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Animal-Assisted Intervention for Autism Spectrum Disorder: A Systematic Literature Review

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Abstract The inclusion of animals in therapeutic activities, known as animal-assisted intervention (AAI), has been suggested as a treatment practice for autism spectrum disorder (ASD). This paper presents a systematic review of the empirical research on AAI for ASD. Fourteen studies published in peer-reviewed journals qualified for inclusion. The presentation of AAI was highly variable across the studies. Reported outcomes included improvements for multiple areas of functioning known to be impaired in ASD, namely increased social interaction and communication as well as decreased problem behaviors, autistic severity, and stress. Yet despite unanimously positive outcomes, most studies were limited by many methodological weaknesses. This review demonstrates that there is preliminary "proof of concept" of AAI for ASD and highlights the need for further, more rigorous research.

Keywords Animal-assisted intervention · Animal-assisted therapy · Autism · Children · Human-animal interaction · Social functioning

Introduction

Interacting with animals can enhance psychosocial well-being (O'Haire 2010). Documented benefits include reduced stress, lowered heart rate and blood pressure, reduced loneliness and isolation, increased social interaction and connection, and increased socio-emotional functioning (e.g., Friedmann and Son 2009; Wells 2009). The

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inclusion of animals in therapeutic activities is known as *animal-assisted intervention* (AAI), which encompasses both *animal-assisted therapy* and *animal-assisted activities* (Griffin et al. 2011; Kruger and Serpell 2010). It dates back to the late eighteenth century when animals were brought into mental health institutions to increase socialization among patients (Serpell 2006). Its current implementation has been related to positive treatment outcomes in a number of clinical populations, including improved physical health and psychological well-being in Alzheimer's patients (Edwards and Beck 2002), increased social functioning in patients with schizophrenia (Barak et al. 2001), and reduced aggressive and pathological behaviors among children with conduct disorder and attention-deficit hyperactivity disorder (Katcher and Wilkins 1998). Recently, autism spectrum disorder (ASD) has been highlighted as a target population that may benefit from AAI (Esposito et al. 2011a).

The rationale for including animals in ASD treatment stems from a multi-disciplinary field of research known as *anthrozoology*, or *human-animal interaction* (HAI), which encompasses "the mutual and dynamic relationships between people and animals and the ways in which these interactions may affect physical and psychological health and well-being" (Esposito et al. 2011b, p. 3). HAI theory suggests that many humans seek out contact with animals as calming and non-judgmental sources of support and facilitators of social interaction (Kruger and Serpell 2010). Particularly for socially isolated individuals such as those with ASD, animals have been speculated to offer a unique outlet for positive social engagement. It has further been suggested that social aversion among individuals with ASD may be human-specific and does not necessarily extend to animals (Johnson 2003). Laboratory based studies have demonstrated that children with ASD tend to prefer

pictures of animals over humans and inanimate objects (Celani 2002; Prothmann et al. 2009). In a meta-analysis of 49 studies of AAI for a range of populations, Nimer and Lundahl (2007) deduced four key areas of improvement from AAI, including autism-spectrum symptoms, medical difficulties, behavioral problems, and emotional well-being. They concluded that AAI may be a promising additive to established interventions for children with ASD; however, only 4 of the 49 reviewed studies included participants with ASD. The limited number of studies in their review is attributed to the exclusion of most studies based on methodological weaknesses, which are common among AAI research. The shortage of robust scientific research on the topic has led to criticism of a reliance on anecdotal evidence (Griffin et al. 2011).

Indeed, anecdotal reports of AAI for ASD are pervasive and subjectively positive. Pavlides (2008) compiled a handbook of predominantly anecdotal evidence of AAI for ASD, which taken together suggests that AAI can assist individuals with ASD to develop sensory and social skills, manage problem behaviors, and improve quality of life. Anecdotal cases are also highlighted in popular media such as news stories, biographical novels, and films of individuals with ASD whose connection with animals leads to improved social functioning and quality of life. Examples include *The horse boy* (Isaacson 2009), *A friend like Henry* (Gardner 2008), and *Songs of the gorilla nation* (Prince-Hughes 2005). The work of Temple Grandin, a world-renowned animal behaviorist with ASD, has also received a great deal of attention through her books, such as *Animals in translation: Using the mysteries of autism to decode animal behavior* (Grandin and Johnson 2005), and her reports of the benefits of animals for some individuals with ASD, including herself (Grandin 2008, 2010, 2011). Whether these cases are unique or indicative of a replicable phenomenon is the subject of growing inquiry. Their influence on ASD treatment selection is currently unknown; however, it has been suggested that media portrayals of AAI with dolphins, in particular, may be falsely alluring to desperate parents of children with ASD (Herzog 2010). There are estimated to be over 100 programs worldwide providing AAI with dolphins (Esposito et al. 2011b, Herzog 2010), which have been both lauded as uniquely effective (Nathanson et al. 1997) and criticized as expensive and poorly evaluated (Marino and Lilienfeld 2007). The number and format of AAI programs with other animals is presently unknown, yet AAI does appear to be a commonly enlisted technique for ASD. For example, an online survey study of 248 parents of children with ASD found that nearly a quarter (23.8 %) of children had participated in AAI, and the majority of their parents (62.7 %) reported perceived improvements from AAI (Christon et al. 2010).

Despite the use of AAI for ASD and its potential popularization through anecdotal media, there has been no comprehensive review of its empirical research base. Therefore, the purpose of this review is to move beyond anecdotal accounts by presenting a comprehensive overview of empirical research on AAI for ASD. The goal is to systematically identify, summarize, and evaluate any existing empirical studies of AAI for ASD in order to document currently researched AAI practices and their reported findings, as well as to provide directions for further, more rigorous research. The specific aims are to: (a) describe the characteristics of AAI for ASD, (b) evaluate the state of the evidence base, and (c) summarize the reported outcomes of AAI for ASD.

Methods

Protocol

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines were consulted to perform this systematic review (Liberati et al. 2009; Moher et al. 2009). The study procedures were defined a priori in a study protocol that specified the search strategy, inclusion and exclusion criteria, and data extraction items.

Eligibility Criteria

The following inclusion criteria were used to select relevant articles for review: (a) publication in English in a peer-reviewed journal, (b) collection of original, empirical data on AAI, which was defined as any intervention that intentionally incorporated a live animal, and (c) reporting of results for participants with a diagnosis on the autism spectrum, including autism, autism spectrum disorder (ASD), autistic disorder, asperger's disorder, or pervasive developmental disorder not otherwise specified (PDD-NOS).

Search Procedure

Studies were identified by searching the following electronic databases from their inception date through June 2012: *ERIC* (1966—Present), *Medline* (1966—Present), *ProQuest* (1971—Present), *PsycARTICLES* (1894—Present), *PsycINFO* (1840—Present), and *Scopus* (1966—Present). In order to increase coverage, two specialized databases of HAI research were also searched: *HABRI Central*, through the Human Animal Bond Research Initiative, and *Anthrozoology.org* (Adams 2011). Search terms for all databases included at least one identifier for ASD and at least one identifier for AAI in the full text of

Table 1 List of terms to identify AAI in database search

Animal intervention	Canine therapy	**Dolphin assisted**	Human animal	**Therapeutic animal(s)**
Animal therapy	**Canine assisted**	Dolphin facilitated	Interaction(s)	Therapeutic dog(s)
Animal assisted	Canine facilitated	Equine therapy	Pet therapy	Therapeutic horse(s)
Animal facilitated	Companion animal(s)	**Equine assisted**	Pet assisted	**Therapeutic horseback**
Anthrozoology	Dog therapy	Equine facilitated	**Pet facilitated**	Therapeutic pet(s)
Assistance animal(s)	Dog assisted	**Hippotherapy**	Service animal(s)	Therapeutic riding
Assistance dog(s)	Dog facilitated	**Horseback riding**	**Service dog(s)**	**Therapy with animals**
Assistance horse(s)	Dolphin therapy	Human animal bond	Service horse(s)	

Bold terms indicate words used to identify animal-assisted intervention (AAI) in the final review sample

the article. Identifiers for ASD included autism OR autistic OR asperger(s) OR pervasive developmental disorder(s). In order to assemble a comprehensive inventory of AAI identifiers, an exhaustive list of 38 search terms was compiled from a collection of HAI terms and synonyms for database searching (Kruger and Serpell 2010; Wood 2006). These search terms are identified in Table 1.

Data Extraction and Evaluation

Information was extracted from each included study in order to achieve the three aims of this review. To achieve the first aim—describe key characteristics of the AAIs—data items included AAI terminology, animals, setting, interventionist, format, activities, and duration. To achieve the second aim—evaluate study methodology and risk of bias—data items included sample size, participant characteristics (including age, gender, and ASD diagnosis), study design, comparison condition, and assessment measures (including type, standardized instruments, and raters/informants). To achieve the third aim—summarize study outcomes—data items included the results of each study, which were subsequently organized by the most commonly reported outcomes. Additional data items were extracted for study identification and exploratory purposes, including first author, publication year, country of corresponding author, and journal name.

Results

Study Selection

The literature search resulted in 1,205 citations. A large proportion of the excluded studies were related to animal models (e.g., using animal subjects to investigate the mechanisms of ASD) rather than HAI. A flowchart of the study selection process is presented in Fig. 1.

Eight studies contained only a subset of participants with ASD (Table 2). The target samples of these studies were not specifically ASD; instead, most of the studies
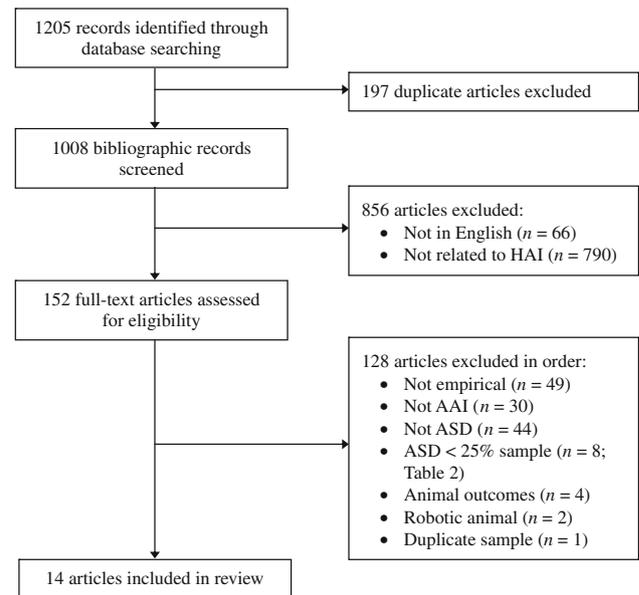

Fig. 1 Flow chart of study selection process. *HAI* human animal interaction, *AAI* animal-assisted intervention, *ASD* autism spectrum disorder

characterized participants as having "severe disabilities." The proportion of participants with ASD ranged from 7 to 24 % ($M = 14.8$ %) of the total sample. None reported specific results for the subset of participants with ASD; therefore, they did not meet the eligibility criteria for inclusion in this review. However, it was noted that this group included the only five AAI studies with dolphins from the database results; hence they are presented briefly in Table 2.

The final sample included 14 articles (1.16 % of the total initial pool) published between 1989 and 2012 that met the inclusion criteria of empirically evaluating AAI for ASD. The majority of these studies (11 of 14) were published in the last 4 years, since 2008. Despite the limitation to English-language articles only, there was an international representation of researchers. Countries of the corresponding authors included the USA (8 studies), Canada (2 studies), Bosnia, Japan, Portugal, and Slovakia

Table 2 AAI studies with a subset of ASD participants

First author (year)	AAI terminology	Animal	Participants		Subset with ASD	
			Description	Age (years)	% of sample	Diagnosis
Nathanson (1997)	Dolphin-assisted therapy	Dolphin	Severe disabilities	2–13	9 % (n = 4)	Autism
Nathanson (1998)	Dolphin-assisted therapy	Dolphin	Severe disabilities	M = 8.2	–	Autism
Heimlich (2001)	Animal-assisted therapy	Dog	Severe disabilities	9–19	7 % (n = 2)	Autism
Winchester (2002)	Therapeutic horseback riding	Horse	Developmental delay	4–7	14 % (n = 1)	Autism
Davis (2004)	Assistance dog	Dog	Pediatric population	5–17	–	Autism
Nathanson (2007)	Dolphin-human therapy	Dolphin	Disabilities	3–20	17 % (n = 6)	Autism & PDD
Breitenbach (2009)	Dolphin-assisted therapy	Dolphin	Severe disabilities	5–10	18 % (n = 21)	Autism
Dilts (2011)	Dolphin-assisted therapy	Dolphin	Children with special needs	–	24 % (n = 9)	Autism

AAI animal-assisted intervention, *ASD* autism spectrum disorder, *PDD* pervasive developmental disorder, – not reported

(1 study each). The articles were published in a variety of disciplines, including journals related to ASD (3 studies), alternative therapies, occupational therapy, and health care (2 studies each), and anthropology, HAI, neuroscience, special education, and veterinary science (1 study each). Because the study designs, participants, interventions, and reported outcome measures varied markedly across the sample, the results of this review focus on descriptive and qualitative synthesis rather than meta-analysis.

Characteristics of AAI for ASD

In order to achieve the first aim, to describe the characteristics of AAI for ASD, the key features of AAI in the selected studies are summarized in Table 3.

Terminology

The terminology used to denote AAI was inconsistent, with 11 different terms used across the 14 studies. No studies used the terms *animal-assisted intervention* or *animal-assisted activities* and only one used *animal-assisted therapy*. Only 3 of the 11 terms for AAI were used in more than one study, including "service dog" (n = 3), "equine-assisted therapy" (n = 2), and "therapeutic horseback riding" (n = 2).

Animals and Setting

The most common AAI animals were dogs (n = 7) and horses (n = 6). Details of animal selection and socialization were limited, with references made to temperament testing, socialization, and training, but few specific criteria or procedures described. None of the studies compared one type of animal to another, and among the studies reviewed, there were no apparent differences in outcomes based on the type of animal. One factor that did appear to vary based

on the animal was treatment setting. All AAIs with horses (n = 6) occurred at riding centers and all service animal programs (n = 3) consisted of dogs that resided in participants' homes. The setting of the remaining AAIs (including dogs, guinea pigs, llamas, and rabbits) was variable, with half (n = 3) taking place in schools.

Interventionist

With the exception of service animals, all AAIs (n = 12) consisted of a series of sessions with an animal and an interventionist. The most common format was one-on-one (n = 9), with one participant, one interventionist, and an animal. The remaining studies (n = 3) conducted sessions in groups with 3–19 participants, one interventionist, and 1–19 animals. For example, one study facilitated group AAI sessions where all 19 participants rode horses at the same time in a large riding arena (Bass et al. 2009). In AAIs with horses (n = 6), interventionists were accompanied by 1–3 helpers per participant for side-walking and horse leading. In studies with service animals (n = 3), there was no specific interventionist; instead, parents experienced a brief training (range: 3–7 days) and were then considered the animal handler for the duration of the intervention.

Across the reviewed studies, there was no replicated standard for interventionist training or knowledge of AAI, whether it be human-focused (e.g., psychology, therapy), animal-focused (e.g., animal behavior, training, instruction), or both. The most common interventionists for non-service animals were therapists (n = 6) and animal instructors or trainers (n = 5). In general, the procedures for interventionist training in AAI were not systematically or thoroughly described. Three studies reported accreditation or training by the professional organization providing the AAI (Bass et al. 2009; Gabriels et al. 2012; Martin and Farnum 2002), three cited different certifications in AAI, including equine-assisted psychotherapy (Memishevikj and Hodzhikj

Table 3 Overview of AAI characteristics

First author (year)	AAI terminology	Animal	Setting	Format	Interventionist	Sessions		
						Duration (weeks)	Number	Length (minutes)
Redefer (1989)	Pet-facilitated therapy	Dog	–	Individual	Therapist	–	18	20
Martin (2002)	Animal-assisted therapy	Dog	School	Individual	Therapist	15	15	15
Sams (2006)	Occupational therapy with animals	Dog, Llama, Rabbit	School	Individual	Occupational therapist	15	2–12	$M = 28.5$ (SD = 5.3)
Burrows (2008)	Service dog	Dog	Home	n/a	n/a	24–48	n/a	n/a
Bass (2009)	Therapeutic horseback riding	Horse	Riding center	Group of 19	Riding instructor	12	12	60
Keino (2009)	Psycho-educational horseback riding	Horse	Riding center	Individual	Riding instructor	48–148	–	–
Taylor (2009)	Hippotherapy	Horse	Riding center	Individual	Pediatric physical therapist	16	16	45
Kršková (2010)	Therapeutic animal	Guinea pig	School	Group of 9	Teacher	10	10	240
Memishevikj (2010)	Equine-assisted therapy	Horse	Riding center	Individual	Occupational therapist	10	10	30
Solomon (2010)	Therapy dog	Dog	Home	Individual	Animal trainer	4–6	4–6	60–120
	Service dog			n/a	n/a	>48	n/a	n/a
Viau (2010)	Service dog	Dog	Home	n/a	n/a	4	n/a	n/a
Kern (2011)	Equine-assisted therapy	Horse	Riding center	Individual	Riding instructor	24	24	60
Silva (2011)	Canine-assisted therapy	Dog	Treatment center	Individual	Psychologist	6	6	45
Gabriels (2012)	Therapeutic horseback riding	Horse	Riding center	Groups of 3–4	Riding instructor	10	10	60

Information is reported for the animal-assisted intervention (AAI) condition only, not any comparison conditions. – not reported, *n/a* not applicable

2010), hippotherapy (Taylor et al. 2009), and therapy dog handling (Silva et al. 2011), and five reported no details regarding interventionist training in AAI (Keino et al. 2009; Kern et al. 2011; Kršková et al. 2010; Redefer and Goodman 1989; Sams et al. 2006).

Activities

The format and activities of each AAI, as well as the role of the interventionist in these activities, were inconsistently described with varying levels of detail. Most reported activities focused predominantly on animal care, knowledge, and games. Some studies identified targeted skills to be obtained through these activities such as verbal communication, prosocial behaviors, and sensory-motor skills; however, the majority of studies provided only brief descriptions of a typical session without behavioral goals. There were no standardized protocols replicated in more than one study. Instead, the commonality among the

procedures was merely the presence of and focus on an animal. None of the reviewed studies reported on treatment fidelity, or the consistent presentation and implementation of AAI across participants.

Duration

Ten studies reported a specific AAI duration. From these studies, it was possible to deduce that the average duration of AAI was 12.2 weeks (range: 4–24, SD = 5.7) with 13.4 sessions (range: 6–24, SD = 5.4), each lasting 40.4 min (range: 15–60, SD = 17.7). However, the two studies that did not report a standardized duration of AAI reported a much longer total duration, ranging from 24 to 148 weeks. The three studies with service animals also reported a wide range of durations, from 4 to over 48 weeks. These outliers aside, it appears that most AAIs ($n = 10$) in the current sample were short-term, generally around 3 months with weekly 15–60 min sessions.

Methodological Evaluation

In order to evaluate the validity of reported outcomes of AAI for ASD, the methodology of the 14 selected studies was reviewed. Key characteristics of the methods are summarized with respect to each study's sample size, characteristics, and study design in Table 4 and assessment type in Table 5.

Sample Size and Characteristics

Sample sizes in the selected studies were notably small, ranging from 1 to 42 participants, with nine studies having a sample size of ≤12. The target population of all studies was children and adolescents (age range: 3–17 years), with no studies on adults with ASD. Ten studies reported the mean age, or relevant details for its calculation. Of these, the weighted mean age (by number of participants) was 8.1 years (range: 7.1–11.0, SD = 1.7). Most studies (n = 12) reported participant gender, which was predominantly male. The percentage of male participants ranged from 50 to 100 % in each study, with males making up 80.9 % (157 of 194 participants) of the total sample across the 12 studies.

The most common description of participant diagnoses included ASD and autism (n = 5 each), followed by pervasive developmental disorder (PDD) and autistic (n = 2 each). Only three studies conducted an independent assessment of ASD to confirm diagnoses and describe the severity of the disorder among participants (Bass et al. 2009; Gabriels et al. 2012; Kern et al. 2011). Information regarding concurrent treatments and medications was also limited, with the same three studies being the only ones collecting and presenting these data. The absence of this information is a limitation of the current research base as ASD severity and concurrent treatments may have influenced AAI outcomes.

Study Design

The most common designs were single-subject or within-participant (n = 13). Only one study used a control group design where half of participants were randomly assigned to a wait-list control group (Bass et al. 2009). Of the nine studies with smaller sample sizes of ≤12, six collected an adequate number of single-subject replications (range: 3–15) in each condition (Burrows et al. 2008; Kršková et al. 2010; Martin and Farnum 2002; Redefer and Goodman 1989; Silva et al. 2011; Solomon 2010). The other three studies used a simple pre-post or pre-mid-post design with only one replication at each time point (Keino et al. 2009; Memishevikj and Hodzhikj 2010; Taylor et al. 2009). These three studies also had particularly small

sample sizes of ≤4; therefore, although they present interesting pilot data, their design and results are notably limited. Only two studies collected data at a follow-up time point, at 2 weeks (Viau et al. 2010) and 1 month (Redefer and Goodman 1989) after the conclusion of the AAI. The lack of long-term follow-up in most studies represents a limitation regarding the maintenance or decline of AAI outcomes over time.

Most studies (n = 9) included a comparison condition. Almost half of these (n = 4) compared AAI to a traditional wait-list control condition in order to determine whether AAI is more effective than no treatment or treatment as usual. The others (n = 5) compared AAI with an animal to the same AAI procedure without an animal in order to determine whether the animal itself impacts treatment outcomes. The weakest designs (n = 5) did not implement a comparison condition, so their results cannot be confidently attributed to AAI over extraneous factors.

Assessment Type

The types of outcome measures were varied, including quantitative and qualitative observation, standardized and investigator-designed surveys, open-ended interviews, and physiological data (Table 5).

Six studies used quantitative observation of experimenter-designated behavioral outcomes. All but one of these studies (Kršková et al. 2010) used multiple raters (range: 2–7, M = 3.4, SD = 2.2) to establish inter-rater reliability. The percentage of sessions coded by multiple raters was 10 % in two studies (Redefer and Goodman 1989; Sams et al. 2006) and 100 % in three studies (Martin and Farnum 2002; Silva et al. 2011; Taylor et al. 2009). All studies reported satisfactory reliability. Raters of observed behavior were predominantly research staff and students (n = 4). Only one observational study used blind raters to code behavior (Taylor et al. 2009); however, this study was limited by a relatively weak pre-mid-post design with a small sample size of only three participants. The lack of blind raters is a major limitation of the current research base as it may be related to positively biased outcomes.

Five studies used survey data as the primary form of data collection. All but one of these studies (Keino et al. 2009) used standardized survey instruments. None of the survey measures were fully replicated in more than one study. Two studies used the same survey instrument (Sensory Profile; Dunn 1999), but each used a different portion of the survey, restricting comparison. All surveys used parents as informants, with two studies including additional informants (research staff and author). Only one survey study enlisted blind raters (Kern et al. 2011). The others were limited by potential expectancy biases, in that informants may have anticipated outcomes from AAI.

Table 4 Summary of participants, study design, and outcomes

First author (year)	Participants				Study design	Comparison condition	Outcomes of AAI
	N	Age (years)	Gender (% male)	Diagnosis description			
Redefer (1989)	12	5–10	75	Autistic	ABA	Treatment without animal	↑ Social interaction (baseline**, no animal**)
							↓ Social isolation (baseline**, no animal**)
Martin (2002)	10	3–13	80	PDD	Alternating treatment	Treatment with ball or stuffed dog	↑ Focus/interest (dog**, ball**)
							↑ Playfulness (dog*, ball**)
Sams (2006)	22	7–13	–	Autism	Alternating treatment	Treatment without animal	↑ Social interaction (no animal**)
							↑ Language (no animal*)
Burrows (2008)	10	4–14	70	Autism	Qualitative ethology	None	↑ Safety & freedom
							↑ Well-being
							↑ Social recognition & interaction
Bass (2009)	34	5–10	85	ASD	Randomized control	No treatment	↑ Sensory profile (baseline**, wait-list control**)
							↑ Social responsiveness (baseline*, wait-list control*)
Keino (2009)	4	4–17	100	PDD	Pre-post	None	↑ Social interaction (baseline*)
							↑ Verbal communication (baseline*)
							—Nonverbal communication
Taylor (2009)	3	4–6	–	Autism	Pre-mid-post	None	↑ Motivation/volition (baseline[a])
Kršková (2010)	9	6–13	56	ASD	AB	Treatment without animal	↑ Social interaction (no animal***)
							Individual differences (5 of 9 benefit)
Memishevikj (2010)	4	8–10	50	ASD	Pre-post	None	↑ Communication, sociability, sensory awareness (50 % sample)
							—Health/behavior
Solomon (2010)	2	9–13	50	Autism	Qualitative case study	None	↑ Social interaction
							↑ Emotional connection
Viau (2010)	42	3–14	88	ASD	ABA	No treatment	↓ Stress (cortisol awakening response: no treatment**)
							↓ Problem behaviors (baseline*)
Kern (2011)	24	3–12	75	Autism	AB	No treatment	↓ Autism severity (baseline**, no treatment*)
							↑ Quality of life (baseline*, no treatment—)
							—Parent–child interactions & sensory profile (select subscale increases: baseline*, no treatment—)
Silva (2011)	1	12	100	Autistic	Alternating treatment	Treatment without animal	↑ Social behaviors (no animal*)
							↓ Problem behaviors (no animal*)

Table 4 continued

First author (year)	Participants				Study design	Comparison condition	Outcomes of AAI
	N	Age (years)	Gender (% male)	Diagnosis description			
Gabriels (2012)	42	6–16	86	ASD	AB	No treatment	↑ Self-regulation (baseline**, no treatment**) ↑ Communication (baseline*, no treatment†) ↑ Motor and adaptive skills (baseline**, no treatment—)

– not reported, *ASD* autism spectrum disorder, *PDD* pervasive developmental disorder, *AB* comparison + treatment, *ABA* comparison + treatment + comparison + treatment, ↑ greater, ↓ less, —minimal/ no change in the AAI treatment compared to (baseline and/or the comparison condition)

† $p < .10$, * $p < .05$; ** $p < .01$; *** $p < .001$

[a] Visual analysis

Two studies took a qualitative approach to assessing AAI for ASD (Burrows et al. 2008; Solomon 2010). These studies combined qualitative observation with open-ended interviews at various time points throughout the intervention. Neither used standardized techniques for observation or qualitative data collection; therefore, although informative about specific cases, their results may not be replicable or generalizable to the broader ASD population. Finally, only one study combined survey data with a more objective assessment—physiological data (Viau et al. 2010). In this study, parents were trained to collect salivary cortisol samples from participants in the home environment. Due to the high ecological validity and low risk of bias, this study represents one of the most robust assessments of AAI for ASD.

Outcomes of AAI for ASD

Given the variety of unique assessment measures used, key outcomes have been categorized into thematic groups based on the frequency of their report across the 14 studies. A list of the results of each study is presented in Table 4. Due to the methodological limitations noted above, most of the following outcomes should be interpreted as preliminary.

Social Interaction

The most common outcome of AAI for ASD was increased social interaction, reported in 9 of 14 studies. Five of these studies enlisted behavioral observation of AAI sessions with and without an animal (Kršková et al. 2010; Martin and Farnum 2002; Redefer and Goodman 1989; Sams et al. 2006; Silva et al. 2011). Social interaction was defined as the frequency and/or duration of verbal and nonverbal social behaviors. All five studies reported significantly greater social interaction in the presence of an animal compared to no animal. Two reported concurrent decreases in social isolation and self-absorption (Redefer and Goodman 1989; Silva et al. 2011). All but one study (Sams et al. 2006) reported separate results for human versus animal-directed social interactions. In that study, animal-directed interactions were included in the overall result and may have inflated social interaction scores for AAI. However, this inflation does not appear to be a major confound as significant increases in human-directed social interaction were also detected in the other four observational studies. Only one study examined social interactions with ASD peers (Kršková et al. 2010), while the others assessed social interactions with the interventionist only. The majority of the observational study results are therefore limited to adult-directed interactions.

Behavioral increases in social interaction are corroborated by data from four survey-based studies (Bass et al.

Table 5 Assessment measures

First author (year)	Type	Standardized instrument(s)	Blind rater(s)	Raters/informants			
				Author	Research staff	Parent	Not specified
Redefer (1989)	Observation	–	–	x	x	–	–
Martin (2002)	Observation	–	–	–	–	–	x
Sams (2006)	Observation	–	–	–	x	–	–
Burrows (2008)	Observation, interview	–	–	x	–	x	–
Bass (2009)	Survey	SRS, SP	–	–	–	x	–
Keino (2009)	Survey	–	–	x	–	x	–
Taylor (2009)	Observation	PVQ	x	–	x	–	–
Kršková (2010)	Observation	–	–	–	x	–	–
Memishevikj (2010)	Survey	ATEC	–	–	–	x	–
Solomon (2010)	Observation, interview	–	–	x	–	x	–
Viau (2010)	Physiological, survey	–	–	–	–	x	–
Kern (2011)	Survey	CARS, QLES-Q, SP, TPCIS	x	–	x	x	–
Silva (2011)	Observation	–	–	–	–	–	x
Gabriels (2012)	Survey	ABC-C, BOT-2, SIPT, VABS-II	–	–	x	x	–

Standardized instruments and raters refer to survey, interview, and observational data only (not physiological). *x* measure used, – measure not used, *ABC-C* Aberrant Behavior Checklist-Community, *ATEC* Autism Treatment Evaluation Checklist, *BOT-2* Bruininks-Oseretsky Test of Motor Proficiency, *CARS* Childhood Autism Rating Scale, *PVQ* Pediatric Volitional Questionnaire, *QLES-Q* Quality of Life Enjoyment and Satisfaction-Questionnaire, *SIPT* Sensory Integration and Praxis Test, *SP* Sensory Profile, *SRS* Social Responsiveness Scale, *TPCIS* Timberlawn Parent–Child Interaction Scale, *VABS-II* Vineland Adaptive Behavior Scales-Interview Edition

2009; Gabriels et al. 2012; Keino et al. 2009; Memishevikj and Hodzhikj 2010). Each survey study used a different measure of social interaction, including three standardized assessments—the Social Responsiveness Scale (Constantino 2002), the Socialization Skills subscale on the Vineland Adaptive Behavior Scales (Sparrow et al. 2005), and the Sociability subscale on the Autism Treatment Evaluation Checklist (Rimland and Edelson 1999)—and one investigator-designed assessment—the Human-Equips Interaction on Mental Activity (Keino et al. 2009). All four studies demonstrated significant increases in social interaction from before to after the full course of AAI. Two of these studies assessed change from before to after AAI compared to change from before to after a no treatment condition of equal duration. One detected significant differences in Social Responsiveness and its subscale Social Motivation (Bass et al. 2009), but the other found no significant differences for Socialization Skills between the AAI and no treatment conditions (Gabriels et al. 2012). These findings suggest that the motivation to socialize and respond to social stimuli, but not necessarily the specific skills required for socializing, may increase more following AAI than they would naturally over time.

Language and Communication

Five studies reported increased communication and use of language as a result of AAI for ASD. Two studies collected observational data from AAI sessions with an animal versus sessions without an animal. One reported significant increases in use of language in the presence of the animal (Sams et al. 2006). The other did not report total use of language, but did report a significantly greater frequency and duration of speaking about the animal rather than unrelated topics in the AAI compared to substitute objects (ball, stuffed dog) in the no animal condition (Martin and Farnum 2002). The second study therefore suggests that individuals with ASD may display greater interest in speaking about animals than other objects, but not necessarily a greater overall propensity for speaking.

Three studies collected survey-data on language and communication (Gabriels et al. 2012; Keino et al. 2009; Memishevikj and Hodzhikj 2010). Outcome measures included two standardized instruments—the Communication subscale of the Vineland Adaptive Behavior Scales (Sparrow et al. 2005) and the Speech/Language Communication subscale on the Autism Treatment Evaluation

Checklist (Rimland and Edelson 1999)—and one investigator-designed assessment—the Verbal Communication subscale on the Human-Equips Interaction on Mental Activity (Keino et al. 2009). Significant increases on all three measures were seen from before to after AAI. One study also compared AAI to a no treatment condition, and found significantly more increases in communication in the AAI condition (Gabriels et al. 2012). These findings suggest that children with ASD may demonstrate increased language and communication during and immediately following AAI.

ASD Severity

Three studies employed specific assessments of ASD severity. Two of these studies demonstrated significant decreases in ASD severity from before to after AAI as well as compared to a no treatment control (Bass et al. 2009; Kern et al. 2011). The assessments in these studies included the Childhood Autism Rating Scale (Schopler et al. 1994) and the Social Responsiveness Scale (Constantino 2002). The third study reported significant improvements on the Autism Treatment Evaluation Checklist (Rimland and Edelson 1999) from before to after AAI for two of four participants (Memishevikj and Hodzhikj 2010). The findings were more definitive in the first two studies, due to controlled methodologies with larger sample sizes. Taken together, these studies suggest that AAI may reduce ASD severity for certain individuals.

The two aforementioned larger studies also assessed sensory processing using different portions of the Sensory Profile (Dunn 1999). One study used 5 of the 9 subscales (Bass et al. 2009), whereas the other used 4 of the 14 section raw scores (Kern et al. 2011). Results were inconsistent, with only one study (Bass et al. 2009) finding significant improvements in sensory processing from before to after AAI, as well as compared to a no treatment control group. These contradictory findings are difficult to compare as each study used a different, yet potentially overlapping, portion of the 125-item Sensory Profile. Given the inconsistent findings, no conclusions can be drawn at this stage about the effects of AAI on sensory processing in ASD.

Problem Behaviors

Three studies reported decreases in problem behaviors associated with AAI. One behavioral study reported significantly fewer instances of physical and verbal aggression in the presence of an animal versus no animal (Silva et al. 2011). Another found that problem behaviors recorded in an open-ended survey significantly decreased after the introduction of a service dog into the home, and remained lower during a 2-week period after the dog was removed (Viau et al. 2010). The third study demonstrated significant decreases in problem behaviors on the Aberrant Behavior Checklist (Aman et al. 1987) from before to after AAI as well as compared to a no treatment control condition (Gabriels et al. 2012). These three studies provide preliminary evidence that AAI may help reduce problem behaviors and aggression in children with ASD.

Stress and Well-Being

A number of studies reported outcomes that fall under the general category of stress and well-being. Two studies found decreased stress associated with service animals. One demonstrated significant decreases in Cortisol Awakening Response during a 4-week period with a service dog as compared to the 2-weeks prior to and following AAI (Viau et al. 2010). The other provided qualitative comments about decreased stress and an increased sense of safety with service dogs (Burrows et al. 2008). These findings are supported by a reduction in fear and nervousness following AAI in another study using the Human-Equips on Mental Activity (Keino et al. 2009).

Two studies described enhanced quality of life as a result of AAI. One study reported qualitative comments (Burrows et al. 2008), while the other demonstrated significant increases on the General Activities subscale of the Quality of Life Enjoyment and Satisfaction Questionnaire (Endicott et al. 1993) from before to after AAI. In this study, no differences were found between the AAI and no treatment condition (Kern et al. 2011). Findings regarding quality of life as a result of AAI are therefore limited and inconclusive at this stage.

A small group of studies also support potential increases in positive mood related to AAI. Results included behavioral increases in smiling (Silva et al. 2011) and laughing (Martin and Farnum 2002) during AAI with an animal versus without an animal, as well as increased survey reports of smiling, or positive emotional expression, from before to after AAI (Keino et al. 2009). Enhanced mood may be related to increases in energy and motivation associated with AAI. One study reported significant increases in motivation to engage in everyday activities on the Pediatric Volitional Questionnaire (Basu et al. 2002) from before to after AAI (Taylor et al. 2009) and another found significant decreases on the Lethargy subscale of the Aberrant Behavior Checklist (Aman et al. 1987) from before to after AAI, and compared to a no treatment control condition (Gabriels et al. 2012). Taken together, these preliminary findings suggest that AAI may be related to reduced stress and increased well-being through enhanced mood, motivation, and energy.

Discussion

Over the past 25 years, an increasing number of studies has begun to examine the inclusion of animals in ASD intervention, known as AAI. The purpose of this review was to assemble, summarize, and evaluate the empirical research base on AAI for ASD. A systematic literature search resulted in 14 studies that met the initial inclusion criteria. Each study was reviewed in order to achieve three aims: (a) present the characteristics of AAI for ASD, (b) evaluate the state of the evidence on AAI for ASD in order to provide recommendations for further research, and (c) summarize the reported outcomes of AAI for ASD. With regard to the first aim, each study was reviewed for key characteristics of the AAI.

Defining AAI

Despite a recent movement to standardize terminology in the field of anthrozoology with regard to HAI (Griffin et al. 2011), not a single study used the term AAI. Only one study used the more specific term *animal-assisted therapy* and none used the term *animal-assisted activities*. Instead, therapeutic intervention involving animals was identified by 11 different terms across the 14 studies. The lack of universal terminology indicates the variability of AAI at a basic definitional level. It may also create confusion for agencies and individuals intending to implement AAI. In order to clarify its meaning, the key characteristics of AAI in each study were collated and summarized. However, instead of identifying uniformity and a coherent picture of AAI, results of this review highlight the great variability of AAI. No two studies replicated the same formula for key components of AAI, including the type of animal, setting, interventionist, and duration. Additionally, the procedures for each AAI, including interventionist training, targeted outcomes, and session activities, were inconsistent and often poorly described. The only uniform factor across all AAIs was the inclusion of an animal.

Given the variability of terminology and protocols in the current research base, it appears that AAI is in the first phase of research for new psychosocial interventions for ASD—technique refinement. In this phase, initial efficacy studies are conducted to provide "proof of concept" before manualized processes are formulated (Smith et al. 2007). The "concept" in the reviewed studies was the inclusion of an animal in ASD intervention, known as AAI, which took a variety of forms. Each study operationalized and evaluated "proof" of this concept in a different way; hence, the second aim of this review was to evaluate each study's methodology in order to provide directions for future research.

State of the Evidence and Future Research Directions

Due to the large number of interventions proposed for individuals with ASD, there has been a push to develop standardized procedures for establishing new interventions. Smith et al. (2007) proposed a four-phase model for developing and evaluating new psychosocial interventions for ASD. Results of this review indicate that AAI is in the first phase—formulating and systematically applying a new intervention. In order to move into the second phase—developing a manual and research protocol—an intervention must meet the criteria for a "probably efficacious treatment," which is the step before a "well-established treatment" (Chambless et al. 1998). This review indicates that AAI meets these criteria by having at least two studies showing that AAI is superior to a wait-list control. However, in order to more rigorously demonstrate its efficacy, AAI research needs to use more robust and comprehensive study designs and be compared to alternative treatments. At present, none of the reviewed studies compared AAI to another treatment. Demonstration that AAI is either equivalent or superior to another established treatment will be essential prior to classification as a well-established treatment. It is therefore recommended that research on AAI for ASD begin to move into phase two, manualization, in order to establish replicable protocols that can be tested against established treatments for ASD. This phase involves compiling a treatment manual, devising treatment fidelity measures, and testing feasibility of implementing the manual with a small number of participants across multiple sites (Smith et al. 2007).

The publication of treatment manuals of AAI for ASD will assist in standardizing the technique for replication in research and in practice. This review indicates that the current research base is widely multi-disciplinary, as evidenced by the breadth of journals in which articles were published, and international, as evidenced by the country of first author correspondence. In order to streamline and unify further research, the use of standardized terminology in treatment manuals is highly recommended. The overarching term AAI, which encompasses both animal-assisted therapy (AAT) and animal-assisted activities (AAA) has been proposed as the preferred standardized terminology for therapeutic intervention with animals (Griffin et al. 2011). The use of a common term, as well as replication of published protocols, will begin to establish AAI as a recognized and refined intervention.

Within AAI, different techniques may be required based on the type of animal. For example, AAI with horses will likely involve mounted riding activities while AAI with small animals will include a different set of activities. However, the basic tenets of approaching and interacting with live animals will be similar throughout. An appropriate

manualized protocol for AAI should include step-by-step procedures for animal introduction, targeted animal-assisted activities to address specific features of ASD, potential variations and problem-solving strategies, and practical indicators of treatment fidelity. It should also identify whether and what level of interventionist training is required. For instance, if extensive training is unnecessary for positive treatment outcomes, AAI may provide a feasible and inexpensive option for parents and teachers to present to individuals with ASD. Or, if formal certification is necessary for or enhances positive treatment outcomes, this information should dictate interventionist selection and standards.

Treatment protocols are already in place for many organizations providing AAI services, such as Green Chimneys, Pet Partners® (formerly Delta Society®), and the Professional Association of Therapeutic Horsemanship (PATH International®, formerly the North American Riding Association for the Handicapped, NARHA®). The key for future studies will be to systematically apply and report their procedures so that they can be replicated and validated. It may also be advantageous to adapt existing, validated treatment manuals for ASD such as those for applied-behavioral analysis (Lovaas 2002; Maurice et al. 1996), naturalistic teaching (Charlop-Christy 2008), or peer training (Carter et al. 2008; Reid and Parsons 2002) to include animals in the process. This will enable direct comparison between AAI and existing treatments, which is necessary to document AAI as a "well-established treatment" (Chambless et al. 1998). It will also build upon current research, which proposes that the critical component of AAI is the animal. Identifying the "active ingredient" of a treatment through component analysis is an important element of rigorous intervention research (Kasari 2002).

In addition to manualizing AAI procedures for ASD, it is vital to raise the standard of methodological rigor in AAI research in order to determine whether AAI can become an evidence-based practice for ASD. An evaluative method has been developed to determine evidence-based practices in ASD intervention (Reichow et al. 2008). Most of the reviewed studies do not meet the methodological rigor required for these standards. In order to encourage high-quality research on AAI for ASD in the future, the following recommendations are offered, based on the limitations of the reviewed studies with regard to sample size, participant characteristics, study design, and outcome measures.

A key limitation in most studies was a small sample size. Although this was largely due to the use of single-subject designs, it may have reduced the statistical power necessary to determine treatment effectiveness. In most cases, a small sample size also limited generalizability and the ability to examine treatment outcomes based on individual differences. Future studies should ensure that sample sizes are large enough to have adequate statistical power. This can be done either through larger numbers of participants or through increased frequency of assessments.

Another limitation among the reviewed studies was poorly characterized samples. In the future, detailed descriptions of participant characteristics should be provided to facilitate generalizability of the results. Although most of the reviewed studies reported standard participant demographics such as age and gender, only three reported the use of concurrent treatments and an independent assessment of ASD severity. Documenting this information is important because previous research has demonstrated a negative correlation between ASD severity and treatment effectiveness (Ben-Itzchak and Zachor 2007). Further, a recent case study documented a procedure to reduce animal maltreatment by a child with ASD, which suggests that not all interactions between children with ASD and animals are unanimously positive and affectionate (Bergstrom et al. 2011). It has also been proposed that some individuals with ASD may demonstrate fear towards animals (Grandin 2011). Potential differences in reactions to animals are often attributed to the great variability of sensory sensitivity associated with ASD (Grandin et al. 2010). Proponents of AAI claim that with appropriate intervention, heightened sensitivity and fear responses decrease, leading to social improvements over time (Law and Scott 1995); however, it seems likely that some children with ASD may not benefit from AAI. Indeed, two studies in this review reported that only half of the sample benefited from AAI, while the other participants did not demonstrate significant change (Kršková et al. 2010; Memishevikj and Hodzhikj 2010). Therefore, future research should systematically collect, evaluate, and report as many participant characteristics as possible in order to determine which individuals may benefit from AAI. The ability to predict who will benefit will enable efficient and effective allocation of AAI services.

Some studies in the review were also limited by low numbers of assessments. Most of the studies employed single-subject designs, which is typical of the first phase of research for new psychosocial interventions for ASD (Smith et al. 2007). For single-subject designs with a smaller sample size, a high replication rate (minimum three) is necessary to allow careful and detailed analysis of the intervention (Gast 2009). The majority reported a sufficient frequency of assessment; however, not all studies met this criterion. Future single-subject design AAI studies should strive for at least three demonstrations of the experimental treatment effect at three different points in time that can be clearly attributed to the independent variable (Reichow et al. 2008). In addition, only two of the

reviewed studies collected follow-up data from 2 to 4 weeks after the AAI was complete (Redefer and Goodman 1989; Viau et al. 2010). Further studies should collected repeated assessments after withdrawal of AAI in order to explore the stability of treatment effects over time.

A major limitation of the current research was the lack of appropriate control conditions. Nearly one-third of the reviewed studies did not implement any control, but instead used simple pre-post designs. It is imperative that subsequent studies enlist techniques to reduce threats to construct validity. For example, the inclusion of a wait-list control can be used to account for changes due to the passing of time. Randomization to an alternative treatment condition can be enlisted to reduce placebo effects of treatment participation and novelty effects of engaging in a new treatment. Or, comparing AAI to a nearly identical treatment without the animal will reduce construct confounding and begin to determine whether the animal is the "active ingredient" of AAI.

Among the reviewed studies, there was only one between-subjects design. These designs offer greater generalizability than single-subject designs; however, they require greater resources to achieve statistical power for treatment evaluation (Smith et al. 2007). In order to carefully allocate resources in the next phase of AAI research, it may be appropriate to continue to implement carefully-designed single-subject (or within-participants) experiments across multiple sites in order to establish and validate manualizable techniques before embarking upon larger scale group-based and clinical trial designs.

Another major limitation of the reviewed studies was the reliance on potentially biased informants of child behavior and treatment outcomes. Only two studies used blind raters of behavior and only one study collected physiological data. Advancing the research base on AAI for ASD will require blind ratings of participant behavior and further physiological assessment in order to reduce the likelihood of expectancy biases and lead to greater confidence in genuine treatment outcomes. Additionally, no two studies in the current review used the same standardized assessment tool, which limited cross-study comparisons. Future studies should also replicate the outcome measures used in the current studies. The use of consistent outcome measures will enable comparisons between studies using different animals or techniques and validate currently reported outcomes. Despite the variety of assessment measures used across the 14 reviewed studies, key outcome trends did emerge. The third aim of this review was to summarize these outcomes.

Preliminary Proof of Concept

All of the reviewed studies reported positive outcomes of AAI for ASD, yet given the preponderance of methodological weaknesses, initial proof of concept is limited. Reported findings show that AAI merits further investigation, but they should be interpreted with due caution. The most commonly reported outcome of AAI for ASD was increased social interaction. Nearly two-thirds of the reviewed studies reported increased social interaction associated with AAI, through increased frequency and duration of social behaviors in the presence of an animal (Kršková et al. 2010; Martin and Farnum 2002; Redefer and Goodman 1989; Sams et al. 2006; Silva et al. 2011), increased socialization from before to after AAI (Gabriels et al. 2012; Keino et al. 2009; Memishevikj and Hodzhikj 2010), and increased social motivation and responsiveness compared to a no treatment control condition (Bass et al. 2009). Three studies also reported decreases in ASD severity, with respect to social functioning (Bass et al. 2009; Kern et al. 2011; Memishevikj and Hodzhikj 2010). These findings support previous HAI research, which demonstrates that interacting with animals can improve social development in typically-developing children (e.g., Melson 2003) and facilitate social interactions between humans (e.g., McNicholas and Collis 2000; Wood et al. 2005). Increased social interaction in the reviewed studies may have been related to reported increases in language and communication during AAI in the presence of an animal (Martin and Farnum 2002; Sams et al. 2006), following AAI (Keino et al. 2009; Memishevikj and Hodzhikj 2010), and compared to a no treatment control condition (Gabriels et al. 2012). These outcomes support theoretical and empirical work, which demonstrates that interacting with animals may inspire vocalization and elicit communication in children (e.g., Endenburg and van Lith 2011; Gee 2011; Melson 2011).

Some of the reviewed studies also found that participants with ASD demonstrated fewer problem behaviors during AAI in the presence of an animal (Silva et al. 2011), following AAI (Viau et al. 2010), and compared to a no treatment control condition (Gabriels et al. 2012). These outcomes are consistent with previous HAI research in non-ASD populations, demonstrating decreases in problem behaviors and aggressiveness in the presence of an animal (e.g., Kortschal and Ortbauer 2003; Tissen et al. 2007). Reductions in problem behaviors may be related to decreases in stress reported in some of the reviewed studies (Burrows et al. 2008; Keino et al. 2009; Viau et al. 2010), as well as increases in positive mood (Keino et al. 2009; Martin and Farnum 2002; Silva et al. 2011), motivation (Taylor et al. 2009), and energy (Gabriels et al. 2012). A wealth of HAI research has demonstrated that interacting with animals can reduce stress, such as physiological data showing decreased heart rate and blood pressure during animal contact (e.g., Katcher et al. 1983; Wilson 1991). The high incidence of stress in individuals with ASD (e.g.,

Baron et al. 2006; White et al. 2009) makes this population a viable target for further research into stress reduction through AAI.

Taken together, these findings support the concept of AAI as a psychosocial intervention worthy of further investigation. Yet despite its conceptual promise, few reviews of ASD intervention even acknowledge the existence of AAI as a treatment option (e.g., National Standards Report 2009; Odom et al. 2010). This may be due to a variety of reasons, most notably the limited number of peer-reviewed studies on the topic and the preliminary nature of these studies (e.g., McConnell 2002). One review of complementary alternative medicine for ASD did include AAI, and concluded that AAI with horses is a promising practice, while AAI with dolphins is not recommended due to limited research, methodological flaws, and cost-benefit concerns (Umbarger 2007). In the current review, a systematic literature search did not identify a single study focused on AAI with dolphins for ASD. Instead, a handful of studies included a small proportion (less than 25 %) of participants with ASD and did not report specific results for this subset. Concerns have also been raised about the safety of swimming with large and sometimes unpredictable aquatic mammals as well as ethical issues surrounding the welfare of captive dolphins (Brakes and Williamson 2007; Serpell et al. 2006). It has been suggested that similar benefits can be obtained from interventions with domesticated animals without the related costs and potential risks to both humans and animals (Beck 2010). AAI with dolphins, or dolphin-assisted therapy, is therefore not recommended for ASD based on weak empirical validation as well as ethical, safety, and financial concerns.

In the present review, all 14 studies used domestic animals and demonstrated the feasibility and potential benefit of their inclusion in AAI for ASD. These studies were conducted by multiple, independent investigators from around the world. The replication of positive outcomes by multiple, independent investigators in single-subject design studies has been documented as an important component of intervention validation (Odom et al. 2010; Smith et al. 2007). Therefore, positive results from these studies may be indicative of the potential effectiveness of AAI.

However, there are a number of limitations to consider. One important limitation is that selective publishing and reporting may be a major cause of bias. The fact that none of the studies reported null effects of AAI for ASD may be evidence of a 'file-drawer' effect, whereby studies that fail to achieve positive outcomes are filed away rather than published. This bias has been cited as a potential concern for AAI studies, in which researchers may be animal enthusiasts that with a vested interest in reporting positive outcomes (Herzog 2011). It is also possible that relevant studies were excluded due to the English-language parameter of the inclusion criteria. HAI appears to be a multi-disciplinary and international field, therefore non-English publications may have broadened the scope of the review. Another limitation is that there were no eligibility criteria with regards to methodological rigor. All identified studies of AAI for ASD were included in order to evaluate the state of an emerging body of evidence. The dearth of high-quality research on the topic may have led to biased conclusions from weak evidence. The included studies are indeed plagued by a number of methodological weaknesses common to the AAI literature, particularly threats to construct validity (Marino 2012). Thus, findings in the current review should not be interpreted as evidence of the benefits of AAI for ASD; instead, they offer preliminary support for the concept of AAI, which must be replicated in larger-scale, more rigorous research if it is to become a validated intervention technique for ASD.

Conclusion

This systematic review provides the first comprehensive overview of empirical research on AAI for ASD. Results indicate that the inclusion of animals in ASD treatment practices is variable and multi-disciplinary, enlisting a wide range of terminology, animals, settings, interventionists, durations, and activities. The research base for AAI is similarly scattered, with few high-quality studies, many methodological weaknesses, and limited replication. The preliminary nature of the reviewed studies suggests that AAI is in the first phase of research on new psychosocial interventions for ASD—proof of concept. Reported outcomes provide preliminary support for the concept of AAI for some individuals with ASD, through increased social interaction and communication as well as reduced problem behaviors, autistic severity, and stress. However, further, more rigorous research will be necessary to progress from the preliminary testing phase to systematic manualization, clinical trials, and if efficacious, routine implementation.

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