [42]. From the animal point of view, humans in this case are probably “their” species and, as in the case of bird imprinting, species-specific behaviours, including sexual behaviour, may then be directed solely towards the “reference” species, here humans [43]. Bottle fed mammals may develop a privileged relationship to their caretaker [44] but may also be a source of problems as they sometimes become invasive (Hausberger unpublished).

Some dogs show signs of attachment to their owner [45, 46] to the point that they may react excessively to separation [47] and/or express strong excitation when reunited. Like us, pets may “use” humans as social substitutes in a context of socially deprived environments, seeking proximity and contact. The bad side is that, when animals consider the human as a conspecific, they may “test” each other’s status as they would do in a real social group, which may result in potential threatening or even biting. Therefore, develop mutual exclusive bond that humans wish may lead to problematic relationships. Finding the right balance between offering life conditions that ensure the animal’s well being and hence optimistic view of its environment (including humans) [48] while ensuring the development of the expected (by humans) bonding is a challenge. Horses kept in appropriate environments (including group housing) may develop a positive and specific relationship towards their trainer [33].

Animal well-being (according to the species standards) is essential in order that pets become secure and positive partners, especially if they are expected to be “social supports”. This is still more the case when they are involved in therapies.

ANIMALS IN THERAPIES

Some historical points

Even if animal domestication dates back around ten thousand years (*e.g.* around 14 000 years BC for the dogs, [49, 50]; 6000 years BC for the cats, [51, 52]), first known intentional use of animal for a therapeutic support appeared in 11st century in a Belgian hospital (*i.e.* patients cared for birds). This use spread out and, in the 18th and 19th centuries, various species have been part of health care institutions in Europe. For example, in 1792, birds and rabbits were used in therapies to help the insane at the York Retreat in England. In 1867, the Bethel Institute (Bielefeld, Germany) developed programs that included activities at farm, in equestrian center, with dogs, cats, birds and so on. These programs were first devoted to epileptic people but were then extended to care for people suffering from a wide range of physical and mental disorders. In the 1940’s, the military hospital in the Pawling Air Force (USA) recommended horseback riding and care of farm animals for the veterans of the Second World War (for a detailed chronology [53]). Scientific investigation on this question appeared though much later, in the second half of the 20th century, on the basis of “chance” observations by Levinson [24] and then Corson and Corson [54]. The American psychiatrist, Boris Levinson is considered the father of the animal assisted therapy. His Labrador Jingles was present, by chance, in his office when he received a child and their parents in consultation. This boy, who refused all contact and did not speak, began to interact with the dog and expressed his desire to come back to play with Jingles. Positive relationship took place gradually between them, leading to an improvement in the boy’s condition (*e.g.* the boy ended up talking for the first time with the dog; [24]). Further experiments led the psychiatrist to conclude that some patients – both children and adults – initially interacted with the animal and that, through these interactions, it was possible to promote positive changes with the human social environment. However, some patients displayed no change in the animal presence [55]. Levinson gave birth to the Pet-Facilitated Psychotherapy and the Pet-Oriented Child Psychotherapy theory. It works on the assumption that the therapist takes advantage of the natural propensity of children and animals to interact (*e.g.* play), the child sharing their feelings and anxieties with the non-judgmental animal.

Levinson’s work inspired the two other American psychiatrists, Samuel and Elizabeth Corson. As the most pioneering experiments, it was conducted by mere chance. The Corsons studied behavioral and

psycho-physiological characteristics of dogs. To facilitate their research, kennels was installed in the hospital. Some patients were aware of this presence and requested to see and to pet the dogs. Observing positive change in patients, Corson *et al.* decided to use pets in the hospital as a therapeutic adjunct for patients that were resistant to conventional therapies [54]. The studied population was 50 adults who displayed social withdrawal, lack of communication and self-esteem. Only three of them did not accept to interact with the pet. For the other 47 patients, improvements were noticed: increase in self-esteem, sense of responsibility and frequency of social interactions. Corson *et al.* also found a decreased intake of psychotropic drugs following the introduction of the pet [54].

After the 1960's, studies about animal-assisted therapy developed with two peaks, in the mid-1980's and at the end of the 1990's [56]. The literature is now abundant and multidisciplinary. It concerns diverse areas such as medicine, veterinary medicine, ethology, psychology, anthropology, sociology.

***Animal-assisted therapy:
a concept that remains to be clarified***

Many terms are used (*e.g.* animal assisted therapy, pet facilitated therapy, zootherapy, animal associated activities) which also reflect a diversity of practices. For example, some have a therapeutic aims, others can perform educational or social functions. Moreover, they vary with respect to the animal used (*e.g.* horse, dog, cat, bird), the people considered (*e.g.* young, old, with mental disabilities or physical handicap), the duration of the intervention (*i.e.* short-term or long-term), the setting in which it is delivered (*e.g.* inpatient or outpatient setting, camp, medical clinic, home, school), and whether the intervention is delivered in a group or individual format.

Today, the majority of practitioners and researchers tend to a relative consensus and propose to use "animal assisted interventions" as the term including

all programs using animal for human [57]. "Animal-assisted therapy" or AAT is a sub-type of "animal assisted interventions" that corresponds to practices that generate change (or learning) allowing people to better overcome their problems [58]. Fine proposed to define AAT as "a goal-oriented intervention in which an animal meeting specific criteria is an integral part of the treatment process. This service is delivered by a health or human service professional working within the scope of his or her professional role" [59].

Animal-assisted therapy in the scientific literature

Recently, two major literature reviews have been on the topic of AAT. First, Nimer and Lundahl performed a broad research on articles reporting on AAT in which they reviewed 250 studies [60]. However, when they applied usual scientific criteria to assess the studies' validity, it appeared that only 49 papers met these criteria (*e.g.* report only on animal AAT, at least five participants in a treatment group). One year later, Michalon *et al.* [56] proposed a more exhaustive study based on 778 references (*Figure 1*), mainly in English but they did not separate scientific based studies from more clinical type reports.

Most papers are concerned with particular age classes : children, adolescent, adult or elderly – in institution or not – and sometimes with comparison between them (*e.g.* [61]). More anecdotal reports are concerned with effects according to gender [62], social status (*e.g.* prisoners [63]; students [64]) or pathologies (*e.g.* autistic disorders, [65]). The types of interaction according to the animal species have been sometimes described. Thus, preschoolers showed a greater tactile interest for the dog and more vocal use with birds during encounters at school [66]. People with social impairments (*e.g.* people with autism; Grandgeorge *et al.*, in preparation) also adopt different behavioral strategies according to the species they encounter. Different species may stimulate different facets in humans and might represent different "therapeutic potentials".

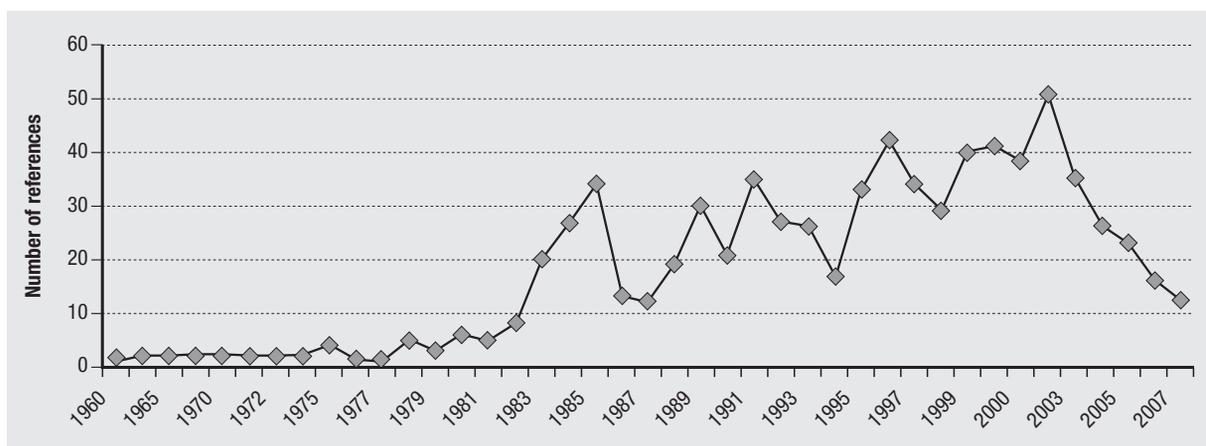


Fig. 1 | Temporal distribution of literature production on animal assisted therapy and education in the last decades [56].

Fur animals remain the most used. Numerous authors agree on the fact that dogs come in first [60, 67, 68] with one paper out of five [56] but the rank of other species use is more controversial. Whereas the second rank of the species used is the horses for Nimer and Lundahl [60] and Maurer [69], Hatch [68] proposed this decreasing list: cats, mice, ferrets, horses, lamas, farm animals (*i.e.* cows and goats) and monkeys. At last, Michalon *et al.* [56] ranked, in descending order, cats (5.8%), horse (5.6%), dolphins (5.3%), birds (1.9%) while fishes, snakes, rodents, turtles, farm and wild animals are little represented in the scientific literature. Surprisingly, around 30% of the studies did not mention the species name and, thus, used the term “pet”. Indeed, even if description of their main characteristics could be expected (species, breed, age or sex could influence their behaviors; *e.g.* [66, 70, 71]) it is mainly not the case [69]. This lack of consideration of species characteristics is indeed deplorable, as it may indicate that animals are just considered as “tools” for therapies and not proper actors of the interaction.

The methodological approaches described are varied. First researches were mainly based on case studies with detailed description of individual changes (*e.g.* Johnny the young boy and Jingles the Labrador [24]). Then, the 1980's marked a turning point in both methodology approaches and measurements. For example, the authors conducted researches in a way of standardization, generalization and reproducibility with the use of statistical analyses (*e.g.* [53, 72]). Today, we can clearly oppose two main types of approaches, on the one hand qualitative researches based on few subjects studied by interviews or case studies and on the other hand, quantitative researches focused on large samples of subjects examined using questionnaires and statistical analyses. At last, observations – such as used in ethology – remain rarely used which is regretted by numerous authors (*e.g.* [61, 73]).

Animal-assisted therapy: the other side of the coin

Literature on AAT tends to be biased as showing only positive aspects. One could question the lack of papers reporting the absence of effects or negative effects of this practice. Indeed, they remain often ignored. Different explanations can be proposed [56, 73-75]. Hines explained that “*the media took an interest in this area and introduced the findings to a wide audience in popular national magazines and a myriad of national and local newspapers*” [74]. These “well-planned media campaigns” exhibit animals as a miracle cure [73] and had a negative influence on scientific researches (*e.g.* difficulties to remain objective when medias want “emotional show”). The promotion of the positive image of animal has led to the involvement of a large network of socio-economic private actors (*e.g.* industry for animal welfare, animal food and veterinary) that may provide most of the funding for this type of research with expectations that may bias research outcomes. Beck

and Katcher [73] warned against scientific work “directed” only by economic stakes and invited to scientific and objective research on AAT and related topics. Finally, more clinical papers are often written by actors involved in the therapies, and hence convinced of the positive outcomes which may lead them to unconsciously oversee potential problems.

For this reason, assessment and methodology are crucial and questioned (*e.g.* [76-79]). Different biases have been identified, the major ones being sample size (*e.g.* case studies; [80, 81]), wide range of ages, especially for young people (*e.g.* between 6 and 19 years old [82]), the lack or insufficient precision about diagnoses (*e.g.* [83]), the absence of a control group (*e.g.* [84]), pre / post processing session (*e.g.* [85, 86]), description of animal (*e.g.* [87]), or information about other therapies (*e.g.* [88]).

Risks are rarely mentioned [56]. Some papers (*e.g.* [89, 90]) refer to security issues, allergies but the most often mentioned risk remains zoonoses (define as “*diseases and infections, which are naturally transmitted between vertebrate animals and human*” [91]). For example, to avoid transmission of zoonotic diseases, the Delta Society advises practitioners to work closely with veterinarians and other public health specialists to ensure the safety of the humans involved. Other risks may be related to the human-animal interaction *per se* and the perception that animals have of the situation (see above). At present, too little is known to appreciate properly this part but thought and care must be given to it.

Overall, there is very limited scientific data on the AAT subject [77, 79] and this literature does not give a clear picture of the practices. The species used in animal assisted therapies are often those who have a long history with humans: dog [49, 50], horse [92] for example. However, we found that their characteristics are less detailed (*e.g.* gender, age) while they may play an important role. This is also true for the study of the impacts of these encounters. If the effects on humans are quite well documented, the impact on animals is much less known (*e.g.* welfare). However, as Heimlich's study has shown [93], lowered attention towards the animal's needs (*e.g.* rest) may have negative and long-term impact on the animal.

WHAT COULD BE THE PROCESSES INVOLVED?

As mentioned before, animals have particularities that may trigger interest and stimulate sensory functions in patients: they bring multisensory stimulation through sounds, postures, smell, touch, their signals may be easier to decode and they may be actively demanding in the interaction [94]. Their actions are simple, repetitive and nonverbal, therefore more accessible to patients with language disorders. Animals are therefore a source and direction for attention [11]. It is generally admitted that, because children may more easily decode their signals, they may appreciate better their needs and feelings and

therefore develop empathy, which seems to be validated by some scientific data [19]. Causal relationships are nevertheless difficult to prove, which may require putting more emphasis on longitudinal aspects and/or home situations where the person may develop a particular bond with the animal. According to Poresky *et al.*, more than the mere owning of an animal or occasional encounters, it is the quality of the bond established that may be crucial [95].

We lack proper scientific evidence on the processes involved in the observed impact of social influences (here including intra- and inter-specific aspects) on the development of social competencies and social cognition. Although there is clear evidence that skills, like language, need social stimulation in order to develop properly (*e.g.* [96]), which aspects of the social stimulation are needed to have such an effect remain poorly known [97]. Social interactions with an adult (and not mere exposure to audio or audiovisual stimulations) may preserve some perceptual skills in babies beyond the expected sensitive period, questioning the link between the social brain and the perceptual brain [98, 99]. Selective attention may be a key feature that is elicited by specific bonding and plays a major role in multimodal integration and sensory processing [100, 101]. Thus, sound processing at the cochlea level may be tuned by a focused attention [100].

Some experimental evidence is provided by animal models. Songbirds are classical models for language development [102] that are strongly dependent upon social influences in order to develop song. Like the babies mentioned before, young birds may learn beyond the neurological sensitive period if they are confronted to social interactions [103]. They may even learn the songs of other species if their unique social partner is from another species, as do captive starlings or parrots [42, 104]. These “exceptional learnings” are restricted to cases where a strong and rather exclusive bond has clearly been established [42]. Parrots and songbirds learn little from an audiotope or an audiovisual stimulation and direct contact remains an essential clue. Competition for attention from the “social partner” may be used to enhance attention and learning [42]. These data reflect the power of social influences to enhance brain plasticity. Clear proofs have been given through neuroethological studies performed on starlings. Thus, not only does in this species song copying reflect directly social bonding, but the selective attention directed towards a particular social partner may prevent “hearing” sounds from the environment [105, 106] and hence the proper development of the corresponding brain areas. Thus, in these young birds, it has been shown that social deprivation may lead to the same deficits in a unisensory primary auditory area (our auditory cortex) as a sensory deprivation [101, 107]. The lack of social partners may have the same impact as the lack of sounds during development!

More intriguing still is the finding that even social segregation may lead to these drastic effects: young

birds that do not bond with adults, even if they are housed together, will not copy their songs but will not either present the species characteristics of neuronal selectivity in their auditory area: social segregation has the same strong effects as social physical separation [108]. Selective attention towards a partner does influence auditory processing very early on and therefore may be essential to “shape” brain development, in particular through multimodal interactions that are influenced by familiarity [109].

For obvious reasons, this type of data are lacking for humans. It is nevertheless highly probable that the human brain is at least as responsive to social stimulation as is a bird’s brain. The finding that the primary auditory area is shaped by social bonding sheds a new light on Gervais *et al.*’s results [110] showing a deficit in voice processing in the brain of autistic patients: is this perceptual disorder a source or a consequence of social withdrawal? Where this questioning is especially interesting in the current review is that if bonding occurs between a patient and an animal, one may wonder whether this new stimulation will not trigger brain plasticity (as observed in the other direction when animals develop new skills as a result of their privileged relationship with humans). Brain plasticity is much larger than long thought and while the predominant view has been that brain controls our behaviours, and it is true that brain disorders lead to behavioural disorders, experimental evidence increases that shows the huge impact of environmental (in particular social) factors on cognitive development and repair. Animal models are very informative in this sense [111].

There is therefore a potential for improvement through AAT but it may require more attention to the processes: is enough bonding achieved through occasional encounters? What kind of stimulations may be favourable on either side for proper bonding? What are the most appropriate species and situations (*e.g.* riding or just observing horses)? How does the interaction work: modalities involved, part due to animal or patient, active or passive presence, attentional cues? Should a “third party” interfere, such as a therapist or should animals and humans interact freely? There are also good chances that interindividual variability is high and that species, situations and modalities may have to differ according to the syndrome or the individual and its characteristics (*e.g.* gender, age).

We are at a turning point where detailed scientific observational and experimental studies must be developed in parallel with sound reliable evaluations of cognitive and social skills in the patients involved. Then we will only be able to find out to whether and to which extent the goal of animal-assisted therapies may bring profound and durable improvements. It is also foreseeable that bonding may only occur if the animal itself is in a good welfare state, which means attention has to be given by the therapist or the family members to its needs and expectations.

ANIMAL ASSISTED THERAPIES AND AUTISM

To face up to social deficits and communicative impairments in the autistic disorders [112], many authors suggested that the animal could “remove the children with autism from their bubble” (e.g. [113]). Many AAT were and are developed to help people with autism. But again, the scientific literature on relationships between people with autism and animals remains scarce [56]. If we rule out case studies (e.g. [80]), theoretical approaches (e.g. [113]) and researches that do not entirely focus on autistic disorders (e.g. large range of clinical syndromes, small number of people with autism; [83, 114]), two main types of studies can be identified. On the one hand, some studies focused on the nature of human-animal interactions in the usual environment (i.e. children’s home); animals were either familiar or non familiar to the human partner [115-117]. On the other hand, the other focused on AAT or merely on the effects of interactions with animals [65, 94, 118-122; Grandgeorge *et al.*, in revision]. In this last group, eight scientific studies can be identified that examining the impact of animals on potential improvements in people with autism (Figure 2).

Redefer & Goodman were pioneers in the scientific approach of the animal’s benefits for children with autism [94]. They proposed that dogs – and by extension, all animals – are powerful stimuli that may compensate for multisensory deficits of children with autism (e.g. visual, tactile, auditory differences; [123, 124]). Observations were performed on a group of children with a therapist. Encounters placed without the animal and then a dog was included and the last sessions were without an animal (i.e. pre- and post-treatment analysis). The “dog session” was structured into three parts. The therapist was passive at both beginning and end while in the middle of the session, he encouraged interactions between children and dogs. The results showed an increase in children’s social behaviors (e.g. more interaction with

both therapist and dog) and a decrease in children’s withdrawal, only in the presence of the dog. These modifications blurred with time, although Redefer & Goodman noticed that they could still be seen – but in a smaller proportion – one month after stopping the sessions with the dog, suggesting that these improvements were not stable over time without the animal’s presence. Unfortunately no control group was used in this study and the authors provide no detail on the observed behaviors (i.e. what are the precise interactions with the dog or the therapist and are they identical?). In addition, children were described as “displaying autistic features” (i.e. social withdrawal, idiosyncratic habits, unusual or absent language) but no diagnosis has been done or, at least, this information had not been mentioned.

More than ten years later, Martin & Farnum [65] proposed that animals can act as a transitional object for the children with autism in accordance with previous Winnicott’s works [125] – and that the bond with animal can be transferred to humans. They used a detailed ethogram to observe several times each child interacting with a therapist in three different conditions: 1) with a nonsocial toy (i.e. ball), 2) a stuffed dog and 3) a live dog specially trained for therapy sessions. The results indicated that children displayed more laughs and social interactions in the presence of a live dog (with more interactions toward the dog than the therapist) than in the two other conditions. Finally, children talked more often about the dog with the therapist than about the toys, with a more appropriate language. The children displayed hand flapping in presence of the dog, a behavior whose function has not been established in the study (e.g. stereotypy, stress or joy?). Again, small sample size (no. = 10) and the absence of a matching control group is unfortunate in this study. In addition, three dogs of different appearance were used (i.e. size) that could influence the children’s behavior (no statistical control was notified).

Year	1989	2002	2006	2008	2009	2009	2010	In revision
Authors	Redefer & Goodman	Martin & Farnum	Sams	Burrows <i>et al.</i>	Bass <i>et al.</i>	Prothmann <i>et al.</i>	Krskova <i>et al.</i>	Grandgeorge <i>et al.</i>
No.	12	10	22	10	34	14	9	260
Age (years)	5-10	3-13	7-13	4-14	4.5-14	6-14	5-13	6-34
Animals	Dog 	Dog 	Dog-Lama-Rabbit 	Service dog 	Horse 	Dog 	Guinea pig 	Dog-Cat-Rodent 
3 rd person	Therapist	Therapist	Therapist	None	Non-therapist	Dog	None	None
Contact	During the sessions	During the sessions	During the sessions	Home	During the sessions	During the sessions	School	Home
Level	Individual	Individual	Individual	Individual	2 groups	Individual	Group	Individual
Methodology	Observations	Observations	Simple observations	Participant observation + semistructured interviews	Parental or teacher questionnaires	Observations	Observations	Parental questionnaire + medical assessment
Duration	18 sessions of 20 minutes (+ pre- and post-treatment)	15 minutes each week over 15 weeks	One standard occupational therapy session and one with animals each week during 15 weeks	Between 6 and 12 months	1 hour per week over 12 weeks	3 times in 3 weeks	10 days	Several years

Fig. 2 | Synthesis of eight empirical studies about animal assisted interventions for people with autism.

In a therapeutic farm, Sams *et al.* [118] hypothesized that animal's use in occupational therapy sessions could improve the human's attentional skills and therefore influence their social behavior. This investigation compared language use and social interaction in children with autism receiving in turn each week two forms of occupational therapy: occupational therapy using standard techniques, and occupational therapy incorporating animals (*i.e.* llamas, dogs and rabbits). The results were brief, assessing only the occurrence and the average time to talk or to socially interact in both therapy conditions. Results suggested that the children with autism displayed greater use of language and increased social interaction in the presence of animals compared to sessions using exclusively standard occupational therapy techniques. However, again, the absence of assessment of the impact of sessions between them and a control group does not enable to reach definitive conclusions.

Burrows *et al.* [119] studied the impact of integrating a service dog into the daily life of children with autism. These authors hypothesized that this introduction could improve the quality of life of both the children and their families. They used qualitative methods (*i.e.* participant observation, video recordings of family-parent-dog interaction, and semi-structured parental interviews) to describe the whole family behaviors in different contexts. The results showed that dogs were considered the guardian of the child's safety (*e.g.* preventing wandering during the night) and increased the family welfare (*e.g.* less stress for child monitoring, easier recreational activities). All parents reported that their children seemed to be happier with the dog. In this study the impact of the co-therapist animal was considered in long term relationship as a familiar pet. Again, the sample size, the absence of qualitative data lowered the reliability of this study. At last, we need to keep in mind that the dog was restrained in his behavior by his "training" and the relationships describing here may be different to relationships with "ordinary dogs".

Bass *et al.* [120] presented a more standardized approach of therapeutic horseback riding, suggesting that these sessions could improve the social functioning of children with autism. Thus they compared a group of children who had regular access to therapeutic horseback riding for 12 weeks to another group of children on waiting list. The results showed that children with autism exposed to therapeutic horseback riding exhibited greater sensory seeking, sensory sensitivity, social motivation, and less inattention, distractibility, and sedentary behaviors. However, these measures were based on scales proposed to parents or teachers, whose objectivity and expectations did not appear to be taken into account.

Prothmann *et al.* [121] studied, in children with autism, the preference and responsiveness to human being, medium sized dog (certified co-therapist) and objects, all unknown at the time of the first session. During the three observation sessions, children have

largely directed their behavior toward the dog, then to the adult and showed little interest in the objects. Behaviors initiated by children with autism suggest that the dog is considered a living partner: interactive play (with or without object involved) and strokes did occur. The frequency of these behaviors increased during the second session. The authors suggested that "familiarity" may amplify the desire to interact with the dog, and above all, they rejected the hypothesis of a novelty effect (*i.e.* the first encounter with an animal could motivate children to interact). According to Prothmann *et al.* [121], animals – especially dogs – communicate their intentions in a more comprehensible way than human beings for children with autism (as previously hypothesized [94]) while autistic patients may be more sensitive to animals than human signals [126] which may explain the observed improvement. It remains to be shown whether these effects are durable (beyond the sessions) and may be extended to other situations (child-pet at home).

Kršková *et al.* [122] investigated the effects of a guinea pig as a small therapeutic animal at school on the social behavior of nine children with autism. They studied the differences in social behaviors – both with human and animal – before pet's arrival (10 days) and during pet's presence (10 days). The results showed an increase in the frequency of social contacts with familiar people after the pet's arrival and an unknown pet seemed to be more attractive than the unknown observer (in frequency of physical contacts). The authors noticed that these differences vary from one child to another which confirmed Levinson's position: "a therapy including a pet is not a generalized method" [55]. This promising study would deserve to be confirmed using a more detailed ethogram (here, only four behavioral categories) and a smaller age range (*i.e.* 5 to 13 years old).

At last, Grandgeorge *et al.* (in revision) studied the introduction of pets in children with autism families and the possible association with an increase of social skills. In a first period, ADI-R evaluations – an evaluation instrument of autistic disorders [127] – were performed by psychiatrists that did not know anything about the child-pet project. In a second period, parents were interviewed by phone by one of the investigators not involved in the ADI-R scoring. They were asked to answer a short standardised questionnaire about pets and their children. Therefore, neither parents nor evaluators were influenced by potential expectations on the possible impact of pets. They used the 36-items ADI-R algorithm to assess changes between two periods according the presence, the absence or the introduction of pets after the age of 5. Extracted from a pool of 260 people with autism according to their experience with pet at home, the first study focused on two groups of 12 children (one with pet's arrival and the control group without pet) and a second one on two groups of 8 children (one with pet's presence before child's birth and the second control group without pet). Amongst the 36 items, two appeared

to have changed between the two periods: “offering to share” and “offering comfort” which were both improved, suggesting that pets may indeed help develop empathy as suggested earlier [19]. Empathy is a step towards theory of mind considered to be particularly lacking in people with autism [128].

Proper scientific evidence of positive impact of animals on skills of children with autism therefore is scarce at present, but promising.

GENERAL CONCLUSIONS

This review elucidates the existence of evidence for animal use for therapeutic aims. However there are a lack of clear scientific data and strong needs for proper scientific researches. Further studies are needed that would be based on adapted observational and experimental approaches on larger samples

of patients. Only precise and quantified descriptions both of the interactions and the outcomes may help evaluate the real impact and understand the process involved. Long term studies, such as researches about human-pet at home, may bring robust results about potential profound and durable improvements. Lastly, if we want that human-animal relationship is beneficial to both partners, a large field of research opens up by giving greater attention to animal and by studying their respective well-being.

Conflict of interest statement

There are no potential conflicts of interest or any financial or personal relationships with other people or organizations that could inappropriately bias conduct and findings of this study.

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