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Animal-Assisted Interventions for Children with Attention Deficit/Hyperactivity Disorder: A Theoretical Review and Consideration of Future Research Directions

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Abstract

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most prevalent neurodevelopmental disorders and is characterized by core symptoms of inattention, impulsivity, and hyperactivity. Given the limitations of the existing treatment strategies, it seems necessary to consider the further exploration of alternative treatment approaches. In this review, the application and complementary use of animal-assisted interventions to the treatment of ADHD were discussed. Several mechanisms including calming, socializing, motivating, and cognitive effects of animal-assisted interventions were explored. Since studies directly investigating these effects on ADHD are scarce, so each of them were examined in terms of how it could benefit the treatment of ADHD. These effects can have a positive effect on several core symptoms of ADHD.

Keywords

Attention Deficit Hyperactivity Disorder (ADHD), animal-assisted interventions (AAI), non-pharmacological treatment

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Introduction

Attention deficit/hyperactivity disorder (ADHD) is a common and well-studied neurodevelopmental disorder, with a worldwide prevalence among children estimated to be 5.29% (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). According to the *Diagnostic and Statistical Manual of Mental Disorders* 5th edition [DSM-V; American Psychiatric Association (APA), 2013], ADHD is characterized by chronic symptoms of inattention, hyperactivity, and impulsivity. In addition to these core symptoms, it is also commonly associated with significant impairments in social, academic, and executive functioning, as well as deficits in motivational processes. Most widely recommended evidence-based treatments for ADHD include stimulant medication and behavioral therapy, but individuals with ADHD and their families also often consider complementary or alternative treatment approaches for a variety of reasons (e.g., medication side effects, availability of professional resources; Bader & Adesman, 2015).

Thus, given the disabling, chronic, and pervasive nature of ADHD as well as issues related to existing treatment approaches (Chacko, Kofler, & Jarrett, 2014), it seems necessary to consider further exploration of already established interventions and the development of novel approaches. One complementary treatment for ADHD that is promising in this endeavor is animal-assisted therapy. However, research concerning animal-based interventions in ADHD is still in its infancy and knowledge about the effects of these interventions on individuals with ADHD is scarce. The aim of the current paper is therefore to discuss the positive effects of animal-assisted interventions that were found for other conditions and disorders (e.g., autism spectrum disorder) in relation to the core symptoms and associated difficulties of ADHD. By reviewing the existing theories and literature, some groundwork can be established for how the proposed effects and mechanisms of animal-assisted interventions can possibly be applied to the treatment of children with ADHD. Implications for future research will be considered.

Definition: Animal-assisted Interventions

To date, several different definitions for animal-assisted therapy are mentioned in the literature (Lajoie, 2003), but the field still lacks a shared terminology. The umbrella term of animal-assisted interventions has been proposed to include both animal-assisted activities and animal-assisted therapies, which will therefore be used for the purpose of this paper to describe these different types of human–animal interactions. Pet Partners [n.d., (a)], formerly Delta Society, a non-profit organization using animals in therapy to improve patients' well-being and quality of life, distinguishes between these two types of interventions as follows. *Animal-assisted therapy* (AAT) "... is a goal-directed intervention in which an animal that meets specific criteria is an integral part of the treatment process. AAT is directed and/or delivered by a health/human service

professional with specialized expertise, and within the scope of practice of his/her profession. AAT is designed to promote improvement in human physical, social, emotional, and/or cognitive functioning [cognitive functioning refers to thinking and intellectual skills]. AAT is provided in a variety of settings and may be group or individual in nature. This process is documented and evaluated" [Pet Partners, n. d. (a)]. *Animal-assisted activities* (AAA) "... provide opportunities for motivational, educational, recreational, and/or therapeutic benefits to enhance quality of life. AAA are delivered in a variety of environments by specially trained professionals, paraprofessionals, and/or volunteers in association with animals that meet specific criteria" [Pet Partners, n. d. (a)].

In general, the field of animal-assisted interventions still lacks strong empirical support and a common theoretical framework (Geist, 2011). In addition, more support from randomized, controlled experiments and efficacy studies are needed (Kruger & Serpell, 2010). Apparently, only three controlled experiments have investigated how contact with therapy animals affects children with ADHD (see Katcher & Teumer, 2006; Somervill, Swanson, Robertson, Arnett, & MacLin, 2009; Schuck, Emmerson, Fine, & Lakes, 2015). Nevertheless, animal-assisted interventions were found to benefit children with other conditions, e.g., children suffering from autism spectrum disorder (e.g., Martin & Farnum, 2002; Sams, Fortney, & Willenbring, 2006; Bass, Duchowny, & Llabre, 2009; Viau, Arsenault-Lapierre, Fecteau, Champagne, Walker, & Lupien, 2010; O'Haire, 2013; Wright et al., 2015) or Down syndrome (Limond, Bradshaw, & Cormack, 1997). Similarly, the positive effects of animals on various conditions and functions, including depression (Holcomb, Jendro, Weber, & Nahan, 1997), physical arousal and anxiety (Katcher, Segal, & Beck, 1984), motivation (Martin & Farnum, 2002), and social functioning (O'Haire, 2013) were demonstrated in clinical and non-clinical samples. In addition to the core symptoms of ADHD, these states or functions are also impaired in many children with ADHD (Barkley, 2006). Therefore, these impairments will be discussed in more detail and in relation to possible improvements through animal-assisted interventions. Different theories and underlying mechanisms have been proposed to explain how and why human-animal interactions appear to be therapeutic (Hart, 2010; Kruger & Serpell, 2010). In the following sections, these mechanisms and how they might be applied to the animal-based treatment of ADHD will be discussed in turn. Moreover, Table 1 was added to give an overview of the studies that were included in the review (structure adopted from Beetz, Uvnäs-Moberg, Julius, and Kotrschal (2012).

Theoretical Frameworks

Prior to discussing the beneficial effects of animal-assisted interventions, including calming, socializing, motivational, and cognitive effects, an overview of the theories on their underlying mechanisms will be given. Various theories

Table 1. Studies Investigating the Different Effects of Human–Animal Interactions.

Authors	Study Objective	Population	N	Main Conclusions
Allen et al. (2002)	Effects of the presence of friends, spouses, and pets (i.e., cats or dogs) on cardiovascular reactivity to psychological and physical stress.	Married adult couples	240	People with pets had lower heart rate and blood pressure levels during baseline, and smaller increase during and faster recovery from the stressor than people without pets. Among pet owners, most stress reduction during the presence of the pet.
Allen et al. (1991)	Effects of the presence of one's pet dog, close friend, or being alone on autonomic responses during a stressful task.	Adult women, ages 27–55 yr.	45	Lowest physiological reactivity (i.e., skin conductance responses, blood pressure, and heart rate) during the presence of own dog.
Anderson et al. (1992)	Comparison of risk factors for cardiovascular disease between pet owners and non-owners.	Pet owners and non-owners	5,741	Pet owners had lower systolic blood pressure and plasma triglycerides than non-owners. No differences in Body Mass Index and self-reported smoking habits.
Banks and Banks (2002)	Comparison of the effects of no animal-assisted therapy, animal-assisted therapy with a dog once per week, or three times per week on loneliness.	Elderly residents in long-term care facilities	45	Loneliness was reduced in both animal-assisted therapy groups.

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Barker and Dawson (1998)	Effect of single dog-assisted therapy session vs single recreational therapy session on anxiety levels.	Adult psychiatric patients	230	Significant reductions in anxiety after dog-assisted therapy session for patients with different psychiatric disorders, but no differences in ratings between the two types of session.
Bass et al. (2009)	Effects of 12-wk. therapeutic horseback riding intervention on social functioning in comparison to a wait list control group.	Children with autism, ages 4–10 yr.	34	Children in a horseback riding group showed greater sensory seeking, sensory sensitivity, social motivation, less inattention, distractibility, and sedentary behavior.
Baun et al. (1984)	Physiological effects during three 9-min. measurement sessions in which participants read quietly, petted an unfamiliar dog, or petted their own dog.	Adults, ages 24–74 yr.	24	At the beginning of the protocol, participants who petted their own dog showed a greeting response, as blood pressure was higher than when petting an unfamiliar dog or reading quietly, but also had the greatest decrease in blood pressure over time.
Beetz (2013)	Effects of the presence of a dog in the classroom compared to a control class without a dog on socio-emotional experience in	Children, third grade, ages 8–9 yr.	46	Children in the classroom with a dog showed greater increase in positive attitudes towards school and positive emotions

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Beetz et al. (2012)	school, depression, and emotion regulation strategies. Social stress test in the presence of a therapy dog, friendly human, or toy dog.	Children with insecure-avoidant or disorganized attachment, ages 7–11 yr.	47	related to learning over the course of the year. Lower cortisol levels in the real dog condition than in the other two conditions.
Daly and Suggs (2010)	Survey of teachers' attitudes and experiences regarding the use of pets in the classroom.	Elementary classroom teachers	75	Majority of teachers reported that presence of pets in the classroom increases empathy and socio-emotional development in children.
DeMello (1999)	Physiological recovery from a mild cognitive stressor in three conditions: unfamiliar pet absent, pet present and visual interaction allowed, and pet present and tactual interaction allowed.	Normotensive adults, ages 26–50 yr.	50	Increase in cardiovascular responses during cognitive stressor in all conditions. Reductions in blood pressure and heart rate greatest when dog was present but only visual interaction allowed.
Gee, Church, and Altobelli (2010)	Object categorization task (match-to-sample) in the presence of a live dog, stuffed dog, or human.	Preschool children, ages 3–5 yr.	12	Fewer irrelevant choices/errors in the presence of the real dog than in the other two conditions.
Gee, Crist, and Carr (2010)	Memory task (object recognition) in the presence of a live dog, stuffed dog, or human.	Preschool children, ages 3–5 yr.	12	Fewest instructional prompts needed in the presence of real dog. Most prompts needed in the presence of a human.

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Gee et al. (2014)	Comparison of heart rate variability and responses to a stressful memory task while touching a dog, stuffed dog, and a human before and after the task.	University students, ages 18–41 yr.	53	Stress response to the working memory task did not differ when participants were touching a dog, a stuffed dog, and a human.
Gee et al. (2012)	Categorization of animate and inanimate objects in the presence of a live dog, stuffed dog, or human.	Preschool children, ages 3–5 yr.	17	Best performance in categorizing animate objects in the presence of a dog compared to the other conditions.
Grandgeorge et al. (2012)	Changes in prosocial behaviors in children with autism after arrival of a new pet.	Individuals with autism spectrum disorder, ages 6–34 yr.	260	Prosocial behaviors (i.e., offering to share and offering comfort) increased after individuals got a pet.
Handlin et al. (2011)	Dog owners stroked, petted, and talked with their dogs for 3 min. Women in a control group did not own and interact with a dog.	Female dog owners	20	Oxytocin levels highest during or shortly after interaction with own dog. Cortisol and insulin levels decreased within an hour after the interaction.
Hansen et al. (1999)	Physical examination in the presence or absence of a therapy dog.	Children, ages 2–6 yr.	34	No difference in physiological measures (i.e., blood pressure, heart rate, and fingertip temperature) between the groups, but less behavioral stress when the dog was present.

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Haughie et al. (1992)	Change in behavior of residents of two separate wards over three conditions: baseline, dog intervention, and photographic intervention (i.e., photos of the dog plus visitor).	Elderly psychiatric patients, ages 65–86 yr.	37	Greater increase in social interactions on both wards in the presence of the dog than during the photographic intervention.
Heimlich (2001)	Effects of a canine-assisted therapy program on behavioral outcomes.	Children with multiple disabilities, ages 7–17 yr.	14	Data indicated improvements in attention span, physical movement, communication, and compliance. No generalizations could be made due to a number of confounding factors.
Hergovich et al. (2002)	Effects of 3-mo. presence vs absence of a dog in the classroom on independence, social competence, and empathy with animals	Children, first grade, of multi-ethnic background, ages 6–7 yr.	46	Increase in independence and empathy with animals in experimental, but not control group (no dog). Teachers rated children in the experimental group to show higher social integration and less aggression compared to children in the control group.
Holcomb et al. (1997)	Effects of the presence or absence of an aviary on depression.	Elderly men participating in a health care program	38	No difference in depression when the aviary was either present or absent. However, utilization of aviary by men

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Kaminski et al. (2002)	Effect of play vs. dog therapy on physical and emotional variables.	Hospitalized children	70	was associated with reductions in depression. Increase in parent-rated mood after both therapies, but children in pet-therapy group were rated to be happier than children in play therapy group. Children in pet-therapy group displayed more positive affect and touching. Heart rate was higher in the pet therapy group prior to and following therapy. No differences in salivary cortisol levels between groups.
Katcher, Segal, and Beck (1984)	Random assignment to one of five treatments prior to elective oral surgery: contemplation of aquarium, contemplation of poster, poster contemplation with hypnotic induction, aquarium contemplation with hypnosis, and non-intervention control.	Adults, ages 21–60 yr.	42	Pretreatment with aquarium contemplation and hypnosis, either alone or in combination, produced greater reductions in blood pressure, heart rate, and subjective and objective measures of anxiety during surgery than poster contemplation or the control procedure.
Kotrschal and Ortbauer (2003)	Behavior observations in the classroom first during a 1-mo. control		24	Decrease in aggression, hyperactivity, and withdrawal. More

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
LeRoux et al. (2014)	period without a dog and then with a dog. 10-wk. animal-assisted reading program with three experimental groups (i.e., reading to a dog in the presence of an adult, reading directly to an adult, or reading to a teddy bear in the presence of an adult) and a control group that was not part of the program.	Elementary school children of multi-ethnic background Children, third grade, ages 7–13.	102	social integration of the group and more attention to the teacher when a dog was present in the classroom. Reading rate higher in dog group than teddy bear group. Reading accuracy and reading comprehension higher in dog group than adult, teddy bear, and control group.
Martin and Farnum (2002)	Three different conditions: interaction with toy, stuffed dog, or real dog.	Children with pervasive developmental disorders, ages 3–13 yr.	10	In the presence of the real dog, children were in a more playful mood, more focused, and more aware of their social environments.
McNicholas and Collis (2000)	Following daily routines for 5 days with and without a dog.	Participant observer	1	The company of a dog increased frequency of social interactions, especially with strangers.
Miller et al. (2009)	Changes in oxytocin levels before and after interacting with own dog or reading without the presence of the dog.	Adult dog owners, ages 22–50 yr.	20	Greater increase in serum oxytocin levels in women who interacted with their dog than women in the reading

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Nagasawa et al. (2009)	Effects of 30 min. interaction with own dog vs not looking at own dog directly on urinary oxytocin concentration	Adult dog owners	55	condition. No difference in oxytocin between interaction with dog or reading in men. Owners who reported a higher degree of relationship with their dog received longer gazes from their dogs and had higher urinary oxytocin levels after interaction, but not in the control experiment (avoiding gazing at own dog).
Nagengast et al. (1997)	Physiological arousal and behavioral distress in response to a physical examination in the presence or absence of an unfamiliar dog.	Preschool children, ages 3–6 yr.	23	Greater reductions in systolic blood pressure, heart rate, and behavioral distress in the presence of the dog.
Nathanson et al. (1997)	Comparison of 2-wk. dolphin-assisted therapy and 6-mo. conventional physical and speech-language therapy.	Children with severe disabilities, ages 2–13 yr.	47	Dolphin-assisted therapy resulted in the acquisition of independent motor and speech-language skill acquisition.
Odendaal and Meintjes (2003)	Positive interactions with own or unfamiliar dog or reading a book.	Adults, ages 19–55 yr.	18	Decrease of cortisol in humans. Increase in b-endorphin, oxytocin, prolactin, phenylacetic acid, and dopamine in dogs and humans. Increase of b-endorphin, oxytocin and

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Sams et al. (2006)	Children received two forms of therapy: occupational therapy using standard techniques and occupational therapy incorporating animals.	Children with autism, ages 7–13 yr.	22	prolactin higher during dog interaction than book reading. Greater use of language and social interaction in sessions with animals than standard occupational therapy.
Schuck et al. (2015)	Randomly assigned 12-wk. cognitive-behavioral group therapy with or without canine-assisted intervention.	Children with ADHD, ages 7–9 yr.	24	Children in the canine-assisted intervention model showed greater reductions in the severity of ADHD symptoms than children who received CBT without the dog. Parents reported improvements in children's social skills, prosocial behaviors, and problematic behaviors in both treatment groups.
Somervill et al. (2009)	Effects of handling an unfamiliar dog on physiological reactions before, during, and after two 15-min. testing sessions: one with a dog present for 5 min. and one with no dog present.	Children with a primary diagnosis of ADHD, ages 7–12 yr.	17	Increase in diastolic blood pressure while children held the dog, and an increase in systolic blood pressure during the time period after holding the dog. Heart rate decreased during both of these periods.
Tissen et al. (2007)	Effect of different training methods (social training without dogs,	Children, third grade, ages 7–10 yr.	230	Teacher ratings indicated an increase in students' social

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Viau et al. (2010)	social training with dogs, dog attendance without social training) on social behavior, empathy and aggression over a period of 10 wk. Physiological effects of service dogs on basal salivary cortisol secretion of children with autism spectrum disorder before and after introduction of service dog to family, and after dog was removed for a short period.	Children with autism spectrum disorder, ages 3–15 yr.	42	behavior and empathy irrelative of program. Aggression decreased most in the group receiving social training with dogs. Decrease in cortisol awakening response after introduction of service dogs, but increased again after dog was removed from families. No effects on diurnal cortisol levels.
Vidovic et al. (1999)	Socio-emotional development of pet owners and children without pets.	School children, ages 10–15 yr.	826	Dog owners were more empathic and prosocially oriented than non-owners. Those who were more attached to their pets showed higher scores on empathy and prosocial behavior and rated family climate higher than non-owners and children who were less attached.
Vormbrock and Grossberg (1988)	Effects of interacting with a dog tactually, verbally, and visually on blood pressure and heart rate.	Undergraduate students, ages 18–24 yr.	60	Blood pressure was lowest when petting a dog and highest while talking to the experimenter. Heart rates were lowest when talking or

(continued)

Table 1. Continued.

Authors	Study Objective	Population	N	Main Conclusions
Walsh et al. (1995)	12-wk. pet as therapy program, in which a dog visited the ward for 3 hr: twice per week vs control group without dog visits.	Adults with dementia	14	touching the dog but higher when doing both at the same time. Reduced heart rate and reductions of noise levels during the presence of the dog.
Wilson (1991)	Effects of a dog on state anxiety. Comparison of three test conditions: reading aloud, reading quietly, and interacting with an unfamiliar dog.	College students, ages 18–39 yr.	92	Reading aloud produced more self-reported state anxiety than reading quietly and interacting with a dog. Interacting with the pet was slightly more stressful than reading quietly, although this effect was not significant.

regarding the possible mechanisms that are responsible for the therapeutic benefits and positive effects of animals on human well-being have been proposed (Kruger & Serpell, 2010). As discussed by Kruger and Serpell (2010), most of these theories emphasized that animals possess unique intrinsic attributes and qualities associated with these benefits. As such, merely the presence of an animal, its reactive behavior, or the availability of a pet for interaction can provide immediate benefits.

In order to explain the mechanisms that may underlie the calming effects of animals, it has been suggested that stimuli with the ability to focus and capture attention have a calming effect on the body (Serpell, 1986). Furthermore, the biophilia hypothesis (E. O. Wilson, 1984) argues that humans have an innate predisposition to be attracted by and attend to other living organisms such as animals. According to this hypothesis, humans evolved to regard animals as environmental signs of safety or danger. Friendly and calm animals were considered to have calming effects on humans, while aggressive animals were thought to have the opposite effect. In addition, biophilia suggests that animals increase alertness and attention in humans, which might promote enhanced concentration and task persistence in the presence of an animal. However, it should be noted that biophilia does not assign priority to animals, but rather involves all living organisms, including plants or people. Thus, one may assume that people are equally responsive to interactions with other humans and that these interactions have the same positive effects compared to those with animals. Nevertheless, various studies provide evidence in support of the unique effects of animals on human behavior that go beyond those of interactions with other humans (Allen, Blascovich, Tomaka, & Kelsey, 1991; Nagengast, Baun, Megel, & Leibowitz, 1997; Gee, Church, & Altobelli, 2010; Gee, Crist, & Carr, 2010; Gee, Gould, Swanson, & Wagner, 2012; Schuck et al., 2015).

Furthermore, animals were found to often function as important attachment figures (Melson, 2001). According to attachment theory (Bowlby, 1969), attachment behavior aims at obtaining social support and protection from the relationships with specified attachment figures that are considered to have four characteristics. Specifically, physical proximity is desired, while distress is experienced when separated from the attachment figure. Moreover, the attachment figure is a source of comfort and safety, and can alleviate stress (Ainsworth, 1991). It was shown that all of these characteristics are provided by dog companionship (Stallones, 1994; Bonas, McNichols, & Collis, 2000). Similarly, the stress coping model (Spence & Kaiser, 2002) considers companion animals a form of social support, as it was shown that petting an animal potentially brings about better coping responses in reaction to stress.

As an extension of biophilia and social support theories, a biopsychosocial model of health (Lindau, Laumann, Levinson, & Waite, 2003) can also be adopted to explain the calming, socializing, and motivating effects of animals. According to this model, health is determined by a combination of biological,

psychological, and social factors, which are interrelated and influence each other, so that any disturbance or improvement in one of these factors also affects the others. In line with these assumptions, it was found that positive physiological changes in response to animal-assisted interventions are frequently linked to enhanced social and psychological well-being, such as reduced anxiety or behavioral distress (e.g., Katcher et al., 1984; Nagengast et al., 1997).

Finally, to further explain the connection between the different effects of human–animal interactions, the role of oxytocin should be considered. Oxytocin is a peptide hormone that regulates various physiological, psychological and behavioral functions. For example, oxytocin is known to reduce heart rate (Dreifuss, Raggenbass, Charpak, Dubois-Dauphin, & Tribollet, 1988), blood pressure (Petersson, Lundeborg, & Uvnäs-Moberg, 1999), and level of stress hormones such as cortisol (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003). In addition, it enhances mood and promotes social interactions, while decreasing depression and anxiety (Uvnäs-Moberg, 2003). Thus, the effects of oxytocin seem to partly correspond with those resulting from human–animal interactions.

Several studies documented that human–animal interactions have the potential to increase oxytocin levels in humans (e.g., Odendaal & Meintjes, 2002; Miller, Kennedy, DeVoe, Hickey, Nelson, & Kogan, 2009; Nagasawa, Kikusui, Onaka, & Ohta, 2009; Handlin, Hydbring-Sandberg, Nilsson, Ejdebäck, Jansson, & Uvnäs-Moberg, 2011). As such, Beetz, Uvnäs-Moberg, et al. (2012) proposed that most of the positive physiological, psychological and social effects of animals on human well-being are mediated via the activation of the oxytocin system. Especially the stress- and anxiety-reducing effects that result from a release of oxytocin in response to animal contact were suggested to be a core mechanism underlying many of these effects (Beetz, Uvnäs-Moberg, et al., 2012). This theoretical approach therefore appears most promising in explaining and integrating the various benefits (e.g., calming, socializing, motivating, and cognitive effects) of human–animal interactions.

Physiological and Calming Effects

Various studies focused on investigating the influence of animals on people's autonomic responses, such as heart rate and blood pressure, as well as on skin conductance and hormone levels, in response to the interaction with, or presence of, an animal. However, these studies provide conflicting evidence regarding the potential of animals to exert de-arousing and calming effects on the physiological activity of humans, which will be discussed in the following paragraphs.

Supporting findings for the calming effects of animals were reported by studies showing that the presence of a dog led to a significant reduction of behavioral distress experienced by children during a stressful physical examination (Nagengast et al., 1997; Hansen, Messinger, Baun, & Megel, 1999). In addition, a greater decrease of physical arousal (e.g., blood pressure or heart rate) was

observed in children who were accompanied by a dog compared to those children undergoing the same examination without a dog (Nagengast et al., 1997). Moreover, lower cortisol levels (i.e., an indicator of reduced stress) were found in the presence of a therapy dog compared to the presence of a toy dog or human in a sample of children with attachment problems who were confronted with a social stress test (Beetz, Julius, Turner, & Kotrschal, 2012), and in children with autism spectrum disorder after the placement of an assistance dog with their families (Burrows, Adams, & Spiers, 2008; Viau et al., 2010).

Similar effects were reported in different adult samples (Allen et al., 1991; DeMello, 1999; Allen, Blascovich, & Mendes, 2002). The presence of a (pet) dog was associated with a smaller increase and reductions in heart rate and blood pressure during and after the performance of a stressful task, as well as faster recovery from a stressor compared to other control conditions, such as being alone or in the presence of a close friend or partner. Furthermore, a study by Katcher et al. (1984) provided evidence that looking at fish in an aquarium led to relaxation and a reduction in anxiety in dental patients prior to oral surgery. The efficacy of aquarium observation in inducing relaxation in these patients was equally effective as a pretreatment with hypnosis. On a similar notion, animals have been found to be valuable contributors to therapy, because they serve as distractors from the anxiety-provoking context of therapy and reduce the emotional discomfort that is often associated with the therapeutic process (Brickel, 1982; Arnold, 1995). For instance, calming effects of animals were demonstrated in therapeutic residential settings, as animal-assisted therapy appeared to relieve anxiety to a greater extent than a recreational session in hospitalized psychiatric patients (Barker & Dawson, 1998). The presence of a therapy dog also led to considerable reductions in noise on a psychiatric ward (Walsh, Martin, Verlander, & Pollard, 1995).

While in the above-described studies all participants were exposed to some kind of stress-inducing situation, calming effects of animals were also found in the absence of a specific stressor, which was indicated by different physiological indices (Vormbrock & Grossberg, 1988; Anderson, Reid, & Jennings, 1992; Odendaal & Meintjes, 2002; Miller et al., 2009; Nagasawa et al., 2009; Handlin et al., 2011). For example, Nagasawa et al. (2009) reported that gazing versus avoiding looking at one's own dog resulted in alterations in oxytocin levels. Oxytocin was also found to significantly increase in women who had been exposed to the presence of their own dog, while cortisol and insulin levels decreased (Miller et al., 2009; Handlin et al., 2011). In comparison, a reduction in oxytocin was observed in a control group performing a reading task (Miller et al., 2009). Similarly, in a study by Odendaal and Meintjes (2002) interactions with one's own or an unfamiliar dog led to a greater decrease of cortisol than reading a book.

On the contrary, other studies have challenged the evidence in terms of the extent of the de-arousing and calming effects of animals on human physiological

activity. Specifically, Baun, Bergstrom, Langston, and Thomas (1984) described an initial excitatory effect in response to the entry of one's own dog, which was characterized by significantly higher systolic and diastolic blood pressures than the response to either an unknown dog or to the introduction of a quiet reading task. In a pediatric hospital setting, Kaminski, Pellino, and Wish (2002) examined how play and pet therapy affected children differently with regard to physiological responses. They found higher heart rates prior to the sessions in children who were exposed to pet therapy than in children following the play therapy in which no animal was present. Moreover, Wilson (1991) demonstrated that interacting with an animal led to a smaller decrease in physiological stress responses than a quiet reading task. Similarly, physiological stress responses to a working memory task did not differ when participants were touching a real dog, stuffed dog, or another person before and after the task (Gee, Friedmann, Stendahl, Fisk, & Coglitore, 2014). Furthermore, a study that investigated a sample of children with ADHD reported increased blood pressure and pulse rates after handling and petting a dog, which suggested an excitatory rather than a calming effect of animals for the children (Somervill et al., 2009).

Although most of the reviewed evidence is based on samples other than the ADHD population, it seems plausible to assume that animal-based interventions can also promote calming and de-arousing effects in children suffering from ADHD. These children are likely to benefit from these effects, as impulsivity and hyperactivity have both been recognized as the core symptoms of ADHD, which are characterized by the individual's inability to restrict one's impulses, restrain one's movements, and control one's own behavior across a variety of situations (Lahey et al., 1998; Barkley, 2006). Thus, interventions that target over-activity and agitation would most likely be beneficial to the improvement of functioning in ADHD (Rapport, Chung, Shore, & Isaacs, 2001).

There is already some evidence supporting the application of animal-assisted interventions in treatment of ADHD. For example, a study by Schuck et al. (2015) reported that when cognitive behavioral therapy (CBT) was complemented with canine-assisted interventions and delivered to children with ADHD, greater reductions in the severity of ADHD core symptoms and problem behaviors were reported in comparison to children who received CBT without canine-assisted interventions. In contrast, the blood pressure of children was shown to be significantly increased during and directly after holding a dog in a previously mentioned study by Somervill et al. (2009) that investigated the effects of holding a dog on the physiological reactions of children diagnosed with ADHD. However, these two studies are difficult to compare, as they have fundamental differences in methodology that might explain differences between the findings. Specifically, in the study of Schuck et al., canine-assisted therapy was administered in combination with CBT group sessions twice a week for a period of 12 wk. Moreover, in the canine-assisted program three trained therapy dogs were included in the sessions, while in the non-canine-assisted intervention

control group (i.e., CBT alone), dog puppets were used instead of live dogs. In addition, while children in both groups followed a standard treatment curriculum including social skills training, parents received a group-based behavioral training once a week.

On the contrary, the study of Somervill et al. (2009) did not include a familiarization period with the animal, so that children were holding an unfamiliar dog for 5 min. in each of two testing sessions and were given no instructions on what to focus their attention or how to interact with the animal. Furthermore, the two studies differed in terms of the outcomes they measured. In the study by Schuck et al. (2015), parent-rated severity of ADHD symptoms, social skills, prosocial orientation, and problem behavior were assessed, while Somervill et al. evaluated physiological measures such as blood pressure and heart rate, as well as teacher-rated mood and behavior after the sessions. In addition, it should be noted that in the study by Somervill et al. stress was minimized by keeping children in their familiar school environment. This could explain why physiological arousal did not further decrease during or after the interaction with the animal, but rather increased, as children were enthusiastic and excited about the dog in a setting in which they felt comfortable. Moreover, the authors discussed the possibility that children with ADHD may be more excitable and experience a short interaction with a dog differently than typically developing children.

In general, it appears that research on human physiological responses to animals has not yielded consistent results, which makes it difficult to draw a firm conclusion about whether calming and arousal-reducing effects can be produced through the exposure to, and interaction with, animals. More specifically, studies investigating these effects in the ADHD population are particularly scarce and the existing research provides mixed findings. Thus, further investigations and more conclusive evidence are needed to determine whether animals have a calming or excitatory effect on children with ADHD. Given the various methodological differences between the discussed studies on the physiological effects of animals (Table 1), a more rigorous and standardized approach should be adopted when designing new treatment programs and conducting future research with regard to the calming effects of human–animal interactions in general, and on children with ADHD in particular.

Socializing Effects

In the following section, various research findings regarding the positive effects of animal-assisted interventions on social functioning will be discussed. These socializing effects of human–animal interactions are relevant to the treatment of children with ADHD, since it was indicated that these children exhibit difficulties with self-regulation, as well as an impaired attention to social cues (Hoza, Mrug, Gerdes, Hinshaw, Bukowski, Gold et al., 2005; Schuck et al., 2015). Thus,

ADHD is commonly associated with problems between parents and their children, whose relationship seems to be influenced by the child's ADHD symptoms such as regular noncompliant and excessive emotional behavior (Fischer, 1990; Mash & Johnston, 1990). As a consequence, these families often experience more stress and familial conflict than control families (Danforth, Barkley, & Stokes, 1991; Johnston & Mash, 2001; Smith, Brown, Bunke, Blount, & Christophersen, 2002). In addition, similar patterns of disruptive and aggressive communication were demonstrated to appear in the interactions of children with ADHD and their teachers (Whalen, Henker, & Dotemoto, 1980; DuPaul, McGoey, Eckert, & VanBrakle, 2001).

It has also been recognized that a substantial proportion of children with ADHD presents with significant difficulties in their social interactions and relationships with peers (Pelham & Bender, 1982). These social impairments seem to originate from the children's low frustration tolerance, their impatience, and their impulsive, disruptive, and more aggressive behavior (Fischer, 1990; Mash & Johnston, 1990; Hoza et al., 2005). In fact, typically developing children often experience hyperactive children and adolescents to be intrusive, uncooperative and noisy, which frequently results in social rejection by others (Johnston, Pelham, & Murphy, 1985; Pope, Bierman, & Mumma, 1989; Bagwell, Molina, Pelham, & Hoza, 2001). For example, in a study by Hoza et al. (2005) it was shown that 86 out of 165 children with ADHD (52%) were rejected when rated by their peers.

Given these social impairments in children with ADHD, animal-assisted interventions can contribute to addressing these difficulties, as it has been demonstrated that animals act as social catalysts and have socializing effects (Wilson & Netting, 1983; Gunter, 1999; Kruger & Serpell, 2010; Esposito, McCune, Griffin, & Maholmes, 2011; O'Haire, 2013). Dogs in particular promote opportunities for social interaction and facilitate social learning, which enhances socio-emotional development and often results in improved social functioning (Melson, 2001). For example, a study by McNicholas and Collis (2000) showed that following daily routines for five days in the presence of a well-trained dog increased the frequency of social interactions, especially with strangers, when compared to completing these tasks in the absence of a dog. An increase in social interactions was also observed in children with autism during animal-assisted occupational therapy sessions (Sams et al., 2006), and in elderly psychiatric patients when they were in the presence of a real dog compared to just looking at photographs of the dog (Haughie, Milne, & Elliott, 1992). Besides their role as social facilitators, animals also often function as important attachment figures that can provide social support and comfort, as well as help to alleviate stress (Bowlby, 1969; Melson, 2001). In support of this notion, it was found that the presence of a dog, compared to the presence of a toy dog or person, had the greatest beneficial effects on children with insecure attachment in stressful social situations, as stress responses were significantly

decreased in these children when receiving support from a real dog (Beetz, Julius et al., 2012).

Furthermore, animals are often used to teach children responsibility (Salmon & Salmon, 1983), humane values (Zasloff, Hart, & DeArmond, 1999), as well as to increase empathy, perspective taking, and prosocial behavior (Daly & Suggs, 2010; Schuck et al., 2015). For example, it was shown that interactions with animals can increase prosocial behavior in children with autism (Grandgeorge, Tordjman, Lazartigues, Lemonnier, Deleau, & Hausberger, 2012) and were rated to enhance empathy and socio-emotional development in elementary school children (Daly & Suggs, 2010). Similarly, children who had a strong attachment to their pets were more likely to exhibit empathy and prosocial behavior, and reported having a more intact family environment than children who were less attached or did not own a pet (Vidovic, Stetic, & Bratko, 1999). Moreover, it was demonstrated that aggressive and hyperactive behavior of children decreased in the presence of an animal and that aggressive children were less antagonistic and had greater social competence in situations in which they had to behave cooperatively (Katcher & Wilkins, 2000; Hergovich, Monshi, Semmler, & Zieglmayer, 2002; Kotrschal & Ortbauer, 2003; Tissen, Hergovich, & Spiel, 2007).

Based on the reported socializing effects of human–animal interactions, animal-assisted interventions may be a valuable addition to improving social functioning, as well as to reducing problem behavior, social rejection, and discrimination of children with ADHD. Indeed, a previously discussed study by Schuck et al. (2015) already provides some evidence to support this notion. Specifically, the authors reported that parent-rated social skills (i.e., communication, cooperation, assertion, responsibility, empathy, engagement, and self control) and prosocial behavior (i.e., helpfulness, generosity, empathy, social understanding, cooperation, and conflict resolution) increased after treatment in children who had followed a combination of CBT and canine-assisted interventions. However, although standardized measures were used, parent ratings were not blind, which might have inadvertently influenced the results. Moreover, these positive changes in behavior did not differ significantly from the treatment with CBT alone. Thus, future research should be encouraged to adopt greater methodological rigor with regard to design, conduct, and reporting when investigating the effectiveness of animal-assisted interventions in promoting social functioning in ADHD. It also needs to be explored how the effectiveness of these interventions compares to that of other treatment approaches. Finally, a further examination of the underlying mechanisms of the positive social effects of animal-assisted interventions can improve understanding of how and under what specific circumstances the interactions with animals can foster distinct social skills, prosocial behavior, and empathy in children with ADHD.

Motivational Effects

In this section, the motivational effects of animals will be discussed in relation to their applicability to the treatment of children with ADHD, as it has been proposed that dysfunctions in motivational processes are present in the disorder (Haenlein & Caul, 1987; Sergeant, Oosterlaan, & van der Meere, 1999). This lack of motivation often has a negative influence on their behavior, cognitive performance, and social interactions (Haenlein & Caul, 1987; Sonuga-Barke, 2002; Volkow, Wang, Newcorn, Kollins, Wigal, Telang et al., 2011). In addition, it has been suggested that people with ADHD are insensitive to reinforcement, a concept that is highly associated with motivation (Haenlein & Caul, 1987; Luman, Oosterlaan, & Sergeant, 2005). More specifically, it implies that an elevated reward threshold explains a higher need for reinforcement for those suffering from the disorder (Haenlein & Caul, 1987).

Evidence for problems in the self-regulation of motivation was provided by studies that demonstrated that children with ADHD show difficulties sustaining their effort during laboratory task performance under conditions of little or no reinforcement (Barber, Milich, & Welsh, 1996; Solanto, Wender, & Bartell, 1997; Luman et al., 2005; Barkley, 2006). In fact, several studies reported that the use of immediate and consistent reinforcement (“high intensity reinforcement”) is often effective to improve task performance, as well as the motivation to persist (Sergeant et al., 1999; Luman et al., 2005).

On a neurobiological level, the dual-pathway model of Sonuga-Barke (2002) was used to explain the apparent motivational deficits that are present in ADHD. It is commonly argued that dysfunctions in the dopamine reward pathways in the brain and the under-arousal of the catecholamine system might account for these deficits (Sonuga-Barke, 2002; Luman et al., 2005; Volkow et al., 2011). Moreover, a study of Cubillo, Halari, Smith, Taylor, and Rubia (2012) demonstrated that both adult and childhood ADHD is associated with brain abnormalities in the prefrontal regions of the brain that are responsible for controlling cognition and motivation.

In support of these findings, various studies demonstrated that reinforcement and the enhancement of motivation improved the cognitive performance and functioning in children with ADHD (Slusarek, Velling, Bunk, & Eggers, 2001; Luman et al., 2005; Gut, Heckmann, Meyer, Schmid, & Grob, 2012). For example, highly motivated children performed equally well compared to normal controls on tasks related to language and mathematical thinking (Gut et al., 2012). Similarly, it was shown that the application of motivational incentives normalized behavior and enhanced cognitive control in people with ADHD (Slusarek, Velling, Bunk, & Eggers, 2001).

Animal-assisted interventions can be useful in addressing the motivational deficits in ADHD. In fact, the results of various studies indicated that the presence of animals can promote motivation in several ways. For example, animals

were shown to encourage interest and increase motivation in children with multiple disabilities, as was shown by enhanced focus and task perseverance in the presence of a dog (Heimlich, 2001). Similarly, motivation for learning activities and concentration were improved in a sample of people with severe (learning) disabilities through the use of dolphin-assisted therapy, which in turn promoted both motor and speech-language acquisition (Nathanson, deCastro, Friend, & McMahon, 1997). While these two studies provide a valuable contribution to human-animal interaction research, several issues with regard to reliability and validity should be considered when evaluating their findings. For example, both studies did not include control groups or provide data to support their reported findings (Nathanson et al., 1997; Heimlich, 2001). Moreover, in the study by Heimlich (2001), the sample size was small ($n = 14$), and the author stated that no generalization of findings could be made due to a number of confounding factors. In addition, Nathanson et al. (1997) used direct observations to assess changes in behavior, for which inter-rater reliability was not clearly established.

Positive attitudes and emotions toward school and learning were increased through the presence of a dog in the classroom. Specifically, greater changes were reported by elementary school students on standardized self-report measures when a dog had been present in their classroom once a week for one year (Beetz, 2013) in comparison to a control class without a dog. Furthermore, a 12-wk. therapeutic horseback riding intervention for children with autism spectrum disorder was shown to increase the motivation to engage in social interpersonal behavior (Bass et al., 2009). Finally, interacting with therapy animals can assist in motivating patients who are in need of therapy to actively engage and participate in the therapeutic process (Fine, 2010; Mallon, Ross, Klee, & Ross, 2010). While it is possible that the presence of an animal during therapy reduces concentration on the verbal interchanges, it was also reported that patients were more motivated to participate in occupational therapy, were able tolerate it for longer periods of time, and showed an increase in verbalizations when a dog was present during sessions (Ferrese, Forster, Kowalski, & Wasilewski, 1998).

Thus, using animal-assisted interventions to boost motivation can be a valuable addition to the treatment of ADHD. Given the evidence of reductions in ADHD symptoms and associated problems when motivation is increased, as well as the generally positive results of animal-assisted interventions on motivation (Nathanson et al., 1997; Heimlich, 2001; Bass et al., 2009; Beetz, 2013), it can be assumed that animal treatments are likely to provide benefits to people with ADHD. Specifically, it might be expected that the interaction with or presence of animals could help children with ADHD to better regulate their motivation to comply with therapy, engage their attention, to increase task performance and persistence, as well as to successfully participate in social interactions. However, as there are currently no studies available that have directly investigated motivational effects of animal-assisted interventions on

children with ADHD, research that investigates and tests this hypothesis is needed. Future research should also further explore and specify the settings in which motivation can be enhanced through the contact with animals, as well as determine how motivation can be assessed in these situations.

Cognitive and Academic Effects

Research has indicated that animal-assisted interventions can have positive effects on cognitive functioning (e.g., attention) and support learning in children. For example, LeRoux, Swartz, and Swart (2014) investigated the effects of a 10-wk. animal-assisted reading program on children's reading rate, accuracy and comprehension. Children were randomly assigned to three experimental groups (i.e., reading to a dog in the presence of an adult, reading directly to an adult, or reading to a teddy bear in the presence of an adult) and a control group that did not participate in the program. It was demonstrated that reading rate was significantly higher in the dog than teddy bear group, while reading accuracy and comprehension were highest in the dog group when compared to the teddy bear, adult, and control group. Moreover, when examining the effects of animals on learning more generally, it was shown that positive attitudes toward school and learning increased in elementary school students (Beetz, 2013), and children were found to pay more attention to the teacher when a dog was present in the classroom (Kotrschal & Ortbauer, 2003).

Thus, the presence of an animal can help children to focus on and sustain their attention to their immediate environment, which may enhance concentration and task persistence (Schuck et al., 2015). This was demonstrated in studies where children with pervasive developmental disorders were more focused and aware of their social environment and showed greater language use when an animal was present (Martin & Farnum, 2002; Sams et al., 2006). In another study, riding a horse reduced inattention and distractibility in children with autism, as assessed by the use of standardized parent- and teacher-rated questionnaires (Bass et al., 2009). Similarly, improvements in attention span were demonstrated in children with multiple disabilities in a canine-assisted therapy program (Heimlich, 2001).

Another series of experiments also provided evidence that in the presence of a dog, children were better able to focus their attention on cognitive tasks, improving object categorization and recognition (Gee, Church et al., 2010; Gee, Crist et al., 2010; Gee et al., 2012). For example, children were shown objects along with a distractor and were then instructed to identify those objects that they had previously been shown either in the presence of a live dog, a stuffed dog, or a human confederate. Results indicated that children needed fewer instructional prompts, implying increased concentration, in the live dog condition, followed by the stuffed dog condition. The greatest number of prompts was needed in the human condition (Gee et al., 2010). These results imply that the

presence of a live dog can promote cognitive task performance and attention to an extent beyond that of a stuffed dog or human. In contrast to the common assumption that the presence of a dog can be distracting for children during the performance of a cognitive task, the authors speculated that the dog served as a highly salient stimulus and model for appropriate behavior, which prompted the children to restrict their attention to the specific task demands. The authors also proposed that the dog is a source of motivation to the children, which encouraged them to be more focused and to put greater effort into task performance. Finally, it was suggested that the presence of the dog helped the children to be less stressed and more relaxed, which is in line with previous research that demonstrated calming and de-arousing effects of animals (e.g., Allen et al., 2002). Thus, it was assumed that the calming effects of the dog allowed these children to better focus on the task demands and improved performance.

Overall, these findings seem to indicate that animals support cognitive functioning and learning in children. However, the mechanisms underlying these effects are not well understood, and it is possible that some of the reported effects result from increased social attention to the experimenter handling the dog in the dog condition. Moreover, the limitations of the positive effect of the presence of a dog on cognitive task performance should be established. For example, it is possible that the presence of a dog will become a distraction to children as the task difficulty or complexity increases (Gee, Church et al., 2010; Gee, Crist et al., 2010; Gee, Gould, Swanson, & Wagner, 2012).

The role of animals as learning facilitators and their ability to improve attention can be applied to the treatment and support of children suffering from ADHD, because these children exhibit both deficits in attention and academic performance (Frazier, Demaree, & Youngstrom, 2004; Barkley, 2006; American Psychiatric Association, 2013). The definition of attention as a construct is multidimensional and may include alertness, sustained attention, selectivity, and distractibility (Barkley & Murphy, 1998; Strauss, Thompson, Adams, Redline, & Burant, 2000), which were shown to be impaired in samples of inattentive children (Rosenthal & Allen, 1980; Swaab-Barneveld, de Sonnevle, Cohen-Kettenis, Gielen, Buitelaar, & van Engeland, 2000; Newcorn, Halperin, Jensen, Abikoff, Arnold, Cantwell et al., 2001; Marzocchi, Lucangeli, De Meo, Fini, & Cornoldi, 2002). As previously discussed, all of these behaviors might be improved through the presence of or interaction with animals (Wilson, 1984; Bass et al., 2009; Gee et al., 2012).

In addition to deficits in attention, ADHD is related to lower academic performance and achievement (Frazier et al., 2004; Barkley, 2006), as well as higher risk for learning disabilities in reading, spelling, and math (Barkley, DuPaul, & McMurray, 1990; Frick, Kamphaus, Lahey, Loeber, Christ, Hart et al., 1991; Brock & Knapp, 1996). In fact, a recent review of 17 studies that investigated the comorbidity of ADHD with learning disabilities indicated that the mean comorbidity rate is as high as 45% (DuPaul,

Gormley, & Laracy, 2013). Low academic performance as well as high school suspensions and attrition of children and adolescents with ADHD can partly be explained as indirectly resulting from their inattentive, impulsive, and hyperactive behaviors, as these were shown to have a negative effect on, e.g., homework management and classroom performance (Langberg, Molina, Arnold, Epstein, Altaye, Hinshaw et al., 2011).

Since it was shown that active and goal-directed interactions with an animal stimulate learning and facilitate motivation, the use of animals could be a valuable approach to support the long-term cognitive and academic development of children with ADHD when deficits in attention and other cognitive functions are targeted. However, more research is needed to investigate the underlying mechanisms of these effects and to what extent animal-assisted interventions can promote cognitive functioning and learning rather than become a distraction in the learning environment.

Practical Considerations in Animal-assisted Intervention Research

Throughout the review it was stated that a lack of standardization of animal-assisted intervention research and methodological differences between studies make it difficult to draw firm conclusions about the effects and efficacy of these interventions. It also poses specific challenges to the evaluation and comparison of such studies. More comprehensive discussions of the (methodological) difficulties that are frequently involved in conducting research on animal-assisted interventions can be found in other reviews (e.g., Johnson, Odendaal, & Meadows, 2002; Stern & Chur-Hansen, 2013; Chur-Hansen, McArthur, Winefield, Hanieh, & Hazel, 2014). In the following sections, only a few general issues and practical considerations regarding human–animal interactions will be discussed that should be taken into account when deciding on the application of or conducting research involving animal-assisted interventions. These issues concern, e.g., the kind of animal used during interventions, the type of contact (i.e., structured vs. unstructured), or whether participants interacted with their own pet or an unknown therapy animal. All of the factors that will be discussed in the following paragraphs can have major implications for the implementation, outcome, evaluation, and interpretation of studies on human–animal interactions.

Individual differences and culture have a strong influence on how people respond to animals. Not only do people of different cultures vary in how they regard and treat animals, but also individuals differ in their attitudes toward animals (Serpell, 2004). For example, children who are afraid of or had negative experiences with animals are unlikely to respond to animal-based treatments (Friedmann, 2000; Melson & Fine, 2010). Moreover, animal-assisted interventions pose specific challenges and dangers: when including an animal as an adjunct to therapy, it should be considered that expenses for food, shelter,

veterinary services, and staff salary have to be covered (Mallon et al., 2010), and that it bears a small risk of transmitting infectious diseases, causing allergic or phobic reactions, as well as injuries to the human who interacts with the animal (e.g., through bites and scratches; Plaut, Zimmerman, & Goldstein, 1996; Morrison, 2001). In samples of children with autism, individual sensory difficulties and arousal levels should be taken into account when planning an animal-assisted intervention (Leekam, Nieto, Libby, Wing, & Gould, 2007; Rogers & Vismara, 2008; Berry, Borgi, Francia, Alleva, & Cirulli, 2013), as some individuals experience hyperarousal to sensory stimuli (Leekam et al., 2007; Wiggins, Robins, Bakeman, & Adamson, 2009). Sensory oversensitivity may prove difficult for some children to tolerate the smell or sound (e.g., barking) of an animal (Grandin, Fine, & Bowers, 2010). In the same way, it was suggested that children with ADHD have similar difficulties with sensory oversensitivity. For example, they may be more sensitive to odor intensity (Romanos, Renner, Schecklmann, Hummel, Roos, von Mering et al., 2008) or auditory volume (Luckner, Geffner, & Koch, 1996).

Moreover, one needs to distinguish between the recreational and therapeutic use of animals, such as the difference between animal-assisted interventions and owning a pet (Beck & Katcher, 1984). Pets provide many benefits to their owners, as they are a source of pleasure and offer companionship, comfort, as well as social and emotional support (Triebenbacher, 1998; Beck, 2002; Fine & Eisen, 2008). It has been suggested that a strong human–animal bond between a pet and its owner represents a relationship that needs to be reciprocal and persistent (Tannenbaum, 1995; Russow, 2002) and promotes well-being in both parties involved (Beck, 1999; Russow, 2002). Animal-assisted interventions differ from the interactions with one's own pet, although these interventions also provide people with the opportunity to interact with a companion animal. However, these animals are trained and certified, and usually belong to their professional handler, with whom they provide psychological and physiological services to others [Pet Partners, n. d. (b)]. Although animal-assisted interventions are goal-directed and specifically aim at increasing psychological support and well-being in humans, pets offer full-time contact, which often has a greater potential in achieving these goals than a part-time relationship with a therapy animal (Hart, 2010). Therefore, both kinds of interactions with animals may offer their own unique advantages and benefits.

Furthermore, research has compared the effects of toy animals, robotic animals, and live animals. As mentioned above, the beneficial effect of canine-assisted interventions on ADHD symptoms was superior to a cognitive-behavioral intervention without canine-assisted intervention, in which only toy dogs (realistic puppets) were utilized (Schuck et al., 2015). Similarly, Melson and colleagues (Melson, Kahn, Beck, & Friedman, 2009; Melson, Kahn, Beck, Friedman, Roberts et al., 2009) described that children perceived a robotic dog as a complex toy and considered its value as a social companion to be much

lower than that of a live dog. In fact, children petted the living dog five times as much as the robotic dog. Moreover, Fine (2005) discovered that when using a robotic dog in clinical practice, children usually considered it to be a toy rather than an animal. As such, the robotic dog, unlike the live therapy dogs, had no calming effects on the children, but rather distracted and redirected their attention. More generally, however, the use of robots in interactions with children was shown to be a promising training tool with beneficial effects (Srinivasan, Lynch, Bubela, Gifford, & Bhat, 2013). Thus, more conclusive evidence regarding the use and potential of robotic animals in animal-assisted interventions is needed.

Finally, the type of animal that is used during interventions also affects the outcome and determines whether people benefit from the interactions (Castelli, Hart, & Zasloff, 2001; Hart, 2010), i.e., different animals have different effects on an individual, and individuals often have different physiological responses to different types of animals (Serpell, 1991; Friedmann & Thomas, 1995). For example, a study by Friedmann and Thomas (1995) showed that owning a dog, compared to owning a cat, had greater beneficial effects on physiological and psychological variables of the owner. Generally, dogs are the most frequently used animals for animal-assisted interventions, as they have unique training and sociability skills (Dimitrijevic, 2009). However, other animals, such as cats or birds, may be more appropriate in some cases as they are usually less expensive and require less care than a dog or a horse (Fritz, Farver, Hart, & Kass, 1996; Castelli et al., 2001; Hart, 2010). Horses are popular for the use in animal-assisted interventions, because of a special quality of interaction they can provide to the rider. In particular, riding a horse affects the neuromuscular system of the human as impulses are continuously received from the animal, which has been shown to have a positive effect on relaxation, body perception, equilibrium, and coordination (Dimitrijevic, 2009). Thus, the choice of a particular type of animal may depend on the patient's context and expectations regarding the role it should fill (Hart, 2010).

These considerations illustrate that a standardization of animal-assisted interventions is difficult to establish. In addition, it has often been argued that research regarding animal-assisted interventions is not suitable for a randomized controlled trials approach due to a variety of reasons (e.g., it is impossible to recruit a random sample; participants and experimenter cannot be blinded to treatment conditions), which are related to some of the issues described above. Nevertheless, in order for the field to further gain recognition and acceptance in the scientific community, future research should take these considerations into account and strive for a more rigorous approach with regard to the development of interventions, the definition of outcome measures, data collection, and the reporting of methods and results when conducting research on animal-assisted interventions in ADHD.

Conclusion

In this review, the possibilities of the application of the animal-assisted interventions to the treatment of ADHD were discussed. Several mechanisms including calming, socializing, motivating, and cognitive effects of animal-assisted interventions were explored. It appeared that all of the discussed animal-assisted intervention effects can contribute to treatment, and that they are unlikely to operate independently from one another. All the effects should therefore be considered when deciding whether animal-assisted interventions are a useful addition to the treatment of ADHD.

The application of animal-assisted interventions to treatment of ADHD is still a new area, and there are very few studies available that have directly investigated the effects of animal-assisted interventions on children with ADHD. Therefore, findings of studies that explored animal-assisted intervention treatment in relation to other disorders were used to argue for the possibility of similar effects in children with ADHD. Supporting this approach, a study of Prothmann, Bienert, and Ettrich (2005) demonstrated that the effects that animals have on humans appear to occur mostly independently from the underlying diagnosis. This suggests that the numerous findings reporting positive effects of animals on, e.g., children with autism spectrum disorder, might be generalized to those with ADHD. In addition, the DSM-V (APA, 2013) now recognizes ADHD and autism spectrum disorder as highly co-occurring disorders, and it was demonstrated that individuals with ADHD present autistic traits more frequently than the general population (Rommelse, Franke, Geurts, Hartman, & Buitelaar, 2010). Although it cannot be stated with absolute certainty that the discussed effects of animal-assisted interventions can be generalized to ADHD, this approach still provides a valid ground for a further investigation of this topic.

Only some of the effects (i.e., physiological, socializing, motivating, and cognitive effects) of animal-assisted interventions were discussed in the current review. However, other reported effects should also be explored in relation to ADHD in the future, as they can possibly support the treatment of ADHD and its associated deficits. For instance, it was shown that petting an animal improved both fine and gross motor movements (Nathanson et al., 1997; Chandler, 2012; Gee et al., 2012), skills that are often impaired in children with ADHD (Harvey & Reid, 2003). Similarly, the presence of, or the interactions with, animals were demonstrated to reduce depression and loneliness in the elderly (Holcomb et al., 1997; Banks & Banks, 2002), as well as to increase parental ratings of mood and the display of positive affect in a sample of hospitalized children (Kaminski et al., 2002). A further exploration of these effects is relevant to the treatment of ADHD, as a review indicated that 9–32% of children with ADHD suffer from comorbid major depressive disorder (MDD; Biederman, Newcorn, & Sprich, 1991).

Nevertheless, there is a need for validation of animal-assisted interventions in the ADHD population, as different effects than reported in studies on other populations might be observed. For example, compared to the apparent calming effects of dogs on children with autism (Burrows et al., 2008; Viau et al., 2010) or socializing effects of animals on the elderly (Francis, Turner, & Johnson, 1985), children with ADHD might respond differently to these interactions due to higher excitability and over-reactivity (Somervill et al., 2009). Furthermore, findings of animal-assisted intervention effects were only discussed with respect to children with ADHD. It would be interesting to examine whether these effects operate in the same way or vary in children and adults with ADHD, since their presentation of ADHD symptoms has been shown to differ (Kooij, Bejerot, Blackwell, Caci, Casas-Brugue, Carpentier et al., 2010). For instance, instead of hyperactive behavior, adults often experience inner restlessness, while inattention is, e.g., expressed as disorganization, being late, a need for variation, or a difficulty making decisions (Kooij, Buitelaar, Van den Oord, Furer, Rijnders, Hodiament et al., 2005).

Finally, over the last decades, the value and benefits of animal-assisted interventions to human mental and physical health have continuously gained recognition, while the scientific literature base on this topic is increasing. However, the underlying mechanisms of the positive effects of animal-assisted interventions are, partly due to methodological limitations, still not well understood. Moreover, it has widely been emphasized that more controlled and systematic research in the field of animal-assisted interventions is required for it to become accepted as an evidence-based treatment approach (Kruger & Serpell, 2010; Stern & Chur-Hansen, 2013). Thus, in order to test the assumptions proposed in this review, and to further determine how animal-assisted interventions affect individuals with ADHD, more rigorous scientific research and randomized controlled trials are needed to investigate the effects of human–animal interactions and their mechanisms.

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