CHILDREN AND ANIMALS IN SYNCHRONY

In search of an underlying mechanism of the effects of Animal-Assisted Therapy on the development of Children with Down Syndrome and Children with Autism Spectrum Disorder

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Richard E. Griffioen

GENERAL INTRODUCTION

GOED TE ZIJN VOOR DIEREN IS NIET ALLEEN EEN PLICHT, MAAR IS OOK EEN WELDAAD VOOR ONS EIGEN HART.

1

GENERAL INTRODUCTION

This dissertation focuses on Animal-Assisted Interventions (AAI), specifically Animal Assisted Therapy (AAT) for children with Down syndrome (DS) and for children with autism spectrum disorder (ASD). In 1962 child psychotherapist Boris Levinson (Levinson, 1962; Levinson, 1972) was the first to report on the effects of the presence of a dog during therapy sessions on the behavior of a child with autism. Since 2012 there has been a significant increase in various AAI programs with different animals and target groups. Several authors believe that more research needs to be done to provide a definitive answer about the effect of these interventions (Kamioka et al., 2014; O'Haire, 2017). This dissertation therefore investigates two AAT programs from a new theoretical perspective that will be explained below. First, however, the two target groups of this dissertation, children with DS and children with ASD, will be described.

1.1 Introduction to children with Down Syndrome (DS)

Individuals with DS have a genetic disorder caused by an extra 21st chromosome (trisomy 21), resulting in a characteristic physical appearance and generalized learning disabilities. In the Netherlands, the prevalence of DS is 15.7 per 10.000 newborn children (Mohangoo & Buitendijk, 2009). Life expectancy of DS individuals in western countries has risen over the past 60 years, mainly due to improved diagnosis and treatment of congenital heart disease, which is frequently present in children with DS (Kortenhorst, Hazekamp, Rammeloo, Schoof, & Ottenkamp, 2005a; Weijerman & de Winter, 2010; Weijerman et al., 2008). In addition, most individuals with DS suffer from mental retardation in the mild (50 – 70) to moderate (35 – 50) IQ range. Impairment of cognitive abilities and difficulties with speech and language skills are present in most children and adults with DS (Rondal, 2009).

The deficits in pre-linguistic communication (e.g. decreased muscle tone of the speech muscles,) and the limited natural growth of language during school age and adolescent years emphasize the need for early (language) intervention in children with DS (Cuskelly et al., 2002; Wishart, 1998).

The degree of cognitive impairments varies widely for children with DS: From close to normal intelligence to severe retardation, with 80% of individuals showing moderate retardation (Roberts, Price, & Malkin, 2007). All individuals with DS have some degree of developmental delay, which means that they tend to learn slower and have more trouble with complex reasoning and judgement.

The learning style of children with DS is often characterized by an increasing use of avoidance strategies when faced with learning new skills, and by a growing reluctance to take the initiative in learning contexts (Wishart, 2001). It is, however, important to recognize that these children's motivation to learn may be undermined by negative experiences with learning new skills, if these are not carefully monitored and managed by their caregivers or teachers (Wishart, 2001). In general, the learning potential of an individual with DS can be maximized through early intervention, higher expectations and encouragement (Bussy, Charrin, Brun, Curie, & des Portes, 2011; Conners, Rosenquist, Arnett, Moore, & Hume, 2008).

Learning how to speak is especially difficult for children with DS. They make less or slower progress compared to other children, find grammar difficult and even when they are able to talk in sentences, they often have difficulty to produce clear speech due to physical impairments (Cuskelly et al., 2002). To be more specific, most individuals with DS have speech and language deficits, particularly in language production and syntax, and have poor speech intelligibility (Chapman, 1997; Roberts et al., 2007). Language delays follow a characteristic pattern, particularly in language production and syntax (i.e. the combination of words into sentences). Research shows that the speech and language skills of children with DS is usually delayed relative to their non-verbal communication abilities (Buckley, Bird, & Sacks, 2002; Luyster et al., 2005).

1.2 Introduction to children with Autism Spectrum Disorder (ASD)

Autism spectrum disorder (ASD) is characterized by significant difficulties in social interaction, along with restricted and repetitive patterns of behavior and interests, such as difficulties using and understanding language, and difficulties relating to people, objects and events; for example, lack of eye contact, unusual play with toys or other objects, and difficulties with changes in routine or familiar surroundings

(Grandin, Fine, & Bowers, 2010; Rutgers, Bakermans-Kranenburg, Ijzendoorn, & Berckelaer-Onnes, 2004). Common comorbid symptoms are stress and anxiety, often due to problems with coping in the field of sudden changes, anticipation, hyper-sensitivity and unpleasant occasions (Gillott & Standen, 2007; Wijker, Leontjevas, Spek, & Enders-Slegers, 2019).

According to the new DSM 5, (American Psychiatric Association, 2013; Volkmar & Reichow, 2013) the diagnosis of Asperger, PDD-NOS (pervasive developmental disorder- not otherwise specified) and McDD (multiple complex developmental disorder) all fall under the heading of 'Autism Spectrum Disorders', resulting in a continuum ranging from mild to severe symptoms.

The prevalence of ASD in the Netherlands is 1.0 -1.16% of the total population (or 100 per 10.000 newborns) (Peters-Scheffer, Didden, Korzilius, & Matson, 2012). Forty to sixty percent of the children with ASD (the ratio of boys and girls equals 4:1) also have a cognitive impairment (Baron-Cohen, 2004; Baron-Cohen, Golan, Chakrabarti, & Belmonte, 2006).

A qualitative impairment in social interaction and an impaired ability to communicate are the main difficulties of children with ASD (Baron-Cohen, 2004; Kern et al., 2011). Children with ASD experience difficulties to understand other people's perspectives and to read their facial expressions, and have an impaired ability to communicate. Both aspects make establishing and maintaining social relationships difficult (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Landa, 2007). These children are missing many of the skills that are essential for developing meaningful (peer) relations (see below). They therefore often prefer to be alone and/or to engage with a limited number of interaction partners that they are used to.

1.3 Social difficulties of children DS and children with ASD

Children with DS and children with ASD have difficulties to engage in social interactions and participate in society, due to delays or an atypical course of their psychological and socio-emotional development (Kortenhorst, Hazekamp, Rammeloo, Schoof, & Ottenkamp, 2005b; Mohangoo & Buitendijk, 2009). These children most commonly show attention problems, social problems and language deficits. Their difficulties to understand others, and to make properly use of language may lead to

experienced stress and emotional and behavioral problems due to these impaired interactions (Jansen, Gispen-de Wied, van der Gaag, & van Engeland, 2003; Jansen et al., 2006; Weijerman & de Winter, 2010).

Children with DS and ASD show less or no initiative to explore their surroundings, often due to their impairments. They also show rigid or fixed patterns of behavior, which make them feel safe and secure. Their development of joint attention is often delayed, as well as their listening skills and manual dexterity (pointing, grabbing) (Inui, Yamanishi, & Tada, 1995). In addition, it takes more time for them to process information and to respond adequately. With regard to learning strategies and processes, it seems that they have to confront substantial barriers, like attention span deficits and weaker social capabilities (Baron-Cohen, 2004; Naess, Nygaard, Ostad, Dolva, & Halaas Lyster, 2017). Most children with DS and ASD have problems to focus and therefore they need a lot of individual attention of their caregivers (or teachers and therapists) and focused stimuli (prompts) to come into action (Cuskelly et al., 2002). The difficulties of these children in daily interactions with their caregivers and others interfere with their development of more advanced interaction skills, resulting in an increasing gap in socio-emotional development between them and typically developing children (Venuti, de Falco, Esposito, & Bornstein, 2009).

1.4 Current interventions for children with DS and children with ASD

In a longitudinal study, Sigman and Ruskin (1999) showed that improvement of early communication and play skills might have long-term consequences for later language use and social competence. They identified the precursors of social competence in the group of DS and the group of ASD. For the design of early intervention programs it may be of particular significance to identify the precursors of verbal communicative and social skills at an early age. For example, identifying joint attention skills in young autistic children as a precursor to language skills has led to some intervention programs to improve the collective attentional skills of these children. Specific therapies for children with DS, such as the so-called early intervention or Macquarie program (Buckley et al., 2002), are given by physiotherapists and speech therapists to provide some cognitive, pre-verbal and sensomotoric training at a very

early age (< 3 years old). There are, however, only a few research findings about this kind of training available in the literature. Connolly (1993) reported motor development benefits, like more core stability and earlier walking for children with DS who participated in an early intervention group compared to children with DS who did not participate. A second well- known early intervention program for children with DS is Feuerstein's instrumental enrichment program (Kozulin et al., 2010). This is a cognitive modification program for children with developmental disabilities. Results show improvement of cognitive functioning, like concentration and execution of tasks, after following this program, regardless of the specific developmental disability, however greater cognitive gains were found when children received the program in an educational setting with trained teachers in mediated learning (Kozulin et al., 2010). A last early intervention program for children with DS is Responsive Teaching (RT). Herman (2006) reported benefits on cognitive skills and social emotional development, e.g., better verbal behavior of children with DS during this particular program.

The Dutch National Health Council reported in the Dutch guidelines for ASD (2009), that there are little to no effective treatments for ASD. The guidelines do emphasize that early interventions directed to the acquisition of adequate communicative and social competences can significantly improve the quality of life. It is concluded that there is international consensus, but no evidence, that the best chances for development occur when children with ASD live in a structured environment with communicative support (Howlin, Magiati, & Charman, 2009; Volkmar, Lord, Bailey, Schultz, & Klin, 2004). According to the Dutch guideline, TEACCH (Treatment and Education for Autistic Children and Children with Communicative Handicaps) is the best known and best studied method (Schopler, Mesibov, & Hearsey, 1995). It is a structural teaching system, administered in collaboration with the parents (as co-therapists). The system is set up to modify the environment of the child in order to meet the individual needs of the child with ASD.

Using TEACCH in pre-school children, Ozonoff and Cathcart (1998) observed significant improvement of social and communicative competences, like imitation and nonverbal conceptual skills. Similarly, Van Bourgondien, Reichle and Schopler (2003) reported short-time positive effects on communicative and social competences, as well as a decrease of attitude problems. However, the results of a meta- analysis showed that TEACCH effects on motor, verbal and cognitive skills

are small (Virues-Ortega, 2013), while a meta-analysis of a long-term Applied Behavior Analysis (ABA) intervention program showed medium to large effects on language development and social functioning of children with ASD (Virués-Ortega, 2010). ABA is a method to apply tactics derived from behavior science systematically to improve socially behavior (Dillenburger & Keenan, 2009). Peters-Scheffer (2011) also mention a strong support for the effectiveness of an ABA-based intervention for children with ASD, compared to other treatments, specifically on expressive and receptive language and adaptive behavior.

1.5 Animal-Assisted Interventions (AAI): A new additional approach to the treatment of Down syndrome and Autism spectrum disorder

Since several decades it has been suggested that AAI, such as Equine-Facilitated Therapy (use of horses), Dolphin-Assisted Therapy and the help of (assistance) dogs, can support the treatment of children with DS and ASD. The bond between humans and other animals has been evident throughout human history. In 1948 Green Chimneys, a children's treatment facility in Brewster, N.Y., began using animals as a positive reinforcement for children's good behavior. In 1962 psychiatrist Boris Levinson discovered by accident that communication with a (previously) nonverbal child improved when Levinson's dog was present during the sessions. Levinson's work has since then been considered as the birth of present-day AAT (Connor and Miller, 2000, Heimlich, 2001, Odendaal, 2000). To promote the psychosocial development of children with special needs, working with animals appears to be beneficial, because it provides joy (pleasure), friendship, powerful attraction, direct physical contact and attachment (Melson, 2003, 2015)

The rationale for including animals in the treatment of, for instance, children with ASD and children with DS, 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, McCune, Griffin, & Maholmes, 2011; O'Haire, 2013a).

According to the definition of the International Association of Human Animal Interaction Organizations (IAHAIO, 2018) AAI can be divided into four categories:

1) Animal-Assisted Activities (AAA), most often conducted on a volunteer basis by people and animals that have received at least an introductory training and preparation for visitation; for example a dog visitation program in a nursery home.
2) Animal-Assisted Pedagogy (or: Education) (AAP/E), which can be conducted by a regular school teacher or a specially trained remedial teacher; for example a reading program in which children learn how to read fluently in the presence of an animal.
3) Animal-Assisted Therapy (AAT), which is a goal-oriented intervention given by a therapist, to improve a patient's cognitive or physical functioning. For examples, see the programs that were studied for this dissertation.
4) Animal-Assisted Coaching/Counselling (AAC), is a goal oriented, planned and structured animal assisted intervention directed and/or delivered by professionals licensed as coaches or counsellors. By means of experience-oriented techniques, clients are stimulated to self- reflection and to actively search for their own solution for the request for help.

This dissertation focuses on two specific AAT programs for children with ASD and DS, with dolphins (chapter 2 and 3) and dogs (chapter 4 and 5).

Since the last two decades the scientific research on AAT has been increasing. In 2007, Nimer and Lundahl published a meta-analysis on AAT in which they reviewed 250 studies, 49 of which met the inclusion criteria and could be submitted to meta-analytic procedures. They concluded that, in general, AAT shows promising results as an additive to established interventions for a variety of target groups. However, they also concluded that more systematic research was needed.

Selby and Osborne (2013) published a systematic review on the effectiveness of complementary Equine-Assisted Therapies across populations with chronic illness or health challenges. Although the evidence was promising, they also concluded that future studies were needed that utilize rigorous and creative designs, especially longitudinal studies. In two systematic reviews on animal assisted interventions for specifically children with ASD, O'Haire (2013, 2017) concluded that despite positive outcomes, most studies were limited by a number of methodological weaknesses, like small sample sizes , poorly characterized samples, no control groups

and different assessment types. However, the review did demonstrate a preliminary "proof of concept" of AAT for children with ASD. The positive outcomes mentioned were increased verbal communication and social interaction, as well as decreased problem behavior and stress. Kamioka et al., (2014) published a systematic review of 11 randomized controlled trials, of which 7 were focused on people (mostly adults) with mental and behavioral disorders. They concluded that AAT may be an effective treatment for this population. Lastly, Maujean, Pepping and Kendal (2015) conducted a systematic review on randomized controlled trials (RCT) and concluded that 7 studies showed beneficial results of AAT to a wide range of individuals with psychological disorders, including children with ASD.

If we look specifically at AAT for children with ASD and DS with dolphins, two early studies showed a positive influence (Nathanson, 1998; Nathanson, de Castro, Friend, & McMahon, 1997a) on the wellbeing of the children. In one of these studies on children with DS and children with ASD (Nathanson, Castro, Friend, & McMahon, 1997), the authors concluded that the positive results of Dolphin Assisted Therapy were established quicker, and that these interventions were therefore more cost-effective than conventional therapies, like speech therapy. In addition, Breitenbach et al. (2009a) conducted a study on AAT for children with ASD and DS using four conditions: an experimental group which participated in three modules of therapy (recreational/vacation atmosphere, counselling and interaction with the dolphins), a non-treatment control group, an outpatient therapy group that received Dolphin- Assisted Therapy, and a group that received therapy involving farm-animals. Parents of both Dolphin-Assisted Therapy groups (experimental and outpatient groups) reported positive effects with regard to verbal speech and non-verbal reactivity. Furthermore, parents of children of the experimental group observed positive effects in social-emotional competence and self-confidence of their children. These therapeutic effects were not found in the non- treatment group and in the group who received therapy with farm-animals.

With regard to Dog-Assisted Therapy for specifically children with ASD, Berry et al., (2013) concluded in a critical review that empirical studies show positive effects on social and interaction behaviors, but further research with good designs is needed to strengthen the translation of such interventions to practice. Moreover, Cirulli et al., (2011) concluded in their review article on Dog-Assisted Interventions for (among others) children with ASD, that Dog-Assisted Interventions have the potential to improve their wellbeing. The only known study on chil-

dren with DS and therapy dogs showed improved verbal and non-verbal initiation and response (J. A. Limond, Bradshaw, & Cormack, 1997).

1.6 Theories behind animal-assisted interventions

Although multiple authors clearly conclude that more research is needed, the initial results of AAT for children with DS and ASD seem positive, as indicated above. For such a new field of study, however, it is of great importance to discuss the theory (or theories) behind these animal-assisted interventions. A strong focus on theory can guide future research, and can help explain the reason(s) behind the positive effects found in the literature (Fine, Tedeschi, & Elvove, 2015; Van der Steen, 2018). Although there is not one specific human animal interaction theory that postulates how animal assisted interventions may affect child development and behavior, five (partly overlapping) theories have been proposed.

(A) The Biophilia hypothesis (Wilson, 1984), according to which humans have an innate tendency to affiliate with other life forms, helps to explain why animals attract and hold our attention, but does not explain the perceived benefits of human-animal interaction. However as a result of this innate tendency it is possible that animals are more or less effective in releasing perceived stress, as they divert our attention from (for example) stressful stimuli (Serpell, McCune, Gee, & Griffin, 2017).

(B) The social catalyst/social capital (interaction) theory (McNicholas & Collis, 2000; Wood, Giles-Corti, & Bulsara, 2005; Wood et al., 2015) explains the benefits of human-animal interactions, but only via the animal's ability to enhance or facilitate interactions with other humans. Animals, especially dogs, are strong mediation interactants, and because of that they do facilitate social interaction between pet owners, their neighbors and others. An example would be a dog owner who engages in more social interactions with neighbors while walking his/her dog.

(C) The social support and attachment theory (Ainsworth, 1979; Cobb, 1976; Enders-Slegers, 2000; Mader, Hart, & Bergin, 1989; Serpell et al., 2017), which

provides a mechanism that could account for direct, beneficial effects of human-animal interactions based on social buffering and attachment. Together with his colleague Ainsworth, Bowlby (Bowlby, 1982) has described how a child's early relationship experiences can affect the development of an individual's future attachment style. A secure attachment to a caregiver means that the child can use his or her caregiver as a secure base to work from and a safe haven to return to when it becomes frightened, whereas a child with insecure attachment is, for a number of reasons, unable to use the caregiver to regulate his/her internal anxiety. The more responsive and accessible the primary caregivers are, the more secure the attachment style will be. More broadly, attachment is an emotional bond that supports a sense of closeness, wellbeing and security (Julius, Beetz, Kotrschal, Turner, & Uvnäs-Moberg, 2014; Mills & Hall, 2014; Zilcha-Mano, Mikulincer, & Shaver, 2011). Multiple studies have demonstrated strong associations between social support and mental health, morbidity and mortality (Friedmann, Galik, et al., 2015; Melson et al., 2009). Animals can stimulate children to behave responsible and to express their emotions, and they offer the opportunity to establish secure attachment. The human-animal attachment theory suggests that animals may provide a source of comfort and safety for children, as transitional objects. That is, children first establish a bond with an animal and learn to extend this bond to another human (Parish-Plass, 2013; Winnicott, 1986), which can alleviate distress and may reduce problem behaviors (Kovács & Umbgrove, 2014; O'Haire, McKenzie, Beck, & Slaughter, 2013). This theory is suggested by several authors over the last two decades (Beck & Katcher, 1996; Beetz, Julius, et al., 2012; Beetz, Uvnäs-Moberg, Julius, & Kotrschal, 2012; Melson, 2003; Myers, 2007; Serpell et al., 2017).

(D) According to Bandura's social cognitive theory, children learn by observing others (Bandura, 1979; Cavicchi & Frances, 2013). According to learning theory definitions, such as operant and classical conditioning, a successfully achieved task tends to lead to a spontaneous increase of that behavior and a decrease of avoidance. This cognitive learning theory is also applied in other therapeutic settings, and has been hypothesized as a therapeutic solution to the attention deficit hypothesis, which suggests that the relative inability of children with a cognitive impairment to learn is primarily a function of a deficit in attention to the relevant dimensions of stimuli, rather than an inability to process informa-

tion (Nathanson, 1998; Nathanson, de Castro, Friend, & McMahon, 1997b). In accordance with this hypothesis and the social cognitive theory, learning of children with a cognitive impairment may occur through long-term exposure to the relevant cues/stimuli, and if the correct response occurs, this is immediately rewarded. A pleasurable activity with an animal can serve as a reward, thereby reinforcing the behavior that resulted in this reward, making it more likely that this behavior occurs in the future. For example, in one of the AAT programs discussed in this dissertation, children are only allowed to work with the dolphin if they make eye-contact and ask the dolphin-trainer's permission to perform an activity with the dolphin (e.g., to signal the dolphin to jump in the water). This pleasurable activity reinforces making eye contact and asking for permission the next time.

(E) Biopsychosocial model (Beetz, 2017; Beetz, Uvnäs-Moberg, et al., 2012; Serpell et al., 2017). This model describes the effects of human-animal interaction on physiologic parameters, such as heart rate variability, cortisol and oxytocin levels as an indication of perceived stress, and also the effect on improving social behavior through decreased cortisol levels and increased oxytocin levels during the interaction with an animal (Beetz, Uvnäs-Moberg, et al., 2012; Handlin et al., 2011). Other researchers have reported that interacting with an animal in a therapeutic setting moderates the physiologic responses of the autonomous nervous system and affect the symptoms of high blood-pressure, stress, anxiety and depression in a positive way leading to a better quality of life (Friedmann, Son, & Saleem, 2015).

1.7 Toward an overarching theoretical framework

Recently, it has been proposed by Verheggen, et al., (2017) that an overarching theoretical framework for AAI/AAT may be found in the notion of mutual coordination of actions (or mutual embodied attunement), by subjects involved in interactions. Borrowing from enactivim (F. J. Varela, Thompson, & Rosch, 1993) and dynamic systems theory (Thelen & Smith, 2007) enactive anthrozoology suggests that all the remarkable and beneficial effects of AAI and AAT may be related to the embodied tuning of behavior, emotions, movements, respiration and so forth between human

and animals. According to the authors, this could, in line with enactive thought, also account for cognitive effects of AAT. Although no empirical research has yet been done to back these hypotheses, notions closely similar to mutual coordination and attunement have been proposed in the literature, such as interpersonal coordination (Bernieri & Rosenthal, 1991), co-regulation (A Fogel, 1993) or mutual coordination of actions (Baerveldt & Verheggen, 2012), and authors emphasizing the concept of (affect) attunement (Beebe, Sorter, Rustin, & Knoblauch, 2003; Feldman, Greenbaum, & Yirmiya, 1999; Stern, 2018). It is important to note that both Fogel and Stern addressed the possibility and importance of co-regulation respectively affect attunement between children and animals. Fink(1993) was the first to explicitly study human-animal interactions in terms of affect attunement.

Stern first introduced the term "affect attunement" in his work on parent-child interactions (Rochat et al., 2013; Stern, 2018). He observed that responsive caregivers use their voice and bodies to reflect their infants' behavior and affective state. These reflections in the behavior of the caregiver are called vitality affects. They are continuously present and can be observed by looking at subtle details in body posture, rhythm, speed and form of movement, as well as minimal changes in muscle tone and sounds, intensity, and timing (Beebe, Sorter, et al., 2003; Stern, 2010). An example is that a caregiver's voice becomes louder when the infant kicks his/her legs faster. In essence, the caregiver is synchronizing with the behavior of the infant, albeit in another modality. In animal-assisted therapy, synchrony between humans and animals is therefore an important precondition that increases the chance of positive outcomes.

Several authors emphasize that synchrony is indeed a fundamental condition in human-pet interactions (Fogel, 1993; Beck & Katcher, 1996). Synchrony has a long research history linked to caregiver-child interactions in infancy (Feldman, 2007; Harrist & Waugh, 2002; Stern, 2018). During early development, synchrony involves a matching of behavior, emotional states, and movement rhythms between caregivers and infants. Behavioral and affective 'synchrony' between parent and child is thought to contribute to the child's wellbeing and development (Beebe, Sorter, et al., 2003; Pipp-Siegel, Siegel, & Dean, 1999; Stern, 2010; Stern, 2018). Studies show that children who experience more synchrony with their parents during the first years of their life have more advanced social skills at a later age (Harrist & Waugh, 2002). In line with this, studies suggest that parent-child dyads often fail to achieve synchrony when the child is diagnosed with DS or ASD (Baranek, 1999;

Osterling, Dawson, & Munson, 2002; M Sigman et al., 1999). Their difficulties make it hard to achieve the mutual regulation and temporal coordination of their interactions. As a consequence, the further development of their social-emotional skills is impaired.

Synchrony is most probably easier to observe and operationalize in research than the wider concepts of mutual coordination and (affect) attunement (of which synchrony is a subset according to Stern). It may thus serve as a viable en central concept to begin exploring the mechanisms of attunement as suggested by the authors mentioned above.

First, research shows that synchrony emerges when two individuals (e.g., caregiver-child) are particularly focused on each other (Verheggen et al., 2017; Van der Steen, 2018), which is in some aspects similar to the mechanism proposed by the Biophilia hypothesis (Wilson, 1984). Earlier research also shows that high levels of parent-child synchrony contribute to the attachment of children to their caregivers (e.g., Feldman, 2007), which is in line with the social support and attachment theory (Cobb, 1976; Enders-Slegers, 2000; Mader, Hart, & Bergin, 1989; Serpell, McCune, Gee, & Griffin, 2017). Furthermore, synchronous interactions elicit physiological responses in our bodies, such as an increase in oxytocin release (Ruth Feldman, Gordon, & Zagoory-Sharon, 2011). This relates to the biopsychosocial model (E). Lastly, as mentioned above, synchrony enables children to practice their social skills (Harrist & Waugh, 2002), which is also what the social-cognitive theory proposes as one of the mechanisms of human-animal interactions (Van der Steen, 2018).

Synchrony is a reciprocal pattern that occurs in the behavior or emotions of two individuals, in other words, it is itself a mutually regulated phenomenon (Harrist & Waugh, 2002, Leclère et al., 2014).

1.8 How to study synchrony

Synchrony requires anticipating and interacting with others' behaviors to coordinate your own behavior (Van der Steen, 2018). Synchrony can therefore be studied by looking for temporal matches between the behaviors of the interaction partners. These patterns of behavior can be simultaneous or can occur with a slight delay, but can also be alternating or mirrored, like in a dance (Reddish, Fischer, Bulbulia,

Bulbulia, & Huici, 2013; Tarr, Launay, Cohen, & Dunbar, 2015). An example of simultaneous behavior is walking in the same pace, whereas an example of alternating or mirrored behavior is taking turns to speak while communicating. This latter example implies that it is possible to observe synchronous patterns of behavior that show leader-follower qualities.

It also implies that fine-grained analysis methods, such as Cross Recurrence Quantification Analysis (CRQA) are needed to examine synchrony, because the timing isoften so complex. Cross recurrence quantification analysis (CRQA) is an appropriate nonlinear technique that originates from the natural sciences (De Jonge-Hoekstra, Van der Steen, Van Geert, & Cox, 2016a), but has never been applied to synchrony between movements and turn-taking behavior of children and animals. CRQA focuses on the shared dynamics of a dyad by detecting repeatedly occurring matches between behavioral states (Dale & Spivey, 2006a; Norbert Marwan, Carmen Romano, Thiel, & Kurths, 2007; Zbilut, Giuliani, & Webber, 1998a). Patterns of matching behavior do not always occur at the exact same moment or neatly after each movement or conversational turn. CRQA therefore detects these matches across all possible timescales, ranging from seconds to the duration of the entire interaction (Cox & van Dijk, 2013a; de Graag, Cox, Hasselman, Jansen, & de Weerth, 2012a).

According to the above, it can be hypothesized that behavioral synchrony in the field of human animal interactions (e.g., between children and animals), has never been investigated so far, although it may be an underlying mechanism among the five theories mentioned above. Synchrony as seen in the relation between children and their parents/caregivers is likely also present in the interaction between children and animals; and as such may be expected to influence the development and behavior of the child.

1.9 Overview of this dissertation

This dissertation has two important goals: First, to strengthen the literature base in the field of Animal-Assisted Therapy (AAT) for children with DS and children with ASD, in particular with dogs and dolphins. The dissertation specifically focuses on the development of verbalization and social skills and a reduction of perceived stress as a result of these interventions. Second, this dissertation will provide a first

empirical indication for framing these studies within the synchrony overarching framework.

In order to systematically study these goals in both children with DS and children with ASD, four studies were conducted. The effects of Dolphin Assisted Therapy will be scrutinized in chapters 2 and 3. In chapter 2 we look at the effect of Dolphin Assisted Therapy on verbalization and social skills. Thus, this chapter can replicate previous findings on the effect on social skills and verbalization of children with ASD and DS, in particular the Breitenbach (2009b) study and two fairly old studies by Nathanson (1998; 1997b). In chapter 3 we look at the same Dolphin Assisted Therapy program, but specifically focused on synchrony (turn-taking behavior). We investigate whether the synchrony between child and therapist indeed increases during the therapy sessions, as we would expect according to the synchronization hypothesis. Because this is a first test of the synchrony framework, we present five case studies in this chapter. In chapter 4, the attention shifts to Dog Assisted Therapy and synchrony. In this chapter, evidence for synchrony between children and therapy dogs is investigated during therapy. In the same context, chapter 5 examines whether there is indeed a decrease of salivary cortisol levels and an increase of heart rate variability as an indication of decreased perceived stress.

1.10 ETHICAL CONSIDERATIONS

We want to stress that during this research, the dolphins' and dogs' welfare was continually monitored by a veterinarian (dolphins) and a handler (dogs). All necessary precautions were taken to prevent possible harm to the dolphins and the dogs. The interaction time with the children was limited to a minimum, and for the dolphin assisted therapy program clients were prohibited from being in the water.

However, with the advancing insight into animal welfare, we support the (fairly recent) statement made by the International Association of Human Animal Interaction Organzations in their white paper (IAHAIO, 2018) on animal wellbeing that non-domesticated animals, e.g., dolphins, elephants, capuchin monkeys, prairie dogs, arthropods, and reptiles, should no longer be involved in animal-assisted therapy programs. The reasons include high risks to clients from zoonoses and animal welfare issues.

REFERENCES

Ainsworth, M. D. S. (1979). Attachment as Related to Mother-Infant Interaction (pp. 1–51). https://doi.org/10.1016/S0065-3454(08)60032-7

American Psychiatric Association. (2013). Diagnostic and Statistical Manual of Mental Disorders (DSM-5®) - American Psychiatric Association -

Autismespectrumstoornissen: een leven lang anders. (2009). Retrieved from https://www.autentiek.nl/docs/Rapport-ASS-gezondheidsraad-23-06-2009.pdf

Baerveldt, C., & Verheggen, T. (2012). Enactivism. *In The Oxford Handbook of culture and psychology* (pp. 165–190). Oxford University Press.

Baron-Cohen, S. (2004). The cognitive neuroscience of autism. *Journal of Neurology, Neurosurgery, and Psychiatry*, 75(7), 945–948. https://doi.org/10.1136/JNNP.2003.018713

Baron-Cohen, Simon, Golan, O., Chakrabarti, B., & Belmonte, M. K. (2006). Autism spectrum conditions. Retrieved from http://irep.ntu.ac.uk/id/eprint/1931/1/220031_1965preprintdoc.pdf

Beck AM, Katcher AH. Future Directions in Human-Animal Bond Research. Am Behav Sci [Internet]. SAGE Publications; 2003 Sep 27 [cited 2017 Dec 18];47(1):79–93. Available from: http://journals.sagepub.com/doi/10.1177/0002764203255214

Beebe, B., Knoblauch, S., Rustin, J., & Sorter, D. (2003). Introduction: A Systems View. *Psychoanalytic Dialogues*, 13(6), 743–775. https://doi.org/10.1080/10481881309348767

Beebe, B., Sorter, D., Rustin, J., & Knoblauch, S. (2003). A Comparison of Meltzoff, Trevarthen, and Stern. *Psychoanalytic Dialogues*, 13(6), 777–804. https://doi.org/10.1080/10481881309348768

Beetz, A. (2017). Theories and possible processes of action in animal assisted interventions. *Applied Developmental Science*. https://doi.org/10.1080/10888691.2016.1262263

Beetz, Andrea, Julius, H., Turner, D., & Kotrschal, K. (2012). Effects of Social Support by a Dog on Stress Modulation in Male Children with Insecure Attachment. *Frontiers in Psychology*, 3, 352. https://doi.org/10.3389/fpsyg.2012.00352

Beetz, Uvnäs-Moberg, K., Julius, H., & Kotrschal, K. (2012, July 9). Psychosocial and psychophysiological effects of human-animal interactions: The possible role of oxytocin. *Frontiers in Psychology.* Frontiers. https://doi.org/10.3389/fpsyg.2012.00234

Bernieri, F., & Rosenthal, R. (1991). Interpersonal coordination: Behavior matching and interactional synchrony. Retrieved from http://psycnet.apa.org/record/1991-98576-011

Berry, A., Borgi, M., Francia, N., Alleva, E., & Cirulli, F. (2013). Use of assistance and therapy dogs for children with autism spectrum disorders: a critical review of the current evidence. *J Altern Complement Med.*, 19(2), 73–80. https://doi.org/10.1089/acm.2011.0835

Bowlby, J. (1982). Attachment and loss: Retrospect and prospect. *American Journal of Orthopsychiatry*, 52(4), 664–678. https://doi.org/10.1111/j.1939-0025.1982.tb01456.x

Breitenbach, E., Stumpf, E., Fersen, L. V., & Ebert, H. (2009a). Dolphin-Assisted Therapy: Changes in Interaction and Communication between Children with Severe Disabilities and Their Caregivers. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals*, 22(3), 277–289. https://doi.org/10.2752/175303709X457612

Buckley, S. (2002). *Down syndrome across the life span*. M. Cuskelly, & A. Jobling (Eds.). Whurr. Ipv Cuskelly, M. etc

Bussy, G., Charrin, E., Brun, A., Curie, A., & des Portes, V. (2011). Implicit procedural learning in fragile X and Down syndrome. *Journal of Intellectual Disability Research*, 55(5), 521–528. https://doi.org/10.1111/j.1365-2788.2011.01410.x

Chapman, R. S. (1997). Language development in children and adolescents with Down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews, 3*(4), 307–312. https://doi.org/10.1002/(SICI)1098-2779

Cirulli, F., Borgi, M., Berry, A., Francia, N., & Alleva, E. (2011). Animal-assisted interventions as innovative tools for mental health. *Annali Dell'Istituto Superiore Di Sanita*, 47(4), 341–348. https://doi.org/DOI: 10.4415/ANN_11_04_04

Cobb, S. (1976). Social support as a moderator of life stress. *Psychosomatic Medicine*, 38(5), 300–314. https://doi.org/10.1097/00006842-197609000-00003

Conners, F. A., Rosenquist, C. J., Arnett, L., Moore, M. S., & Hume, L. E. (2008). Improving memory span in children with Down syndrome. *Journal of Intellectual Disability Research*, 52(3), 244–255. https://doi.org/10.1111/j.1365-2788.2007.01015.x

Cox, R. F. A., & van Dijk, M. (2013). Microdevelopment in Parent-Child Conversations: From Global Changes to Flexibility. *Ecological Psychology*, 25(3), 304–315. https://doi.org/10.1080/10407413.2013.810095

Cuskelly, M., Jobling, A., & Buckley, S. (2002). *Down syndrome across the life-span.* Whurr.

Dale, R., & Spivey, M. J. (2006). Unraveling the Dyad: Using Recurrence Analysis to Explore Patterns of Syntactic Coordination Between Children and Caregivers in Conversation. *Language Learning*, 56(3), 391–430. https://doi.org/10.1111/j.1467- 9922.2006.00372.x

Dawson, G., Meltzoff, A. N., Osterling, J., Rinaldi, J., & Brown, E. (1998). Children with Autism Fail to Orient to Naturally Occurring Social Stimuli. *Journal of Autism and Developmental Disorders*, 28(6), 479–485. https://doi.org/10.1023/A:1026043926488

de Graag, J. A., Cox, R. F. A., Hasselman, F., Jansen, J., & de Weerth, C. (2012). Functioning within a relationship: Mother–infant synchrony and infant sleep. *Infant Behavior and Development*, 35(2), 252–263. https://doi.org/10.1016/j.infbeh.2011.12.006

De Jonge-Hoekstra, L., Van der Steen, S., Van Geert, P., & Cox, R. F. A. (2016). Asymmetric Dynamic Attunement of Speech and Gestures in the Construction of Children's Understanding. *Frontiers in Psychology*, 7, 473. https://doi.org/10.3389/fpsyg.2016.00473

Dillenburger, K., & Keenan, M. (2009). None of the As in ABA stand for autism: Dispelling the myths. *Journal of Intellectual & Developmental Disability*, 34(2), 193–195. https://doi.org/10.1080/13668250902845244

Enders-Slegers, M. J. (2000). *Een leven lang goed gezelschap,* Universteit Utrecht.

Esposito, L., McCune, S., Griffin, J. A., & Maholmes, V. (2011). Directions in Human- Animal Interaction Research: Child Development, Health, and Therapeutic Interventions. *Child Development Perspectives*, 5(3), 205–211. https://doi.org/10.1111/j.1750-8606.2011.00175.x

Feldman, R., Greenbaum, C. W., & Yirmiya, N. (1999). Mother-infant affect synchrony as an antecedent of the emergence of self-control. *Developmental Psychology*, 35(1), 223–231.

https://doi.org/10.1037/0012-1649.35.1.223
Feldman, Ruth. (2007). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *Journal of Child Psychology and Psychiatry*, 48(3–4), 329–354. https://doi.org/10.1111/j.1469- 7610.2006.01701.x
Feldman, Ruth, Gordon, I., & Zagoory-Sharon, O. (2011). Maternal and paternal plasma, salivary, and urinary oxytocin and parent-infant synchrony: Considering stress and affiliation components of human bonding. *Developmental Science*, 14(4), 752–761. https://doi.org/10.1111/j.1467-7687.2010.01021.x
Finck, K. S. (1993). Finck - 1993 - Children, their pet dogs, and affect attument. pdf, Adelphi University.
Fine, A. H., Tedeschi, P., & Elvove, E. (2015). Forward Thinking: The Evolving Field of Human–Animal Interactions. *Handbook on Animal-Assisted Therapy*, 21–35. https://doi.org/10.1016/B978-0-12-801292-5.00003-1
Fogel, A. (1993). *Developing through relationships: Origins of communication, self, and culture*. University of Chicago Press.
Friedmann, E., Galik, E., Thomas, S. A., Hall, P. S., Chung, S. Y., & McCune, S. (2015). Evaluation of a Pet-Assisted Living Intervention for Improving Functional Status in Assisted Living Residents With Mild to Moderate Cognitive Impairment. *American Journal of Alzheimer's Disease & Other Dementias®*, 30(3), 276–289. https://doi.org/10.1177/1533317514545477
Friedmann, E., Son, H., & Saleem, M. (2015). The Animal–Human Bond: Health and Wellness. *Handbook on Animal-Assisted Therapy*, 73–88. https://doi.org/10.1016/B978- 0-12-801292-5.00007-9
Gillott, A., & Standen, P. J. (2007). Levels of anxiety and sources of stress in adults with autism. *Journal of Intellectual Disabilities*, 11(4), 359–370. https://doi.org/10.1177/1744629507083585
Grandin, T., Fine, A. H., & Bowers, C. M. (2010). The use of therapy animals with individuals with autism spectrum disorders. In *Handbook on Animal-Assisted Therapy* (pp. 247–264). Elsevier. https://doi.org/10.1016/B978-0-12-381453-1.10013-3
Handlin, L., Hydbring-Sandberg, E., Nilsson, A., Ejdebäck, M., Jansson, A., & Uvnäs- Moberg, K. (2011). Short-Term Interaction between Dogs and Their Owners: Effects on Oxytocin, Cortisol, Insulin and Heart Rate—

An Exploratory Study. *Anthrozoos: A Multidisciplinary Journal of The Inter-actions of People & Animals*, 24(3), 301–315. https://doi.org/10.2752/175303711X13045914865385

Harrist, A. W., & Waugh, R. M. (2002). Dyadic synchrony: Its structure and function in children's development. *Developmental Review*, 22(4), 555–592. https://doi.org/10.1016/S0273-2297(02)00500-2

Howlin, P., Magiati, I., & Charman, T. (2009). Systematic Review of Early Intensive Behavioral Interventions for Children With Autism. *American Journal on Intellectual and Developmental Disabilities,* 114(1), 23–41. https://doi.org/10.1352/2009.114:23-41

Inui, N., Yamanishi, M., & Tada, S. (1995). Simple Reaction Times and Timing of Serial Reactions of Adolescents with Mental Retardation, Autism, and down Syndrome. *Perceptual and Motor Skills*, 81(3), 739–745. https://doi.org/10.2466/pms.1995.81.3.739

Jansen, L. M. C., Gispen-de Wied, C. C., van der Gaag, R.-J., & van Engeland, H. (2003). Differentiation between autism and multiple complex developmental disorder in response to psychosocial stress. *Neuropsychopharmacology: Official Publication of the American College of Neuropsychopharmacology,* 28(3), 582–590. https://doi.org/10.1038/sj.npp.1300046

Jansen, L. M. C., Gispen-De Wied, C. C., Wiegant, V. M., Westenberg, H. G. M., Lahuis, B. E., & Van Engeland, H. (2006). Autonomic and neuroendocrine responses to a psychosocial stressor in adults with autistic spectrum disorder. *Journal of Autism and Developmental Disorders*, 36(7), 891–899. https://doi.org/10.1007/s10803-006-0124-z

Julius, H., Beetz, A., Kotrschal, K., Turner, D., & Uvnäs-Moberg, K. (n.d.). Attachment to Pets An Integrative View of Human-Animal Relationships with Implications for Therapeutic Practice.

Kamioka, H., Okada, S., Tsutani, K., Park, H., Okuizumi, H., Handa, S., ... Mutoh, Y. (2014). Effectiveness of animal-assisted therapy: A systematic review of randomized controlled trials, 22(2), 371–390. https://doi.org/10.1016/j.ctim.2013.12.016

Kern, J. K., Fletcher, C. L., Garver, C. R., Mehta, J. A., Grannemann, B. D., Knox, K. R., & Trivedi, M. H. (2011). Prospective trial of equine-assisted activities in autism spectrum disorder. *Alternative Therapies in Health & Medicine, 17*(3).

Kortenhorst, M. S. Q., Hazekamp, M. G., Rammeloo, L. A. J., Schoof, P. H., & Ottenkamp, J. (2005a). [Complete atrioventricular septal defect in children with Down's syndrome: good results of surgical correction at younger and younger ages]. *Nederlands Tijdschrift Voor Geneeskunde*, 149(11), 589–593. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15799643

Kovács, G., & Umbgrove, I. (n.d.). *Psychotherapie in beweging : dieren en natuur bij psychodynamische therapie.* Maklu.

Kozulin, A., Lebeer, J., Madella-Noja, A., Gonzalez, F., Jeffrey, I., Rosenthal, N., & Koslowsky, M. (2010). Cognitive modifiability of children with developmental disabilities: A multicentre study using Feuerstein's Instrumental Enrichment—Basic program. *Research in Developmental Disabilities,* 31(2), 551–559. https://doi.org/10.1016/j.ridd.2009.12.001

Landa, R. (2007). Early communication development and intervention for children with autism. *Mental Retardation and Developmental Disabilities Research Reviews,* 13(1), 16–25. https://doi.org/10.1002/mrdd.20134

Leclère, C., Viaux, S., Avril, M., Achard, C., Chetouani, M., Missonnier, S., & Cohen, D. (2014). Why Synchrony Matters during Mother-Child Interactions: A Systematic Review. *PLoS ONE, 9*(12), e113571. https://doi.org/10.1371/journal.pone.0113571

Levinson, B. (1962). The dog as a "co-therapist." *Mental Hygiene*, 46, 59–65. Retrieved from https://psycnet.apa.org/record/1963-01441-001

Levinson, B. M. (1972). *Pets and human development.* Charles C Thomas. Retrieved from https://psycnet.apa.org/record/1973-10868-000

Limond, J. A., Bradshaw, J. W. S., & Cormack, M. K. F. (1997). Behavior of Children with Learning Disabilities Interacting With a Therapy Dog. *Anthrozoös*, 10(2–3), 84–89. https://doi.org/10.2752/089279397787001139

Luyster, R., Richler, J., Risi, S., Hsu, W.-L., Dawson, G., Bernier, R., ... Lord, C. (2005). Early Regression in Social Communication in Autism Spectrum Disorders: A CPEA Study. *Developmental Neuropsychology, 27*(3), 311–336. https://doi.org/10.1207/s15326942dn2703_2

Mader, B., Hart, L. A., & Bergin, B. (1989). Social Acknowledgments for Children with Disabilities: Effects of Service Dogs. *Child Development*, 1529-1534.

Marwan, N., Carmen Romano, M., Thiel, M., & Kurths, J. (2007). Recurrence plots for the analysis of complex systems. *Physics Reports*, 438(5–6), 237–329. https://doi.org/10.1016/J.PHYSREP.2006.11.001

McNicholas, J., & Collis, G. M. (2000). Dogs as catalysts for social interactions: Robustness of the effect. *British Journal of Psychology*, 91(1), 61–70. https://doi.org/10.1348/000712600161673

Melson, G. F. (2003). Child Development and the Human-Companion Animal Bond. *American Behavioral Scientist,* 47(1), 31–39. https://doi.org/10.1177/0002764203255210

Melson, G. F. (2015). Animals in the Lives of Children. *Handbook on Animal-ssisted Therapy,* 179–194. https://doi.org/10.1016/B978-0-12-801292-5.00013-4

Melson, G. F., Kahn, P. H., Beck, A., Friedman, B., Albert, J., Freier, N., ... Roberts, T. (2009). *Robotic Pets in Human Lives: Implications for the Human-Animal Bond and for Human Relationships with Personified Technologies. Journal of Social Issues* (Vol. 65). Retrieved from http://faculty.washington.edu/pkahn/articles/robotic_pets2.pdf

Mills, D., & Hall, S. (2014). Animal-assisted interventions: Making better use of the human-animal bond. *Veterinary Record*, 174(11). https://doi.org/10.1136/vr.g1929

Mohangoo, A., & Buitendijk, S. (2009). Aangeboren afwijkingen in Nederland 1997-2007 Gebaseerd op de landelijke verloskunde en neonatologie registraties.

Myers, O. G. (2007). *The significance of children and animals: Social development and our connections to other species.* Purdue University Press.

Naess, K.-A. B., Nygaard, E., Ostad, J., Dolva, A.-S., & Halaas Lyster, S.-A. (2017). Disability and Rehabilitation The profile of social functioning in children with Down syndrome. https://doi.org/10.1080/09638288.2016.1194901

Nathanson, D. E. (1998). Long-Term Effectiveness of Dolphin-Assisted Therapy for Children with Severe Disabilities. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals*, 11(1), 22–32. https://doi.org/10.2752/089279398787000896

Nathanson, D. E., de Castro, D., Friend, H., & McMahon, M. (1997b). Effectiveness of Short- Term Dolphin-Assisted Therapy for Children with Severe Disabilities. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals*, 10(2), 90–100. https://doi.org/10.2752/089279397787001166

O'Haire, M. E. (2013). Animal-assisted intervention for autism spectrum disorder: a systematic literature review. *Journal of Autism and Developmental Disorders*, 43(7), 1606–1622. https://doi.org/10.1007/s10803-012-1707-5

O'Haire, M. E. (2017). Research on animal-assisted intervention and autism spectrum disorder, 2012–2015. *Applied Developmental Science*, 21(3), 200–216. https://doi.org/10.1080/10888691.2016.1243988

O'Haire, M. E., McKenzie, S. J., Beck, A. M., & Slaughter, V. (2013). Social behaviors increase in children with autism in the presence of animals compared to toys. *PloS One*, 8(2), e57010. https://doi.org/10.1371/journal.pone.0057010

Parish-Plass, N. (Ed.). (2013). *Animal-assisted psychotherapy: Theory, issues, and practice*. Purdue University Press.

Peters-Scheffer, N., Didden, R., Korzilius, H., & Sturmey, P. (2011). A meta-analytic study on the effectiveness of comprehensive ABA-based early intervention programs for children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 5*(1), 60-69.

Peters-Scheffer, Nienke, Didden, R., Korzilius, H., & Matson, J. (2012). Cost comparison of early intensive behavioral intervention and treatment as usual for children with autism spectrum disorder in the Netherlands. https://doi.org/10.1016/j.ridd.2012.04.006

Pipp-Siegel, S., Siegel, C. H., & Dean, J. (1999). Chapter II. Neurological Aspects of the Disorganized/disoriented Attachment Classification System: Differentiating Quality of the Attachment Relationship from Neurological Impairment. *Monographs of the Society for Research in Child Development*, 64(3), 25–44. https://doi.org/10.1111/1540- 5834.00032

Reddish, P., Fischer, R., Bulbulia, J., Bulbulia, J., & Huici, C. (2013). Let's Dance Together: Synchrony, Shared Intentionality and Cooperation. PLoS ONE, 8(8), e71182. https://doi.org/10.1371/journal.pone.0071182

Roberts, J. E., Price, J., & Malkin, C. (2007). Language and communication development in down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews*, 13(1), 26–35. https://doi.org/10.1002/mrdd.20136

Rochat, M. J., Veroni, V., Bruschweiler-Stern, N., Pieraccini, C., Bonnet-Brilhault, F., Barthélémy, C., ... Rizzolatti, G. (2013). Impaired vitality form recognition in autism. *Neuropsychologia*, 51(10), 1918–1924. https://doi.org/10.1016/j.neuropsychologia.2013.06.002

Rondal, J. A. (2009). *Spoken Language in Persons with Down Syndrome. International Journal of Early Childhood Special Education* (Vol. 138). Retrieved from https://dergipark.org.tr/tr/download/article-file/91562

Rutgers, A. H., Bakermans-Kranenburg, M. J., Ijzendoorn, M. H., & Berckelaer-Onnes, I. A. (2004). Autism and attachment: a meta-analytic review. *Journal of Child Psychology and Psychiatry*, 45(6), 1123–1134. https://doi.org/10.1111/j.1469-7610.2004.t01-1- 00305.x

Schopler, E., Mesibov, G. B., & Hearsey, K. (1995). Structured Teaching in the TEACCH System. In *Learning and Cognition in Autism* (pp. 243–268). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4899-1286-2_13

Serpell, J., McCune, S., Gee, N., & Griffin, J. A. (2017). Current challenges to research on animal-assisted interventions. *Applied Developmental Science*, 21(3), 223–233. https://doi.org/10.1080/10888691.2016.1262775

Sigman, M., Ruskin, E., Arbeile, S., Corona, R., Dissanayake, C., Espinosa, M., ... Zierhut, C. (1999). Continuity and change in the social competence of children with autism, Down syndrome, and developmental delays. *Monographs of the Society for Research in Child Development,* 64(1), 1–114. https://doi.org/10.2307/3181510

Stern. (2018). *The interpersonal world of the infant: A view from psychoanalysis and developmental psychology. The Interpersonal World of the Infant: A View from Psychoanalysis and Developmental Psychology.* https://doi.org/10.4324/9780429482137

Stern, D. (2010a). The issue of vitality. *Nordic Journal of Music Therapy,* 19(2), 88–102. https://doi.org/10.1080/08098131.2010.497634

Steen, van der S. (2018). Theory and research methods in Animal-Assisted Interventions (Key-note). Symposium, One health in AAI: current trends and future collaborations in research and practice. Amsterdam

Tarr, B., Launay, J., Cohen, E., & Dunbar, R. (2015). Synchrony and exertion during dance independently raise pain threshold and encourage social bonding. *Biology Letters*, 11(10). Retrieved from http://rsbl.royalsocietypublishing.org/content/11/10/20150767

The IAHAIO Definitions for Animal Assisted Interventions and Guidelines for Wellness of Animals Involved in AAI. (2014). Retrieved from http://iahaio.org/wp/wp- content/uploads/2019/01/iahaio_wp_updated-2018-19-final.pdf

Thelen, E., & Smith, L. B. (2007). Dynamic Systems Theories. In *Handbook of Child Psychology*. Hoboken, NJ, USA: John Wiley & Sons, Inc. https://doi.org/10.1002/9780470147658.chpsy0106

Varela, F. J., Thompson, E., & Rosch, E. (1993). *The embodied mind : cognitive science and human experience*. MIT Press.

Venuti, P., de Falco, S., Esposito, G., & Bornstein, M. H. (2009). Mother–Child Play: Children With Down Syndrome and Typical Development. *American Journal on Intellectual and Developmental Disabilities*, 114(4), 274–288. https://doi.org/10.1352/1944-7558-114.4:274-288

Verheggen, T., Enders-Slegers, M. J., & Eshuis, J. (2017). Enactive anthrozoology: toward an integrative theoretical model for understanding the therapeutic relationships between humans and animals. *Human-animal interaction bulletin, 5*(2), 13-35.

Virués-Ortega, J. (2010). Applied behavior analytic intervention for autism in early childhood: Meta-analysis, meta-regression and dose–response meta-analysis of multiple outcomes. *Clinical psychology review, 30*(4), 387-399.

Virues-Ortega, J., Julio, F. M., & Pastor-Barriuso, R. (2013). The TEACCH program for children and adults with autism: A meta-analysis of intervention studies. *Clinical psychology review, 33*(8), 940-953.

Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T., & Klin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry*, 45(1), 135–170. https://doi.org/10.1046/j.0021-9630.2003.00317.x

Volkmar, F. R., & Reichow, B. (2013). Autism in DSM-5: progress and challenges. *Molecular Autism*, 4(1), 13. https://doi.org/10.1186/2040-2392-4-13

Weijerman, M. E., & de Winter, J. P. (2010). Clinical practice. The care of children with Down syndrome. *European Journal of Pediatrics*, 169(12), 1445–1452. https://doi.org/10.1007/s00431-010-1253-0

Weijerman, M. E., van Furth, A. M., Vonk Noordegraaf, A., van Wouwe, J. P., Broers, C. J. M., & Gemke, R. J. B. J. (2008). Prevalence, Neonatal Characteristics, and First-Year Mortality of Down Syndrome: A National Study. *The Journal of Pediatrics*, 152(1), 15–19. https://doi.org/10.1016/j.jpeds.2007.09.045

Wijker, C., Leontjevas, R., Spek, A., & Enders-Slegers, M.-J. (2019). Effects of Dog Assisted Therapy for Adults with Autism Spectrum Disorder: An Exploratory Randomized Controlled Trial. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-019-03971-9

Winnicott, D. W. (1986). The theory of the parent-infant relationship. *Essential papers on object relations*, 233-253.

Wishart, J. (2001). Motivation and learning styles in young children with Down syndrome. *Down Syndrome Research and Practice*, 7(2), 47–51. https://doi.org/10.3104/reports.113

Wishart, J. G. (1998). Development in Children With Down Syndrome: facts, findings, the future. *International Journal of Disability, Development and Education*, 45(3), 343–363. https://doi.org/10.1080/1034912980450309

Wood, L., Giles-Corti, B., & Bulsara, M. (2005). The pet connection: Pets as a conduit for social capital? *Social Science & Medicine*, 61, 1159–1173. https://doi.org/10.1016/j.socscimed.2005.01.017

Wood, L., Martin, K., Christian, H., Nathan, A., Lauritsen, C., Houghton, S., ... McCune, S. (2015). The Pet Factor - Companion Animals as a Conduit for Getting to Know People, Friendship Formation and Social Support. *PLOS ONE*, 10(4), e0122085. https://doi.org/10.1371/journal.pone.0122085

Zbilut, J. P., Giuliani, A., & Webber, C. L. (1998). Detecting deterministic signals in exceptionally noisy environments using cross-recurrence quantification. *Physics Letters A*, 246(1–2), 122–128. https://doi.org/10.1016/S0375-9601(98)00457-5

Zilcha-Mano, S., Mikulincer, M., & Shaver, P. R. (2011). Pet in the therapy room: An attachment perspective on Animal-Assisted Therapy. *Attachment & Human Development*, 13(6), 541–561. https://doi.org/10.1080/14616734.2011.608987

Richard E. Griffioen & Marie-Jose Enders-Slegers

THE EFFECT OF DOLPHIN-ASSISTED THERAPY ON THE COGNITIVE AND SOCIAL DEVELOPMENT OF CHILDREN WITH DOWN SYNDROME

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Abstract

Cognitive and speech development are delayed in children with Down syndrome (DS). We investigated the effect of dolphin-assisted therapy (DAT), a form of animal-assisted intervention, on the development of speech/language and social behavior in children with DS.

We hypothesized that DAT would improve the social and cognitive functions with respect to verbalization and thereby promote task performance. A semi-crossover design was used to study 45 children with DS: 18 received a weekly one-hour session of DAT for 6 weeks (group A), 12 children (group B) started with swimming pool sessions (control period of 6 weeks) and thereafter received DAT, and 17 children (group C) were put on a waiting list (control period of 6 weeks) before receiving DAT. The parameters "verbalization", "impulsiveness", "proper understanding of rules", "recognition of persons", and "establishing contacts" were measured using the Matson Evaluation of Social Skills for Individuals with Severe Retardation (MESSIER) before and after DAT, as well as before and after each of the control periods. Repeated measures ANOVA revealed no significant changes for any of the variables during the control periods (swimming pool, waiting list). Following the period of DAT there was a significant improvement in "verbalization" and "recognition of persons," while "impulsiveness" decreased. No significant changes were found for the other parameters. "Verbalization" continued to increase during the follow-up period of 6 months, while "recognition of persons" slightly decreased. The results of this study provide support for our hypothesis. Through improvements in verbalization and the recognition of persons, the execution of tasks among children with DS receiving DAT improved. Additional studies are needed to determine if these positive effects of DAT are long-term.

Keywords

Animal-assisted interventions, dolphin-assisted therapy, Down syndrome

2

THE EFFECT OF DOLPHIN-ASSISTED THERAPY ON THE COGNITIVE AND SOCIAL DEVELOPMENT OF CHILDREN WITH DOWN SYNDROME

Richard E. Griffioen & Marie-Jose Enders-Slegers

Individuals with Down syndrome (DS) suffer from a genetic disorder caused by the presence of an extra 21st chromosome (trisomy 21), resulting in a characteristic physical appearance and generalized learning disabilities. In the Netherlands the prevalence of DS is 15.7 per 10,000 newborn children (Mohangoo and Buitendijk, 2009). The life expectancy of DS individuals in western countries has risen over the past 60 years, mainly due to improved diagnosis and treatment of congenital heart disease, which is frequently present in children with DS (Kortenhorst et al., 2005; Weijerman, 2011). Most individuals with DS suffer from mental retardation in the mild (50–70) to moderate (35–50) IQ range. Impairment of cognitive ability and difficulty with speech and language skills is present in most children and adults with DS (Rondal, 2009). Language delays follow a characteristic profile, particularly in language production and syntax (combination of words into sentences). The other three domains of delayed language development are phonology (formation of speech sounds), semantics (meaning of words and knowledge of vocabulary and concepts about objects and events), and pragmatics (use of language in social contents for the purpose of communication) (Roberts, 2007).

Little research has focused on the effectiveness of intervention strategies for improving communication skills among individuals with DS. The deficits in pre-linguistic communication (such as a slow transition from babbling to speech, decreased muscle tone of the speech muscles, etc) emphasize the need for early intervention, while the continued growth of language during school age and adolescent years highlight the need for language intervention (Wishart, 1998, 2002). The "natural" learning style

of children with DS is characterized by an increasing use of avoidance strategies when faced with learning new skills and a growing reluctance to take the initiative in learning contexts (Wishart, 2002). One longitudinal study (Sigman and Ruskin, 1999) showed improvement in early communication and play skills might have long-term consequences for later language and social competence. Speech experts, some of whom specialize in training DS children, implement interventions known to improve the development of speech and language.

A specific therapy to stimulate cognitive and speech development of children with DS is given by physiotherapists and speech therapists to provide some cognitive, pre-verbal, and sensomotoric training at a very early age (< 3 yr), the so-called early intervention or Macquarie program (Buckley, 2000). Another method used to improve cognitive development of children with DS is dolphin-assisted therapy (DAT), a form of animal-assisted intervention. Recent research suggests animal-assisted interventions support the treatment of people with disabilities (Odendaal, 2000; Connor and Miller, 2000; Heimlich, 2001; Melson, 2003). According to the definitions of the International Society for Animal-Assisted Therapy (www.aat.isaat.org), such interventions can be divided into three categories: 1) Animal- assisted activities, most often conducted on a volunteer basis by people and animals who have received at least introductory training and preparation for visitation; 2) Animal-assisted pedagogy, which can be conducted by a regular school teacher or a specially trained remedial teacher, and 3) Animal-assisted therapy (AAT), which is a goal- oriented intervention given by a therapist, to improve a patient's cognitive or physical functioning. Unfortunately the evidence supporting the effectiveness of the various types of AAT has not been established by the results of controlled studies. Nimer & Lundahl (2007) published a meta-analysis on AAT in which they reviewed 250 studies, 49 of which met the inclusion criteria and could be submitted to meta-analytic procedures. AAT showed promising results as an additive to established interventions. Also the question remains how AAT may be used in specific practice settings.

During the last decade several studies point to a role for dolphins in the treatment of cognitive and social disturbances in children with special needs. DAT uses the interaction with dolphins to assist professional therapists in enhancing the cognitive and social capabilities of children with mental disabilities. The rationale behind this

form of therapy is that the attention of a child to the questions of the professionally trained therapist (speech therapist, child physiotherapist, or child psychologist with special training in DAT) will increase as a result of the desire to interact with dolphins. DAT is used to reward correct cognitive, physical, and affective behavior of the child as well as to motivate such behavior (Naert, van de Velde and Servais, 1996). The concentration of the child is enhanced and when good behavior is rewarded the child becomes motivated to repeat such behavior. According to principles of learning theory, an activity that is pleasurable will be self-reinforcing, and will more likely occur in the future (Fine, 2010). Through operant conditioning, an association is made between a behavior and the consequence of that behavior. Due to the structure of the sessions and the positive reward, the child develops more and more self-confidence. Several theories support the rationale behind DAT. The attention deficit hypothesis suggests the relative inability of people with a cognitive impairment to learn is primarily a function of a deficit in physiological attention to the relevant dimensions of stimuli, rather than an inability to process information (Nathanson & deFaria, 1993; Nathanson et al., 1997; Nathanson, 1998). In accordance with this hypothesis, learning may occur in those with cognitive impairment by long-term exposure to the relevant cues/stimuli, which in turn elicit behavior indicating that learning has taken place.

Another theoretical concept applied in several therapeutic settings such as equine therapy is the "transmission-triangle" (carry-over, transfer), described by Malan (de Wolff & van IJzendoorn 1998; Malan 1999; Kovacs and Umbgrove 2005). According to this theory, the interaction of child, animal (dolphin), and therapist creates a triangular communication (child–animal–therapist) to elicit the correct response on the invitation of the therapist. Studies dealing with dolphin–child interaction are relatively few. Results of two non- comparative studies (van Kraalingen, 1996; Nathanson, 1998) show a positive effect on the well-being of children and adults. Preservation or improvement of skills, acquired during therapy, occurred in 50% of participants, which persisted for 12 months (Kraalingen, 1996). In one comparative study (Nathanson et al., 1997), positive results of DAT were found more quickly and were more cost-effective than those of conventional therapy.

Breitenbach et al. (2009) conducted a study with four groups: an experimental group which participated in three modules of therapy (recreational/vacation atmosphere, counseling and interaction with the dolphins); a non-treatment

group, designed to control; an outpatient therapy group (dolphin- assisted therapy); and a farm-animal group. Parents of both DAT groups (experimental and outpatient) reported stable and important functional therapy effects in verbal speech and non- verbal reactivity. Furthermore, parents of children of the experimental group observed positive effects in social-emotional competence and self-confidence of their children.

The main goals of DAT are to achieve a higher level of motivation for executing tasks by improving the concentration span of children with DS and improving speech by a language- training program. In the current study we hypothesized that DAT would improve the social and cognitive functioning, such as verbalization and the execution of tasks, in children with DS, and as a result would improve their self-esteem. To test this hypothesis, we performed a prospective study of 45 children with DS to find out if DAT within a relatively short period induces changes in cognitive functioning, as shown by the development of speech/language (communication) and specifically in the capability to increase attention and motivation as shown by the execution of tasks.

2.1 METHODS

2.1.1 Participants

Between April 2004 and September 2007 45 children diagnosed with DS were recruited through the website of the SAM Foundation, (www.stichtingsam.nl), which facilitates DAT in the Netherlands. Children aged 6 to 10 years with an IQ > 40 participated in the study. Children visiting a regular primary school or classes for children with special needs were eligible to be included in the study. Excluded were children with anxiety for water and/or animals, children suffering from epileptic disorders or heart failure, and children with severe problems of hearing or vision. The diagnosis was confirmed by a pediatrician (in some children following genetic testing). Four children included in this study were using medication (levothyroxine for thyroid dysfunction). At baseline, 45 children (Table 1) were eligible for participation in the study. All children attended DAT for the first time. Prior to the start of the study, parents of children with DS signed an informed consent form and provided a medical certificate from the treating therapist or general practitioner, stating that there were no reasons why the child would not be able to participate in the study. In addition, an intake examination was performed during which a questionnaire was completed, medical information (e.g., motor development, vision, and hearing quality) was obtained, and data about specific social goals to be achieved were collected (i.e., speech and language vs. execution of tasks).

Table 1. Demographic characteristics of the 45 children in the study.

	Group A DAT only (n=18)	**Group B** Control treatment (swimming pool) and DAT (n=10)	**Group C** Control treatment (waiting list) and DAT (n=17)
Males/females	08-okt	05-mei	13-apr
Mean age (and range)	8.4 (7-11)	8.1 (6-11)	7.8 (6-11)
Primary school	8	4	7
Special education	9	6	7
Other	1		3
Limited hearing	2	1	3
Wearing glasses	9	1	2
Use of drugs (levothyroxine)	2	1	1

Group A = Dolphin-assisted therapy (DAT) only; Group B = Control treatment (swimming pool) and DAT; Group C = Control treatment (waiting list) and DAT.

2.1.2 Study Design

Our semi-crossover study (Schwartz, 2001) started with 18 children with DS, who received a weekly one-hour session of DAT for a period of 6 weeks. Before and immediately after this period, the parameters "verbalization," "impulsiveness," "proper understanding of rules," "recognition of persons," and "establishing contacts" were evaluated using the Matson Evaluation of Social Skills for Individuals with Severe Retardation (MESSIER) questionnaire (Matson, Carlisle & Bamburg, 1998; Matson, LeBlanc & Weinheimer, 1999; LeBlanc et al., 1999; Paclawsky et al., 1999). Additionally, the measurements of these variables were studied during two control periods: a second group of newly presented children with DS participated in a 6-week course of weekly one-hour sessions in a swimming pool (no dolphins) (group B); a third group consisted of children with DS who were put on a waiting list for DAT (group C) and were solely observed for 6 weeks. Before (T1) and at the end (T2) of the control period children in groups B and C were evaluated in the same way as group A. The intervention (a 6-week course of DAT as in group A) in groups B and C started after a 3–4-week interval. The MESSIER was completed at the start (T3) and at the end (T4) of DAT. All three groups were also tested at 4–6 months after the end of the intervention (T5). The DAT protocol was the same for all three groups of children.

The children were not randomly assigned to the groups. The control group (swimming pool) was asked to cooperate voluntary; the waiting list group was used as a second control. An overview of the three groups and the different time intervals of testing are shown in Table 2.

Table 2 Number of participants in the various groups at various intervals

		T1 Start of control period	T2 End of control period	T3 Before DAT	T4 After DAT	T5 Follow-up
Group A	Only DAT	--	--	18	18	12**
Group B	Control (swimming pool) and DAT	10	10	10	10	7**
Group C	Control (waiting list) and DAT	17	17	15*	16	13**
	Total	27	27	43*	44	32**

T1 = Start of control period; T2 = End of control period; T3 = Before DAT; T4 = After DAT; T5 = Follow-up.

* total of 43 instead of 44 at T3 as one questionnaire was not returned.

**At T5 several questionnaires have not been returned

2.1.3 Procedure of Dolphin-Assisted Therapy (DAT)

The DAT interventions took place at the Dolphinarium Harderwijk (The Netherlands), an open water lagoon resembling a natural dolphin habitat, containing 17 bottlenose dolphins (6 males and 11 females). To monitor the wellbeing of the dolphins during the study, behavior was investigated prior to the study at rest, during training sessions, and during the pilot therapy session. The respiratory frequency of the animals was recorded as a parameter of excitement, increased activity, or stress. During training and therapy sessions, as well as afterwards during the resting period, the animals showed the same behavior as on the days without sessions (Boneh & van Leeuwen, 2003).

It should be emphasized that the children did not swim with the dolphins during the sessions. There are very strict rules at the Dolphinarium; the lagoon is the habitat of the dolphins and by no means people are allowed to enter the water. The children and the therapists were sitting or standing on a platform at the waterside. Each session took about one hour to execute the protocol. During the first part (20 minutes) at the underwater observatory (in front of a glass wall) the children could familiarize themselves in a structured way (i.e., following a program of saying hello and playing ball with the dolphins). The second part (max. 20 minutes) was carried out on a platform at the waterside of the lagoon. A behavioral approach, as described before, was used to teach the children to perform a task (e.g., to signal that a dolphin should jump and/or exercise speech/language tasks). In the third part (max. 20 minutes) free and spontaneous interactions between the children and the dolphins were allowed in close proximity of the trainer. During the second part (platform) of the session standard materials, such as a ball and whistle, were used as adjunct to physical therapy and speech-language therapy. In addition, emotion pictures (pictos) were shown on 40 cm square boards and explained to the children. These were used to help the children express their emotions.

The team, which carried out DAT, consisted of a professional therapist (child psychologist, child physiotherapist, specialized speech therapist, or a remedial educationalist) who was trained to carry out this specific program, a dolphin trainer, and a trained observer who scored the behavior of the child during the sessions. Every session was evaluated with the parents and afterwards with all therapists who were involved in a session.

2.1.4 Controls (Interventions without Animals)

Children in control group B wore a wetsuit (as in group A) and were accompanied by a therapist of the SAM Foundation. A (dolphin) trainer was responsible for assisting the child when playing with a radio-controlled ship (instead of a dolphin). A third person was responsible for scoring the behavior of the children (observational report). Like the DAT group, every session was evaluated with the parents and afterwards with all therapists who were involved in a session. The therapy started at the side of the swimming pool, with the same water temperature as during the DAT sessions, where the children were asked to perform certain tasks. All sessions lasted 20 minutes, and were once a week for a period of 6 weeks (like the DAT sessions at the Dolphinarium). During the sessions the children were asked to perform different tasks such as to point out the right picto according to their emotional state, to name the object on the picto shown, and to make eye contact when asking a question. Other activities were steering the radio-controlled ship to the other side of the pool and playing with a ball. Positive behavior was rewarded with permission to play with the radio-controlled boat.

2.1.5 Questionnaire

Both conditions, the intervention and the control periods, were evaluated using the MESSIER. The MESSIER has demonstrated good reliability, as internal consistency is high for the entire scale and for each clinically derived subscale ($r = 0.76$ to 0.96). Test-retest and interrater reliability are adequate as well ($r = 0.86$, $r = 0.79$, respectively). Changes in social skills were compared prior to and after intervention, as well as prior to and after the control period.

The MESSIER consists of five parts measuring the parameters "impulsiveness," "verbalization," "proper understanding of rules," "establishing contacts," and "recognition of persons." For each part a scoring scale was developed allowing calculation of the total score for that part (the sum of the answers to the various questions: in total 82). The scale was identical for all five parts and all answers were weighted identically. The questions were grouped according to the grouping used in the Dutch language version (Vermeulen, 2001). Cronbach's alpha of the five parameters ranges from 0.79 to 0.89. (Vermeulen, 2001). Examples of items on

the MESSIER are: expresses verbally his/her needs, saying hello, clarifies by using words or sounds (verbalization), executes simple instructions, reacts upon being addressed (proper understanding), takes initiatives (impulsiveness), distinguishes different people, calls acquaintances by name (recognition), is interested in other people, reacts adequately when getting acquainted by shaking hands, and/or introducing him/herself (contact).

The score obtained on the MESSIER could be positive or negative, depending on the good or bad behavior of the child. To compare the outcome of the intervention and control period, the mean total scores of the various parameters of the questionnaire at different times were calculated. The MESSIER was completed at one week before and one week after the control or intervention period. Group A filled out two questionnaires, one prior to (T3) and one after the DAT period (T4). Groups B and C filled out four questionnaires, at the start of the control period (T1), at the end of the control period (T2), at the start of the DAT period (T3) and at the end of the DAT period (T4). In addition, all three groups completed the questionnaire at 4–6 months after DAT (T5). The parents completed the ratings and the analysis of these data was reliable.

2.1.6 Statistical Analysis

Statistical analyses were performed using SPSS 11.0 (Chicago, IL, USA). Baseline characteristics were compared using a t-test. A three-way repeated measures ANOVA with factors Group (2 levels: group B and group C), Time (3 levels: T1, T2, T3), and MESSIER score (5 levels: verbalization, impulsiveness, establishing contacts, proper understanding of rules, recognition of persons) was performed to determine if the behavior of the children changed while waiting for DAT, and to compare the behavior of the children in the swimming-pool group and the children on the waiting list before DAT. The assumption of sphericity for all models was checked with the Mauchly's sphericity test. We applied the Greenhouse-Geisser correction if the assumption of sphericity was violated. As for all other tests, we used $p < 0.05$ as the level of significance. To control for the possibility of biased test results, the model residuals were inspected (e.g., distribution, outliers), but no biased test results were found.

2.2 RESULTS

2.2.1 Control Period

Table 3 shows the mean values of the five parameters of the MESSIER for group B during the control period (swimming pool) and group C during the waiting list period prior to DAT treatment (T1, T2). For "verbalization" the results were similar over time in groups B and C. The results for "recognition of persons" showed larger values for group B than for group C, but there were no changes over time in both groups. This was confirmed by a repeated measures ANOVA (verbalization: $F(2, 46) = 0.11$, $p = 0.89$; impulsiveness: $F(2,46) = 0.27$, $p = 0.76$; establishing contacts: $F(2,46) = 1.01$, $p = 0.37$; proper understanding of rules: $F(2, 46) = 1.36$, $p = 0.27$; and recognition of persons: $F(2, 46) = 1.61$, $p = 0.21$). We did not detect an interaction between time (T1, T2, T3) and groups (B, C) for any of the factors. There were no differences between the individual scores of the children in the waiting-list group and the swimming-pool group.

Table 3 Mean values (SD) of the social and cognitive parameters measured (MESSIER) in groups A, B and C over time (T1-T5).

Measure	Group	T1	T2	T3	T4	T5
Verbalization	A			1.51 (0.51)	1.54 (0.41)	1.68 (0.26)
	B	1.22 (0.50)	1.22 (0.49)	1.27 (0.58)	1.37 (0.51)	1.36 (0.50)
	C	1.32 (0.40)	1.34 (0.38)	1.30 (0.37)	1.45 (0.38)	1.55 (0.35)
Impulsiveness	A			0.83 (0.33)	0.70 (0.38)	0.80 (0.37)
	B	0.73 (0.48)	0.77 (0.55)	0.71 (0.48)	0.60 (0.47)	0.63 (0.40)
	C	0.85 (0.37)	0.83 (0.34)	0.87 (0.43)	0.70 (0.30)	0.65 (0.37)
Contact	A			1.23 (0.40)	1.13 (0.33)	1.28 (0.41)
	B	1.10 (0.29)	1.24 (0.18)	1.09 (0.27)	1.10 (0.21)	1.16 (0.17)
	C	1.08 (0.49)	1.05 (0.26)	1.10 (0.25)	1.04 (0.24)	1.02 (0.18)
Understanding of rules	A			2.48 (0.35)	2.44 (0.34)	2.43 (0.43)
	B	2.16 (0.63)	2.18 (0.60)	2.37 (0.44)	2.49 (0.35)	2.51 (0.30)
	C	2.15 (0.49)	2.22 (0.33)	2.13 (0.49)	2.32 (0.37)	2.30 (0.40)
Recognition	A			2.63 (0.38)	2.72 (0.22)	2.63 (0.31)
	B	2.67 (0.33)	2.72 (0.25)	2.60 (0.38)	2.71 (0.26)	2.65 (0.27)
	C	2.40 (0.40)	2.39 (0.29)	2.36 (0.34)	2.58 (0.33)	2.62 (0.40)

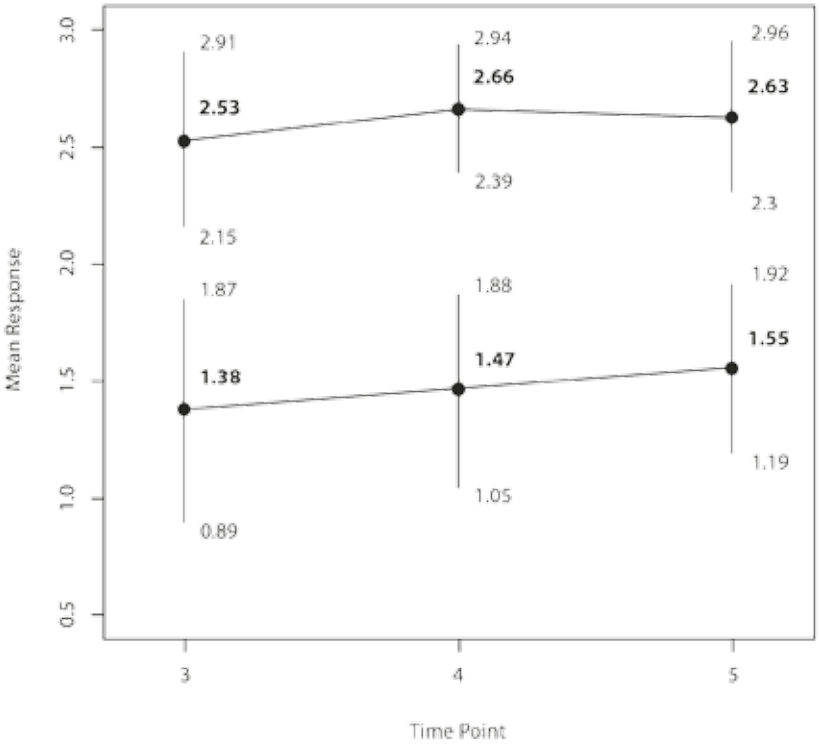
MESSIER = Matson Evaluation of Social Skills for Individuals with Severe Retardation. Group A = Dolphin-assisted therapy (DAT) only; Group B = Control treatment (swimming pool) and DAT; Group C = Control treatment (waiting list) and DAT.
T1 = Start of control period; T2 = End of control period; T3 = Before DAT; T4 = After DAT; T5 = Follow-up.

2.2.2 Intervention Period (T3–T4–T5)

The scores for "recognition of persons" increased for all three groups between T3 and T4, and slightly decreased or were similar at T4 and T5. Regarding "verbalization," the scores for group A decreased slightly, whereas the scores for groups B and C increased over time. To test for sphericity, we applied Mauchly's test and found a violation for "recognition of persons," so we applied the Greenhouse-Geisser correction for that factor. For "verbalization" we did find an interaction between time and group ($F(4, 58) = 3.38$, $p = 0.02$), which may be explained by a combined effect of time and group. The ANOVA showed significant results for "verbalization" ($F(2, 58) = 5.19$, $p = 0.01$) and "recognition of persons" ($F(1.56, 45.19) = 4.02$, $p = 0.03$). For "establishing contacts" ($F(2, 58) = 0.68$, $p = 0.51$) and "proper understanding of rules" ($F(2, 58) = 1.69$, $p = 0.19$), we could not detect significance. "Impulsiveness" decreased over time ($F(2, 58) = 2.09$, $p = 0.13$), but not significantly.

We also applied repeated measures ANOVA for "verbalization" ($F(1.68, 52.02) = 3.78$; $p = 0.04$) and "recognition of persons" ($F(1.51, 46{,}85) = 4.43$; $p = 0.03$) after the three groups that received DAT were combined (Figure 1). Both showed improvement over time (T3–T4), but for "recognition of persons" no improvement was found during the follow-up period (T4–T5). Improvement in "verbalization" also occurred at T4–T5.

Figure 1. Mean responses (bars represent SD) over time (T3-T5) for recognition (top line) and verbalization (bottom line) for the children (T3, n=43, T4, n=44, T5, n=32) which received DAT.



2.3 DISCUSSION

In this semi-crossover study of children with DS, the effect of DAT on variables of cognitive development (verbalization, establishing contacts, impulsiveness, recognition of persons, and proper understanding of rules) were monitored using the MESSIER (Matson, LeBlanc and Weinheimer 1999). Results indicated "verbalization" and "recognition of persons" improved significantly during the 6-week DAT course. During follow-up studies (4–6 months) the improvement in "verbalization," but not of "recognition of persons," remained. No significant changes during and after DAT were found for "establishing contacts" and "proper understanding of rules."

The follow-up period in our study was limited to 4 to 6 months after DAT. It is possible that improvement in "verbalization" and "recognition of persons" require more time to show if, and to what extent, these changes become sustainable.

Previous studies (Nathanson et al. 1997; Nathanson 1998; Kohn 2003; Breitenbach et al. 2009) have demonstrated a positive effect of DAT on verbalization, self-esteem, personal confidence, and communication in children with a variety of disabilities such as autism and DS. Marino and Lilienfeld (1998, 2007), who analyzed the validity of five peer-reviewed DAT studies, concluded that all showed methodological shortcomings such as no experimental control and no controlled novelty effects. To minimize construct confounding, we exposed the control group (swimming pool) and the DAT intervention group to highly similar procedures, as advised by Marino (2012). To deal with novelty aspects, we used a radio-controlled boat, instead of a dolphin, in the control group (alternative intervention).

We included a second control group, which is absent in the studies of Nathanson. The waiting list control (no treatment group) was used to record how children react without any intervention and to exclude that the effect of the dolphin could possibly be due to being exposed to water. It should be emphasized that the conditions for the control and treatment groups were almost the same, although the location of the intervention was different. The conditions during the control protocol, such as wearing a wet suit, the water temperature, the (dolphin) trainer, and the therapist were all the same as during the DAT intervention period.

Our study is unique because, in contrast to earlier studies, we included two control periods and our study was restricted to children with DS. Using the results of these control periods (i.e., a swimming pool course and monitoring while on the waiting list for an equal period as DAT), we demonstrated that the parameters for the tested cognitive functions did not significantly change during the 6-week control period and allowed a direct comparison with the data from the intervention period.

How can the effects of DAT in children with DS be explained? When the theoretical "transmission triangle" concept described by Malan (Malan, 1999; de Wolff & van IJzendoorn, 1998) is applied to our study, the interaction of child, a dolphin, and therapist creates a triangle in which the communication of and toward the child is redirected via the animal, which motivates the child to give the right response upon the invitation of the therapist.

Besides the dolphin, both the dolphin trainer and the therapist each have an important role in the transmission of information. The therapist provides safety and dedication and teaches the child how to act toward the dolphin, while the dolphin trainer has the knowledge and experience required to interact with and control the dolphins. He or she knows, through observation, the temperament and actual mood of the dolphin which is used for DAT. This allows the child to completely fix his/her mind on the questions of the therapist and the execution of the tasks. It should be emphasized that the explanation for the improved learning is not restricted to the interaction of the child with the dolphin, but it is the total of factors which determines the context of learning (Servais, 1999).

Our hypothesis was that DAT would improve the social and cognitive functioning, such as verbalization and the execution of tasks, in children with DS and would improve their self-esteem. The improvement in verbalization found in our study means the child will be able to speak in a better way. The improved recognition of people will help the child in the interaction with other individuals and as such will lead to better social interaction and contact.

Future studies are necessary to determine the optimal duration of the intervention period and the frequency of the sessions. The intervention period in this study lasted 6 weeks, with a frequency of one session per week. It would be interesting to know

if the effect of DAT is larger when the duration and frequency of the intervention is increased. A longer period of training/learning of the children with special needs may lead to more powerful results, and according to learning theory, the positive effect may be greater when the frequency of interventions is increased. It may also be of interest to use another animal instead of a radio-controlled boat in the control group (Marino, 2012), and to compare the results of DAT with those of other successful programs, such as the Macquarie (Buckley, 2000).

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REFERENCES

Boneh, L. and van Leeuwen, J. 2003. Dolphin-assisted therapy: The dolphins perspective. Masters thesis, University of Amsterdam, The Netherlands.

Breitenbach, E., Stumpf, E., Fersen v. L. and Ebert, H. 2009. Dolphin-assisted therapy: Changes in interaction and communication between children with severe disabilities and their caregivers. *Anthrozoös* 22(3): 277–289.

Buckley, 2000. Speech, language and communication for individuals with Down syndrome—An overview. Down syndrome issues and information. www.down-syndrome.org.

Connor, K. and Miller, J. 2000. Animal-assisted therapy: An in-depth look. *Dimensions of Critical Care Nursing* 19(3): 20–26.

Fine, A. H. 2010. *Handbook on Animal-Assisted Therapy: Theoretical Foundations and Guidelines for Practice.* 3th edn. London: Elsevier.

Heimlich, K. 2001. Animal-assisted therapy and the severely disabled child: A quantitative study. *Journal of Rehabilitation* 67(4): 48–54.

Kohn, N. 2003. Delphin Therapie, Untersuchungen zur therapeutischen Wirksamkeit. Dissertation Maximillian Universitat Munchen, Germany.

Kortenhorst, M. S., Hazekamp, M. G., Rammeloo, L. O., Schoof, P. H. and Ottenkamp, J. 2005. Compleet atrioventriculair septumdefect bij kinderen met het syndroom van Down: goede resultaten van chirurgische correctie op steeds jongere leeftijd. *Nederlands Tijdschrift Geneeskunde* 149: 589–593.

Kovacs, G. and Umbgrove, I. 2005. Het inzetten van het paard als metafoor en overdrachtsfenomeen in de psychotherapie, een paardenmiddel? *Kinder en-Jeugdpsychologie* 32(4): 47–66.

van Kraalingen, J. 1996. The effect of the interaction with wild dolphins on human psychological well-being. Masters thesis, University of Utrecht, The Netherlands.

LeBlanc, L. A., Matson, J. L., Cherry, K. E. and Bamburg, J. W. 1999. An examination of the convergent validity of the Matson Evaluation of Social Skills for Individuals withSevere Retardation (MESSIER) with sociometric ranking. *British Journal of Developmental Disabilities* 45(89): 85–91.

Malan, D. 1999. *Individual Psychotherapy and the Science of Psychodynamics.* 2nd edn. London: Butterworth-Heinemann.

Marino, L. 2012. Construct validity of animal-assisted therapy and activities: How important is the animal in AAT? *Anthrozoös* 25 (Suppl.): s139–s151.

Marino, L. and Lilienfeld, S. O. 1998. Dolphin-assisted therapy: Flawed data, flawed conclusions. *Anthrozoös* 11: 194–200.

Marino, L. and Lilienfeld, S. O. 2007. Dolphin-assisted therapy: More flawed data and more flawed conclusions. *Anthrozoös* 20(3): 229–249.

Matson J. L., Carlisle C. B. and Bamburg J. W. 1998. The convergent validity of the Matson Evaluation of Social Skills for Individuals with Severe Retardation (MESSIER). *Resaerch in Developmental Disabilites* 19(6): 493–500.

Matson, J. L., LeBlanc, L. A. and Weinheimer, B. 1999. Reliability of the Matson Evaluation of Social Skills in Individuals with Severe Retardation (MESSIER). *Behavior Modification* 23 (4): 647–661.

Melson, G. F. 2003. Child development and the human–animal bond. *American Behaviora l Scientist* 47(1): 31–39.

Mohangoo, A. D. and Buitendijk, S. E. 2009. Aangeboren afwijkingen in Nederland 1997–2007. Gebaseerd op de landelijke verloskundige en neonatologie registraties. TNO 2009; jaargang 34(4). Leiden. The Netherlands.

Naert, A., van de Velde, A. and Servais, V. 1996. Een onderzoek naar de invloed van dolfijnen op het leergedrag en op het sociaal-communicatief gedrag van kinderen met autisme. Het Auti-dolfijn project research report. Ter Dreve, Brugge and University of Luik, Belgium.

Nathanson, D. 1998. Long-term effectiveness of dolphin-assisted therapy for children with severe disablilities. *Anthrozoös* 11(1): 22–32.

Nathanson, D. 2007. Reinforcement effectiveness of animatronic and real dolphins. *Anthrozoös* 20(2): 181–194.

Nathanson, D., de Castro, D., Friend, H. and McMahon, M. 1997. The effectiveness of shortterm dolphin-assisted therapy for children with severe disabilities. *Anthrozoös* 10(2/3): 90–100.

Nathanson, D. and de Faria, S. 1993. Cognitive improvement of children in water with and without dolphins. *Anthrozoös* 6(1): 17–29.

Nimmer, J. and Lundahl, B. 2007. Animal-assisted therapy: A meta-analysis. *Anthrozoös* 20(3): 225–238.

Odendaal, J. S. J. 2000. Animal-assisted therapy—magic or medicine? *Journal of Psychosomatic Research* 49: 275–280.

Paclawskyj, T. R., Rush, K. S., Matson, J. L. and Cherry, K. E. 1999.

Factor structure of the Matson Evaluation of Social Skills for Individuals with Severe Retardation (MESSIER). *British Journal of Clinical Psychology* 38(3): 289–293.

Roberts, J. E. 2007. Language and communication development in Down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews* 13: 26–35.

Rondal, J. A. 2009. Spoken language in persons with Down syndrome, a life-span perspective. *International Journal of Early Childhood Special Education* 1(2): 138–163.

Schwartz, C. E. 2001. Design issues for clinical research in health psychology. *In Health Psychology,* 137–151, ed. D. W. Johnston and J. Johnston. Amsterdam, The Netherlands: Elsevier.

Servais, V. 1999. Some comments on the context embodiment in zootherapy: The case of the autidolfijn project. *Anthrozoös* 12(1): 5–15.

Sigman M. and Ruskin E. 1999. Continuity and change in the social competence of children with autism, Down syndrome, and developmental delays. *Monographs of the Society for Research in Child Development* 256(1): 64–72.

Vermeulen, J. 2001. Het meten van sociale vaardigheden bij mensen met een ernstige of diepe verstandelijke handicap. Masters thesis, University of Leiden. The Netherlands.

Weijerman, M. 2011. Consequences of Down syndrome for patient and family. Dissertation. Free University, Amsterdam, The Netherlands.

Wishart, J. G. 1998. Early learning in children with Down syndrome: Developmental strengths, developmental weaknesses. *In Proceedings of the First Biennial Scientific Conference on Down Syndrome*, 83–96, ed. N. Virji-Babul and D. Kisly. Vancouver, Canada: Down Syndrome Research Foundation/Simon Fraser University.

Wishart, J. G. 2002. Motivation and learning styles in young children with Down syndrome. *Down Syndrome Research and Practice* 7(2): 47–51.

de Wolff, M. S. and van IJzendoorn, M. H. 1998. Sensitiviteit en gehechtheid: een meta-analyse van antecedente factoren bij ouders die bepalend zijn voor de gehechtheid van het kind. *Nederlands Tijdschrift voor Opvoeding, Vorming en Onderwijs* 14: 1–34.

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VERBAL INTERACTIONAL SYNCHRONIZATION BETWEEN THERAPIST AND CHILDREN WITH AUTISM SPECTRUM DISORDER DURING DOLPHIN ASSISTED THERAPY: FIVE CASE STUDIES

Animals 2019, 9, 716

Simple Summary

This study investigates synchrony in conversations (i.e., turn-taking) between a therapist and five children with Autism Spectrum Disorder during dolphin-assisted therapy. Videos of the first and last dolphin-assisted therapy sessions were analyzed with regard to turn-taking between therapist and child in the presence of a dolphin. The results show that adequate turn-taking seemed to increase over time, but mainly for children who had reasonable verbal communication skills at the start of the therapy sessions.

Abstract

Synchronizing behaviors in interactions, such as during turn-taking, are often impaired in children with Autism Spectrum Disorder. Therapies that focus on turn-taking generally lead to increased social skills, less interruptions and silent pauses, however a positive non-demanding environment is therefore thought to be beneficial. Such an environment can be achieved by incorporating animals into therapy. Our study was guided by the following research questions: 1) How can we characterize the interaction between child and therapist during dolphin-assisted therapy, with regard to synchrony in verbalizations (turn-taking), and 2) does synchrony change over the course of six sessions of therapy? To answer these questions, we performed a cross-recurrence quantification analysis on behavioral data of five children, to give a detailed view of the interaction between therapist and child in the context of dolphin-assisted therapy. We were able to detect synchrony (i.e., adequate turn-taking) in all dyads, although not all children improved equally. The differences might be explained by a delayed reaction time of some children, and their level of language development.

Keywords

animal assisted interventions; autism spectrum disorder; dolphin assisted therapy; verbal synchrony; turn-taking behavior.

3

VERBAL INTERACTIONAL SYNCHRONIZATION BETWEEN THERAPIST AND CHILDREN WITH AUTISM SPECTRUM DISORDER DURING DOLPHIN ASSISTED THERAPY: FIVE CASE STUDIES

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Children diagnosed with Autism Spectrum Disorder (ASD) have limitations with regard to their functional and effective communication and are impaired in initiating and sustaining reciprocal social interactions (American Psychiatric Association, 2013). While there is large variation in the language and communication skills of children with ASD, there is often a limitation in the ability to adapt their language to the interaction partner, the social context and the situation (Mody & Belliveau, 2013; Sterling, 2018; Volden, Coolican, Garon, White, & Bryson, 2009). Deficits in social skills, such as play and imitation are also highly prevalent in children with ASD (Landa, 2007; Rutgers, Bakermans-Kranenburg, Ijzendoorn, & Berckelaer-Onnes, 2004). Furthermore, the social and communication problems these children experience are often not compensated for by the use of gestures or eye contact (Landa, 2007; Watt, Wetherby, & Shumway, 2006).

An important part of social interactions is synchrony, a rhythmic pattern of behavior that is mutually regulated, reciprocal, and harmonious (Feldman, 2007; Harrist & Waugh, 2002; Lindsey, Cremeens, Colwell, & Caldera, 2009; Trevarthen, 1979). Synchrony emerges between two interaction partners (Bernieri & Rosenthal, 1991; Fogel, 1993; Stern, 2010), and is expressed as a temporal match between their behaviors (Feldman, 2007; Leclère et al., 2014). Synchrony, in terms of speed, rhythm and amplitude of verbalizations and movements can increase the social

attunement between interaction partners, and can lead to a higher quality of social interactions (Reuzel et al., 2013; Stern, 2010). In this way, synchrony in interactions facilitates the development of social emotional skills (Feldman, 2007; Forster & Iacono, 2014; Harrist & Waugh, 2002; Jaffe et al., 2001; Marsh, Richardson, & Schmidt, 2009). Recent studies suggest that there is less synchronization in interactions of children with ASD (Fitzpatrick, Diorio, Richardson, & Schmidt, 2013; Leclère et al., 2014; Lord et al., 2000; Marsh et al., 2013; Osterling, Dawson, & Munson, 2002). Children with ASD have trouble to achieving mutual regulation and temporal coordination in their interactions with others, and as a consequence, it is hard for them to develop their social emotional skills (Feldman, 2007; Harrist & Waugh, 2002). Several experts therefore point out the importance of specific studies on synchrony-related interventions for children with ASD (Kasari, Locke, Gulsrud, & Rotheram-Fuller, 2011; Leclère et al., 2014).

Synchrony in verbal interactions is a complex behavioral pattern in which one speaker anticipates on what the other speaker does, and vice versa. It is characterized by adequate turn-taking behavior, that is, alternating verbalizations of varying size between two or more persons (Dumas, Nadel, Soussignan, Martinerie, & Garnero, 2010; Levinson, 2016; Pika, Wilkinson, Kendrick, & Vernes, 2018; Stivers et al., 2009). Similar to other synchronizing behaviors, turn-taking behavior is often impaired in children with ASD (Leclère et al., 2014). Some researchers therefore suggest that improving turn-taking behavior leads to fewer interruptions and silent pauses, and increased social skills (Reuzel et al., 2013; Siller & Sigman, 2002; Steiner, Gengoux, Smith, & Chawarska, 2018; Yoder & Stone, 2006). It is important to be aware of the role of the parents (or therapist) when it comes to turn-taking, and especially their sensitivity to the child. For example, the study of Siller and Sigman (Siller & Sigman, 2002) shows that parents of children with ASD who show higher levels of synchronization stimulate their children's joint attention and language skills to a greater extent than parents who show less synchronization. At the same time, however, a recent study shows that a more directive style of parents to achieve synchrony, such as placing more demands on their child's attentional focus, is associated with negative affect of young children who are at risk of an ASD diagnosis (Steiner et al., 2018). In other words, trying to impose synchronous behavior in children with ASD may sometimes be counterproductive. Therapies that increase synchrony but at the same time create a positive non-demanding environment are therefore thought to be beneficial.

Some authors argue that such a positive and non-demanding environment can be achieved by incorporating animals into therapy and that animals would contribute to children's social attunement (Malcolm et al., 2018). Animals can have a positive effect on our psychological and physical well-being, and this positively influences our social interactions and helps us to regulate our emotions (Bureau et al., 2017; Sable, 2013). Various studies have shown that Animal Assisted Therapy (AAT) can be promising in itself, as well as an addition to existing interventions (Becker, Rogers, & Burrows, 2017; Griffioen & Enders-Slegers, 2014; Kamioka et al., 2014; Nimer & Lundahl, 2007b; O'Haire, McKenzie, McCune, & Slaughter, 2014; Silva, Correia, Lima, Magalhães, & de Sousa, 2011). Researchers have indicated that the presence of animals, such as dolphins, may make children with ASD feel safe in a therapy environment (Parish-Plass, 2013). Research specifically focusing on dolphin-assisted therapy shows that this intervention positively contributes to the language development of children with ASD (Griffioen & Enders-Slegers, 2014; Nathanson, Castro, Friend, & McMahon, 1997; Nathanson, 1998), and that dolphin-assisted therapy has a positive effect on social interaction and greater self-esteem (Breitenbach, Stumpf, Fersen, & Ebert, 2009; Griffioen & Enders-Slegers, 2014; Nathanson, de Castro, Friend, & McMahon, 1997; Servais, 1999). Studies on interventions with other animals report decreased behavioral problems (Nimer & Lundahl, 2007a), increased social interaction and communication (O'Haire, McKenzie, Beck, & Slaughter, 2013), a more playful mood, more focus, and more awareness of the social environment (O'Haire, 2017).

In summary, synchronizing behaviors, such as turn-taking are often impaired in children with ASD (Leclère et al., 2014). Improving turn-taking behavior would lead to improved social interaction less interruptions and silent pauses (Reuzel et al., 2013; Siller & Sigman, 2002; Steiner et al., 2018; Yoder & Stone, 2006). Therapies that aim to increase synchrony are therefore valuable, but a positive non-demanding environment seems therefore thought to be beneficial. (Steiner et al., 2018). Such an environment can be achieved by incorporating animals into therapy (Breitenbach et al., 2009). While most studies on AAT report increased social and communication skills of children with ASD, the effect of this therapy on synchronizing behaviors, and especially turn-taking has not been investigated.

Our study was guided by the following research question: How can we characterize the interaction between child and therapist during dolphin-assisted therapy, with regard to synchrony in verbalizations (turn-taking), and does synchro-

ny change over the course of six sessions of therapy? To answer these questions we performed a cross-recurrence quantification analysis (see methods section), to give a detailed view of the shared dynamics between therapist and child in the context of dolphin-assisted therapy.

3.1 MATERIALS AND METHODS

3.1.1. Ethical considerations

In this study, five children with ASD were followed for six weeks while they received dolphin-assisted therapy. At the start of the study, written consent was obtained from the parents of the children. The parents were also informed about the aim of the study, as well as about the protocol of the therapy. It was made clear to them that they were free to stop their participation at any moment. During the research, the dolphins' welfare was continually monitored by a veterinarian. All necessary precautions were taken to prevent possible harm to the dolphins, such as limiting the time of interacting with people to a minimum and not allowing people to be in the water (swim) with the dolphins. The study was evaluated by the Health Care Inspectorate (IGZ) of the Dutch Ministry of Health, Welfare and Sport, and assessed as a low-risk study.

3.1.2. Participants

Five children (four males, one female) with ASD participated in this study. The children were recruited through the website of the SAM Foundation, (www.stichtingsam.nl), which facilitated dolphin-assisted therapy (DAT) in the Netherlands. Parents voluntarily registrated their children for therapy after reading newspaper articles about this program. Upon registration, parents were asked for permission to participate in the study. After registration children were placed on a waitlist and were called in for an extensive intake as soon as there was room to start therapy.

The exclusion criteria for participation included fear of water, epilepsy, poor vision and a history of aggressive behavior toward animals. The therapy program was partly sponsored and therefore parents paid a reduced price.

We obtained information about the speech language development of the children from intake forms completed by the parents at the start of the therapy program, such as the number of words they used and whether they were able to express their feelings. The parents of three children indicated that they only used single words to communicate, and the parents of the remaining two children indicated they could produce short sentences (3-4 words). Table 1 provides a detailed description of the participants.

Table 1. Participant characteristics

	Pp 1	**Pp 2**	**Pp 3**	**Pp 4**	**Pp 5**
Age	7.5	8.5	6	7.5	8
Gender	Female	Male	Male	Male	Male
Diagnosis	ASD	ASD/ADHD	ASD	ASD	ASD
Education	Special	Special Salbutamol (Asthma) and Methylphenidate (ADHD)	Special	Special	Special
Medical treatment	-	-	-	Levetiracetam (Epilepsy)	-
Sensory problems	-	-	-	Glasses	Glasses
Motor problems	Physiotherapy	-	-	Orthopedic shoes	-
Behavioral problems	Anxious and aggressive behavior in unexpected situations	Aggressive toward sibling, often screams, runs away	Easily over-stimulated, repetitive movements	-	Acts young for age, frustration when he cannot pronounce words

From the educational background we can infer that children in this study had an IQ between 40 and 60, based on the eligibility for special education in the Netherlands.

3.1.3. Procedure

The therapy took place in the Netherlands at the Dolphinarium Harderwijk. The dolphins live in a artificial lagune of 7000 square meter and are not used for shows.

They live together as a small pod (17 dolphins, including males, females, juveniles and babies). The SAM foundation was responsible for the organization of the program. They provided the trained speech and language therapists. All therapist were trained at universities of applied science in the Netherlands and had followed an intensive training on how to work with the dolphins, organized by the foundation.

This professional team, consisting of three female therapists and three female dolphin trainers, guided the children through this specific DAT program. Each child worked with one therapist and one dolphin trainer during six sessions. All therapists had at least ten years of experience in working with children with disabilities. The therapy setting with the child, therapist, dolphin trainer and dolphin was set up to create an atmosphere in which the child felt safe (Bachi & Parish-Plass, 2017; Beck & Katcher, 2003; Parish-Plass, 2013). According to the literature, children feel attracted by the dolphin because of its anatomically shaped smile and its gentle movements in the water (Nathanson, 1998). The interaction between child, dolphin and therapist enables a triangular communication (transmission triangle or carry-over) to provoke children's verbal or non-verbal responses. That is, observing the animal's behavior, interacting with the animal, and watching other people interact with the animal can stimulate children's social and communication skills.

We worked with 3 dolphins for 5 children, and each child worked with the same dolphin during the sessions. At the start of a session, the dolphin trainer would call the dolphins to the raft, and one dolphin was chosen to work with during the session. After the first session, the preferred choice of dolphin was always the dolphin the child had worked with before. Due to pregnancy of one dolphin we had to change dolphins for two children in the last session. In addition, because the dolphins were not forced to interact with the children, we only once switched dolphins when the regular dolphin did not come to the raft when the dolphin trainer called. We did not have to cancel a session due to stress signals of the dolphins. In an earlier study the stress signals of the dolphins during a training session, a therapy session of this DAT program, and at rest time were investigated (Boneh and & Leeuwen, 2003; Griffioen & Enders, 2014). In this study, the respiratory frequency of the dolphins was measured as a parameter of arousal. Similar levels of respiratory frequency were measured during days with and without training sessions.

The dolphin trainer selected the dolphin at the start of the therapy sessions (depending on the dolphin's condition and behavior at that moment), and supervised the behavior and possible stress signals of the dolphin. Before the therapist

and child wanted to engage with the dolphin, they always had to ask permission of the dolphin trainer and no confusing situations for the dolphin would occur. Apart from that, the dolphin trainers were instructed not to interfere in the interaction between child and dolphin or therapist, unless the situation called for immediate action (e.g., when the dolphin showed stress signals or inappropriate behavior).

During the six sessions, the child, therapist and dolphin trainer were standing or sitting on a raft at the waterfront. At the start of the session the therapist introduced the child to the dolphin and the dolphin-trainer. Then the therapist started a conversation about the dolphin and its behavior, inviting the child to verbally express his/her observations. The children were then taught to use gestures to make the dolphin perform certain actions. For example, children learned to signal so that the dolphin would jump or clap with the fins. The child was only allowed to make the gestures if he/she first made eye contact and verbally asked permission. In this way, the children's interactions with the therapist were reinforced by their wish to play with the dolphin. Furthermore, to help the children to express their emotions, 40 cm square boards with emotion pictures were shown, and the therapist started a conversation about these emotions. Since recognizing, naming and describing emotions is something children with ASD often have trouble with, the therapy program incorporated a task in which these skills are practiced. To include the dolphin in this task, the boards were thrown into the water for the dolphin to return.

3.1.4 Measurements

Coding of verbal behavior

Videos of the first and last session of the therapy were systematically observed by means of timeserial event coding, using the program Mediacoder (Steenbeek & Van Geert, 2006). This means that both the category of the behavior as well as the timing of that behavior were registered. We coded the following four behavioral categories: 1) Therapist speaks, 2) Therapist is silent, 3) Child speaks, 4) Child is silent. Three student-raters first completed a training in which they coded one therapy session, and compared their codes with those of an expert-rater, who constructed the codebook with coding rules. Inter-rater reliability was considered sufficient when

at least 80% of the codes of the rater and expert-rater were similar with regard to both the timing and the chosen category. If this percentage was not reached, raters received an additional explanation of the coding rules and coded a second therapy session, after which the percentage of agreement was determined again. All raters reached sufficient inter-rater reliability (> 80%) after coding two sessions and proceeded with coding of the videos.

Data analysis

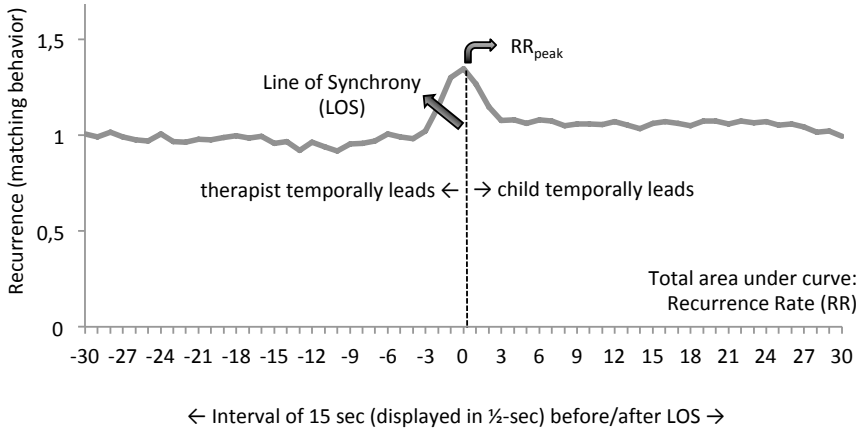
We present the data for each participant separately. We first transformed the codes and accompanying times to a time series with a sampling rate of 2 Hz and then applied Cross Recurrence Quantification Analysis (CRQA; see (Marwan, Carmenromano, Thiel, & Kurths, 2007; Norbert Marwan & Webber, 2015; Zbilut, Giuliani, & Webber, 1998). CRQA originates from the natural sciences, and has recently been introduced to the study of human interactions (see e.g. Cox & van Dijk, 2013; López Pérez et al., 2017; Vink, Wijnants, Cillessen, & Bosman, 2017), and recently also human-animal interactions (Griffioen, van der Steen, Cox, Verheggen, & Enders-Slegers, 2019). This study investigated the course of behavioral synchrony on movement patterns (and the outcome on problem behaviors) of children with Down syndrome (DS) and children with ASD while interacting with a dog. We used CRQA to operationalize the movement synchrony between a dog and child and found an increase in the coupling between child and dog during the final session, meaning that child and dog became mutally attuned in their movements.

CRQA focuses on the shared dynamics of two coupled systems by detecting repeatedly occurring matches between the behavior of two interaction partners (Cox, van der Steen, Guevara, de Jonge-Hoekstra, & van Dijk, 2016). In this case, matching behavior was defined as correct turn-taking behavior in the conversation between child and therapist, that is, speaking when the other person is silent, and vice versa (cf. (Reuzel et al., 2014, 2013). CRQA detects these matches across all possible timescales, ranging from seconds to the duration of the entire interaction (Cox et al., 2016) This means that even when the appropriate turn is (slightly) delayed, it will still be detected.

From CRQA it is possible to calculate several measures. We looked at the Diagonal Cross-Recurrence Profile (DCRP; see e.g. (Abney, Warlaumont, Oller, Wallot, & Kello, 2017; Cox et al., 2016; Davis, Pinto, & Kiefer, 2017; Nomikou,

Leonardi, Rohlfing, & Rączaszek-Leonardi, 2016), allowing for leader-follower analysis of the interaction. Figure 1 shows the average DCRP of the first session for all five children, as an example and to highlight the main measures. Concretely, we focused on matching behaviors (adequate turn-taking) within an interval of 30 seconds around the Line of Synchrony (LOS). The LOS represents instances of matching behavior of child and therapist at the exact same time. This either means that the child speaks while the therapist remains silent, or vice versa. The percentage of matching behavior at the exact same moment (i.e., on the LOS) is called the percentage of synchrony (%Sync). Yet, patterns of matching behavior do not always occur at the exactly same moment, there is often some delay (Stivers et al., 2009). The recurrence rate (RR) therefore represents the proportion of matching behavior within an interval of 30 seconds around the LOS (15 seconds before/after the LOS). The highest proportion of matching behaviors that can be measured within that interval is called RRpeak. A final measure that can be derived from the DCRP is Qlos, which is the proportion of matching behavior on the left side of the LOS divided by the proportion of matching behavior on the right side. If Qlos is higher than 1, the therapist temporally leads the interaction. This means that the behavior of the therapist (speaking or listening) influences the child's behavior to a greater extent than vice versa. If Qlos is smaller than 1, the child temporally leads the interaction.

Figure 1. Average Diagonal Cross-Recurrence Profile (DCRP) plot of the first session, with an indication of the Line of Synchrony (LOS), Recurrence Rate (RR), and RR_{peak}.



The Q_{los} measure can be calculated by dividing the proportion of recurrence on the left side of the LOS by the proportion of recurrence on the right side.

3.2 RESULTS

Table 2 shows descriptive statistics relatad to the CRQA analysis. Below, the results will be discussed for each participant separately.

Table 2. Total time of spoken language measured in seconds and DCRP measures for the five cases.

	Seconds of spoken language participant		Seconds of spoken language therapist		RR		Rrpeak		Qlos	
	first	last	first	last	first	last	first	last	first	last
Pp 1	232	278	542	490	.18	.26	.24	.29	-.03	-.02
Pp 2	199	138.5	599	450	.17	.19	.23	.24	-.07	-.03
Pp 3	113.5	126	562.2	605.5	.08	.09	.11	.12	.005	.02
Pp 4	176	174.5	854	943	.19	.07	.06	.04	-.02	-.01
Pp 5	153	34.5	509	276.5	.2	.08	.16	.04	-.04	.04

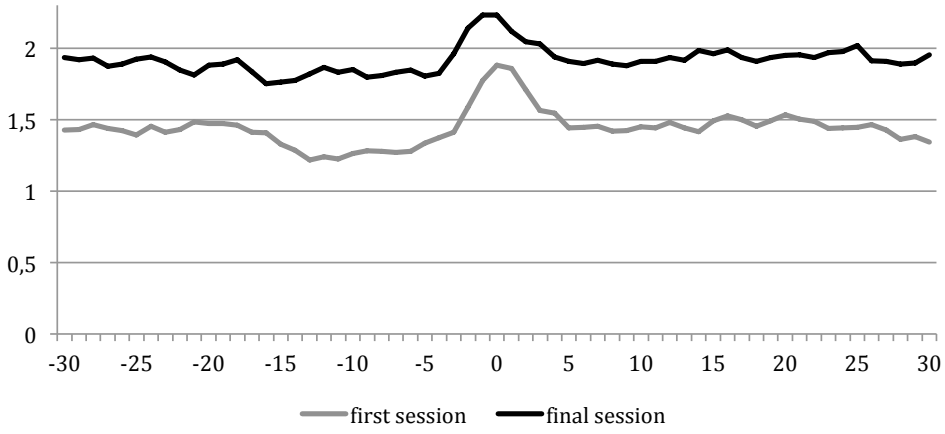
3.2.1 Participant 1

According to her parents, participant 1 has good verbal skills. She speaks a lot, but does make grammatical errors. Formulating a coherent sentence takes more time, and she has difficulty expressing and interpreting emotions and feelings. She feels comfortable around animals.

Analysis of turn-taking

During the first session, we recorded 232 seconds total time of spoken language, of the participant and 542 seconds of spoken language of the therapist. During the last session, the seconds of spoken language of participant increased to 278 (19.8%) and decreased for the therapist to 490 (9.8%). Figure 2 shows the Diagonal Cross-Recurrence Profile (DCRP) of participant 1 during the first and final session. The recurrence rate increased from 0.18 to 0.26. This means that the proportion of behavioral matches (i.e., adequate turn-taking) increased with 44.4%. The RRpeak measure, which is the highest proportion of recurrence observed, also showed an increase, from 0.24 to 0.29. The Qlos measures show that during both sessions, the child more often temporally led the conversation than the therapist (both values < 1). Compared to the first session (Qlos = -0.03), the dominance of the child's behavior in the interaction appeared to be slightly less (Qlos = -0.02).

Figure 2. Diagonal Cross-Recurrence Profile (DCRP) of participant 1.
Note. The X-axis displays the delay in steps of 0.5 seconds, and the Y-axis the recurrence rate (i.e. the proportion of accurate turn-taking).



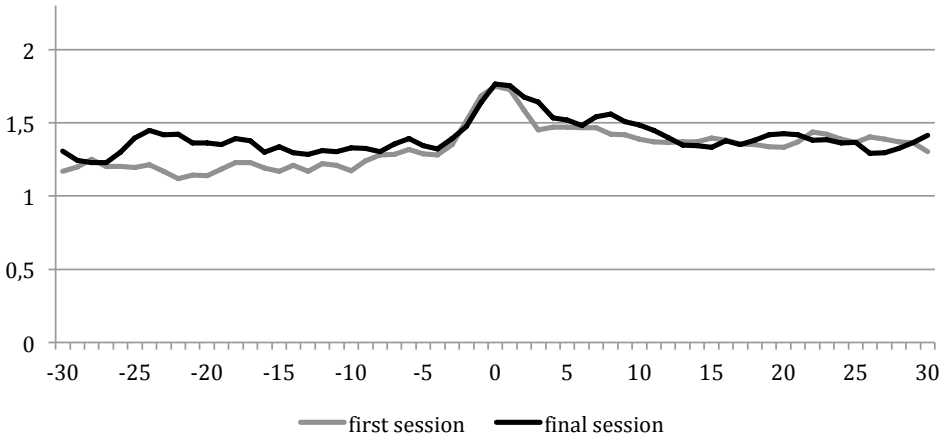
3.2.2 Participant 2

As reported by his parents, participant 2 started speaking when he was three years old. His language development is delayed, and he has difficulty producing meaningful sentences and expressing his emotions.

Analysis of turn-taking

During the first session, we recorded 199 seconds of spoken language of the participant and 599 seconds of the therapist. During the last session the number of participants seconds of spoken language decreased to 138.5 (30.4%) and decreased for the therapist to 450 seconds (24.8%). The Diagonal Cross-Recurrence Profile (Figure 3) shows the recurrence rate, the proportion of behavioral matches (i.e., adequate turn-taking), slightly increased from 0.17 to 0.19. The highest proportion of recurrence (RRpeak) increased from 0.23 to 0.24. The QLOS changed from -0.066 to -0.032. This means that the child temporally led the interaction, but that his dominance became less apparent over time. Overall one could conclude that the conversational dynamics in terms of these measures did not change significantly between the two sessions.

Figure 3. Diagonal Cross-Recurrence Profile (DCRP) of participant 2.
Note. The X-axis displays the delay in steps of 0.5 seconds, and the Y-axis the recurrence rate (the proportion of accurate turn-taking).



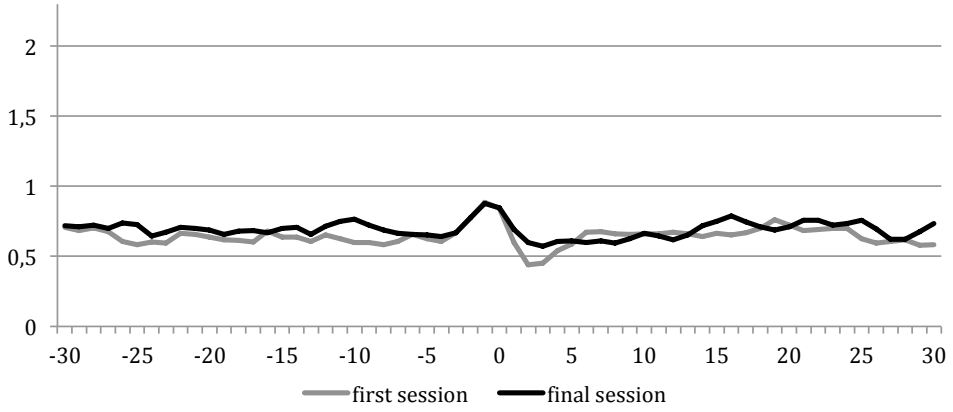
3.2.3 Participant 3

According to his parents, participant 3 is able to speak, but it is hard for him to communicate with the right words. He has weak mouth motor skills, which results in difficulty to formulate sounds with his mouth and slow speech. He uses single words and sometimes 3-4 word sentences, with regular echolalia. He is quickly over-stimulated, and is only able to communicate with supportive gestures. His parents often let him finish sentences, such as: "We go to"…."the dolphins".

Analysis of turn-taking

This participant's total time of spoken language increased from 113.5 to 126 seconds(11.0%). Also for the therapist this increased from 562.5 to 605.5 seconds (7.6%). As Figure 4 shows, the recurrence rate remained relatively stable (a slight increase from 0.08 to 0.09). RRpeak also remained stable (a slight increase from 0.11 to 0.12). QLOS increased from 0.005 to 0.02, which means that the therapist temporally led the interaction, and even more so during the final session. As for participant 3, also for this child, the conversational dynamics in terms of these measures remained relatively stationary.

Figure 4. Diagonal Cross-Recurrence Profile (DCRP) of participant 3.
Note. The X-axis displays the delay in steps of 0.5 seconds, and the Y-axis the recurrence rate (the proportion of accurate turn-taking).



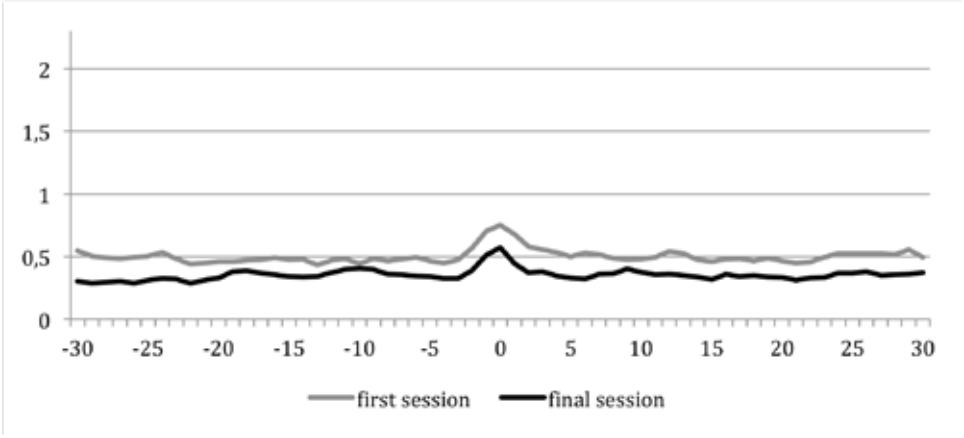
3.2.4 Participant 4

Participant 4 speaks unclearly according to his parents and rather points to what he wants. He speaks with single and simple words, or very short sentences in combination with gestures.

Analysis of turn-taking

There is a minor decrease in the participant's total time of spoken language from 176 to 174.5 seconds (0.8%). The therapist's total time of spoken language increased from 854 to 943 seconds (10.4%). The DCRP of participant 4 showed a lower RRpeak and RRLOS during the final session compared to the first session, with RRpeak decreasing from 0.19 to 0.07, and RRLOS decreasing from 0.06 to 0.04. QLOS changed from -0.02 during the first session to -0.01 during the last session. This means that the child temporally led the interaction, but that his dominance became less apparent over time.

Figure 5. Diagonal Cross-Recurrence Profile (DCRP) of participant 4
Note. The X-axis displays the delay in steps of 0.5 seconds, and the Y-axis the recurrence rate (the proportion of accurate turn-taking).



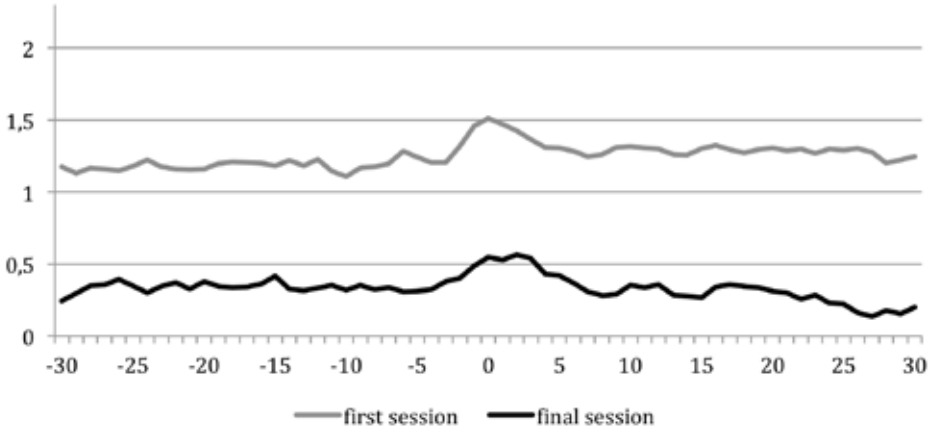
3.2.5 Participant 5

The fifth participant has trouble making certain sounds and is therefore not always well-understood, but has a good vocabulary according to his parents. He uses short sentences of 3 to 4 words and supports this with gestures.

Analysis of turn-taking

We recorded 153 seconds of spoken language of the participant and 509 seconds of the therapist during the first session. During the last session the number of participant's seconds decreased to 34.5 (77.5%) and also for the therapist to 276.5 (45.6%). Figure 6 shows the DCRP of this participant during the first and final session. The RRpeak and RRLOS decrease during the final session, respectively from 0.2 to 0.08, and from 0.16 to 0.04 respectively. The QLOS is higher during the final session and changes from negative to positive (from -0.04 to 0.04), which means that during the first session the child temporally led the interaction while the therapist followed, whereas the therapist temporally led during the final session.

Figure 6. Diagonal Cross-Recurrence Profile (DCRP) of participant 5
Note. The X-axis displays the delay in steps of 0.5 seconds, and the Y-axis the recurrence rate (the proportion of accurate turn-taking).



3.4 DISCUSSION

A positive non-demanding environment is therefore thought to be beneficial to increase synchronizing verbal behavior, such as turn-taking, for children with ASD (Siller & Sigman, 2002; Steiner et al., 2018; Yoder & Stone, 2006). Such an environment can be created by incorporating animals into therapy situations (Breitenbach et al., 2009; Griffioen & Enders-Slegers, 2014). Until now, however, studies have not investigated whether synchronizing behaviors, and especially turn-taking, increase in the context of animal-assisted therapy (AAT). This study therefore examined videos of the interaction between child and therapist during dolphin-assisted therapy (DAT) in terms of turn-taking, using data of five child-therapist interactions during both the first and final (sixth) session of DAT.

Because this exploratory study intended to investigate whether DAT influences changes in turn-taking behavior, it was beyond our scope to compare the effect of the therapy to a control group. However, in an earlier study (Griffioen & Enders, 2014) we reported the positive effect of this program on verbalization and social interaction measures, by comparing DAT to two control groups (using a radio-controlled boat in a swimming pool, and a waitlist). As advised by Marino (2012) we minimized construct confounding as we exposed the control group and the DAT intervention group to highly similar procedures.

The results of this study, however, seemed only partially in line with our expectations that synchronization of verbalizations (i.e., turn-taking behavior) would improve during DAT. The data revealed increases in turn-taking for participants 1 and 2. They showed an increase in RRpeak and RRlos, which implies that the proportion of "matching behaviors" (i.e., speaking while the other person remains silent, and vice versa) between the participant and the therapist increased from the first to the last session. The Qlos measures for participants 1 and 2 indicate that these children temporally led the interaction during both the first and last session, but that they became less dominant leaders during the final session. Participant 3, however, showed no changes in RRpeak between the first and the last DAT session. The Qlos measures indicate that the therapist temporally led the interaction, and even more so during the final session. The final two participants (4 and 5) showed a decrease in synchronization of verbalization (verbal turn-taking behavior). Their RRpeak and RRlos measures decreased between the first and the sixth DAT session. The Qlos

measures revealed that participant 4 temporally led the interaction during the first session, but that this became less apparent during the final session. Participant 5 also led the interaction during the first session, but this was reversed in the final session, when therapist mostly led the interaction.

For three out of five children, the total time of spoken language increased during the final session of DAT (see table 2) while the total time of spoken language of the therapist measured in seconds decreased.

Some authors have suggested that turn-taking behavior requires a reasonable good vocabulary (Yoder & Stone, 2006). Taking an active role both as speaker-initiator or listener requires sufficient communication skills while children with disabilities mostly lack such skills (Stanton-Chapman & Snell, 2011). Some differences in our results can therefore be explained by initial difference in communication skills between the children. While participants 1 and 2 had less trouble speaking, the parents of participants 3, 4 and 5 reported that their children were only able to speak using supportive gestures (i.e., substituting words for gestures, frequent use of pointing instead of verbal indications). Participants 1 and 2, with better communication skills, indeed seemed to improve with regard to their turn-taking skills, which confirms the suggestion of Yoder and Stone (Yoder & Stone, 2006) that a reasonable vocabulary is a prerequisite for adequate turn-taking. Future studies on animal-assisted interventions and turn-taking are therefore advised to take a baseline level of verbal skills into account e.g. using videotapes of the participants prior to the study.

To our knowledge, this study is the first to investigate the effect of DAT on verbal synchronizing behaviors (turn-taking). While a bigger sample would aid in the generalization of our findings, our small sample size enabled us to perform an in-depth analysis. The most important result revealed in this study, that is, turn-taking during DAT seems to increase for children with reasonable verbal communication skills, could be further examined in larger studies, that could also include other variables, such as the age of the children, the severity of the disorder, or gender.

Note that the five children in this study worked with three different therapists, and that the dolphin changed depending on its condition and availability. Although each child was always guided by the same therapist during the sessions, differences in the therapists' behaviors may affect children's synchronizing behaviors and turn-taking skills. Given that this was an exploratory study (do we see any changes in synchrony?), and because of the labour-intensive nature of the coding, this study only compares the child-therapist synchrony in two sessions. Future re-

search could investigate more sessions to track the development of therapist-child synchrony over time. Moreover, differences in the dolphin's behavior could have influenced the communication between therapist and child, and the child's experience of the therapy setting. Although this may be hard to incorporate in practice, future studies are advised to let the same therapist guide all children, and to use the same dolphin throughout the sessions. Alternatively, therapists could receive more extensive instructions with regard to what they say to the participants and instructions with regard to taking delayed reaction times into account.

There is an indication that children with ASD show additional attention deficits and a relatively delayed reaction time compared to typically developing children. This may result in the need for more time to verbally respond to others (Noterdaeme, Amorosa, Mildenberger, Sitter, & Minow, 2001; Travers, Klinger, & Klinger, 2011). These attentional deficits and delayed reaction time were not taken into account in this study, but may have influenced the results on turn-taking behavior. For example, when a question takes more time to answer for the child, and the therapist is already moving on, a turn is "missed". According to Levinson (Levinson, 2016), "turn-taking precedes language in ontogeny, but when language is acquired children struggle for years to squeeze complex language into short turn sizes with adult response time." This skill may require even more time to master for children with ASD.

In future studies, the effect of Animal-Assisted interventions on synchrony could be further investigated, using conditions of therapy with and without animals, or by comparing synchrony between child and therapist in the presence of different animals, such as dogs or horses. This will allow us to check the synchrony of turn-taking behavior with and without an animal and compare the different species. The results of this research can be useful in future research because it makes clear that there is a great variation in language development in children with ASD. Finally, future studies could also investigate the optimal duration of DAT programs. It could be that a longer DAT program yields better results for children with weaker verbalization skills.

3.4 CONFLICTS OF INTEREST

In accordance with the journals policy and our ethical obligation as researchers, we are reporting that during the research the first author was president of the SAM Foundation, a non-profit foundation offering dolphin assisted therapies in the Netherlands for children with Down Syndrome and children with Autism Spectrum Disorder. The SAM Foundation may be affected by the research reported in the enclosed paper in a non-financial or non-commercial manner. By not interfering in data collection (carried out by professional therapists) and by having an independent third party to do the statistical analyses, we believe we have done our utmost to secure scientific objectivity of design, procedures and results under all circumstances.

REFERENCES

Abney DH, Warlaumont AS, Oller DK, Wallot S, Kello CT. Multiple Coordination Patterns in Infant and Adult Vocalizations. Infancy [Internet]. 2017 Jul [cited 2018 Jan 11];22(4):514–39. Available from: http://doi.wiley.com/10.1111/infa.12165

American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders (DSM-5®) - American Psychiatric Association –

Bachi K, Parish-Plass N. Animal-assisted psychotherapy: A unique relational therapy for children and adolescents. Clinical Child Psychology and Psychiatry. 2017.

Beck AM, Katcher AH. Future Directions in Human-Animal Bond Research. Am Behav Sci [Internet]. SAGE Publications; 2003 Sep 27 [cited 2017 Dec 18];47(1):79–93. Available from: http://journals.sagepub.com/doi/10.1177/0002764203255214

Becker JL, Rogers EC, Burrows B. Animal-assisted Social Skills Training for Children with Autism Spectrum Disorders. Anthrozoos [Internet]. 2017 Apr 3 [cited 2017 Jun 4];30(2):307–26. Available from: https://www.tandfonline.com/doi/full/10.1080/08927936.2017.1311055

Bernieri F, Rosenthal R. Interpersonal coordination: Behavior matching andinteractional synchrony. 1991 [cited 2018 Oct 10]; Available from: http://psycnet.apa.org/record/1991-98576-011

Breitenbach, E., Stumpf, E., Fersen, L. V., & Ebert, H. V. (2009). Dolphin-assisted therapy: Changes in interaction and communication between children with severe disabilities and their caregivers. Anthrozoös, 22(3), 277-289.

Bureau J-F, Martin J, Yurkowski K, Schmiedel S, Quan J, Moss E, et al. Correlates of child–father and child–mother attachment in the preschool years. Attach Hum Dev [Internet]. 2017 Mar 4 [cited 2017 Oct 9];19(2):130–50.

Cox RFA, van Dijk M. Microdevelopment in Parent-Child Conversations: From Global Changes to Flexibility. Ecol Psychol [Internet]. 2013 Jul [cited 2017 Jan 16];25(3):304–15. Available from: http://www.tandfonline.com/doi/abs/10.1080/10407413.2013.810095

Cox, R. F., van der Steen, S., Guevara, M., de Jonge-Hoekstra, L., & van Dijk, M.

(2016). Chromatic and anisotropic cross-recurrence quantification analysis of interpersonal behavior. In Recurrence plots and their Quantifications: Expanding horizons(pp. 209- 225). Springer, Cham.

Dale, R., & Spivey, M. J. (2006). Unraveling the dyad: Using recurrence analysis to explore patterns of syntactic coordination between children and caregivers in conversation. Language Learning, 56(3), 391-430.

Davis, T. J., Pinto, G. B., & Kiefer, A. W. (2017). The stance leads the dance: the emergence of role in a joint supra-postural task. Frontiers in Psychology, 8, 718.

De Jonge-Hoekstra L, Van der Steen S, Van Geert P, Cox RFA. Asymmetric Dynamic Attunement of Speech and Gestures in the Construction of Children's Understanding. Front Psychol [Internet]. Frontiers Media SA; 2016 [cited 2018 Jan 11];7:473. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27065933

Dumas G, Nadel J, Soussignan R, Martinerie J, Garnero L. Inter-Brain Synchronization during Social Interaction. Lauwereyns J, editor. PLoS One [Internet]. 2010 Aug 17 [cited 2017 Jun 4];5(8):e12166. Available from: http://dx.plos.org/10.1371/journal.pone.0012166

Feldman, R. (2007). Parent–infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. Journal of Child psychology and Psychiatry, 48(3-4), 329-354.

Fitzpatrick P, Diorio R, Richardson MJ, Schmidt RC. Dynamical methods for evaluating the time-dependent unfolding of social coordination in children with autism. Front Integr Neurosci [Internet]. Frontiers; 2013 Apr 8 [cited 2018 Apr 3];7:21. Available from: http://journal.frontiersin.org/article/10.3389/fnint.2013.00021/abstract

Fogel A. Developing through relationships: Origins of communication, self, and culture. University of Chicago Press; 1993

Forster, S., & Iacono, T. (2014). The nature of affect attunement used by disability support workers interacting with adults with profound intellectual and multiple disabilities. Journal of Intellectual Disability Research, 58(12), 1105-1120.

Griffioen, R. E., & Enders-Slegers, M. J. (2014). The effect of dolphin-assisted therapy on the cognitive and social development of children with Down syndrome. Anthrozoös, 27(4), 569-580.

Griffioen, R. E., van der Steen, S., Verheggen, T., Enders-Slegers, M. J., & Cox, R. (2020). Changes in behavioural synchrony during dog-assisted therapy for children with autism spectrum disorder and children with Down syndrome. Journal of Applied Research in Intellectual Disabilities, 33(3), 398-408.

Forster, S., & Iacono, T. (2014). The nature of affect attunement used by disability support workers interacting with adults with profound intellectual and multiple disabilities. Journal of Intellectual Disability Research, 58(12), 1105-1120.

Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., Jasnow, M. D., Rochat, P., & Stern, D. N. (2001). Rhythms of dialogue in infancy: Coordinated timing in development. Monographs of the society for research in child development, i-149.

Kamioka, H., Okada, S., Tsutani, K., Park, H., Okuizumi, H., Handa, S., ... & Honda, T. (2014). Effectiveness of animal-assisted therapy: A systematic review of randomized controlled trials. Complementary therapies in medicine, 22(2), 371-390.

Kasari, C., Locke, J., Gulsrud, A., & Rotheram-Fuller, E. (2011). Social networks and friendships at school: Comparing children with and without ASD. Journal of autism and developmental disorders, 41(5), 533-544.

Landa, R. (2007). Early communication development and intervention for children with autism. Mental retardation and developmental disabilities research reviews, 13(1), 16-25.

Leclère, C., Viaux, S., Avril, M., Achard, C., Chetouani, M., Missonnier, S., & Cohen, D. (2014). Why synchrony matters during mother-child interactions: a systematic review. PloS one, 9(12), e113571.

Levinson, S. C. (2016). Turn-taking in human communication–origins and implications for language processing. Trends in cognitive sciences, 20(1), 6-14.

Lindsey, E. W., Cremeens, P. R., Colwell, M. J., & Caldera, Y. M. (2009). The structure of parent–child dyadic synchrony in toddlerhood and children's communication competence and self-control. Social Development, 18(2), 375-396.

López Pérez, D., Leonardi, G., Niedźwiecka, A., Radkowska, A., Rączaszek-Leonardi, J., & Tomalski, P. (2017). Combining recurrence analysis and automatic movement extraction from video recordings to study behavioral coupling in face-to-face parentchild interactions. Frontiers in psychology, 8, 2228.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P. C., ... & Rutter, M. (2000). The Autism Diagnostic Observation Schedule—Generic: A standard measure of social and communication deficits associated with the spectrum of autism. Journal of autism and developmental disorders, 30(3), 205-223.

Malcolm, R., Ecks, S. and Pickersgill, M., 2018. 'It just opens up their world': autism, empathy, and the therapeutic effects of equine interactions. Anthropology & medicine, 25(2), pp.220-234

Marsh, K. L., Richardson, M. J., & Schmidt, R. C. (2009). Social connection through joint action and interpersonal coordination. Topics in Cognitive Science, 1(2), 320-339.

Marsh, K. L., Isenhower, R. W., Richardson, M. J., Helt, M., Verbalis, A. D., Schmidt, R. C., & Fein, D. (2013). Autism and social disconnection in interpersonal rocking. Frontiers in integrative neuroscience, 7, 4.

Marwan, N., Romano, M. C., Thiel, M., & Kurths, J. (2007). Recurrence plots for the analysis of complex systems. Physics reports, 438(5-6), 237-329.

Marwan, N., & Webber, C. L. (2015). Mathematical and computational foundations of recurrence quantifications. In Recurrence Quantification Analysis (pp. 3-43). Springer, Cham.

Mody, M., & Belliveau, J. W. (2013). Speech and language impairments in autism: insights from behavior and neuroimaging. North American journal of medicine & science, 5(3), 157.

Nathanson, D. E., de Castro, D., Friend, H., & McMahon, M. (1997). Effectiveness of short term dolphin-assisted therapy for children with severe disabilities. Anthrozoös, 10(2- 3), 90-100.

Nathanson, D. E. (1998). Long-term effectiveness of dolphin-assisted therapy for children with severe disabilities. Anthrozoös, 11(1), 22-32.

Nimer, J., & Lundahl, B. (2007). Animal-assisted therapy: A metaanalysis. Anthrozoös, 20(3), 225-238.

Nomikou, I., Leonardi, G., Rohlfing, K. J., & Rączaszek-Leonardi, J. (2016). Constructing interaction: the development of gaze dynamics. Infant and Child Development, 25(3), 277-295.

Noterdaeme, M., Amorosa, H., Mildenberger, K., Sitter, S., & Minow, F. (2001). Evaluation of attention problems in children with autism and children with a specific language disorder. European child & adolescent psychiatry, 10(1), 58-66.

O'Haire, M. E., McKenzie, S. J., McCune, S., & Slaughter, V. (2014). Effects of classroom animal-assisted activities on social functioning in children with autism spectrum disorder. The journal of alternative and complementary medicine, 20(3), 162-168.

O'Haire, M. E., McKenzie, S. J., Beck, A. M., & Slaughter, V. (2013). Social behaviors increase in children with autism in the presence of animals compared to toys. PloS one, 8(2), e57010.

O'Haire, M. E. (2017). Research on animal-assisted intervention and autism spectrum disorder, 2012–2015. Applied Developmental Science, 21(3), 200-216.

Osterling, J. A., Dawson, G., & Munson, J. A. (2002). Early recognition of 1-year-old infants with autism spectrum disorder versus mental retardation. Development and psychopathology, 14(2), 239-251.

Parish-Plass, N. (Ed.). (2013). Animal-assisted psychotherapy: Theory, issues, and practice. Purdue University Press.

Pika, S., Wilkinson, R., Kendrick, K. H., & Vernes, S. C. (2018). Taking turns: bridging the gap between human and animal communication. Proceedings of the Royal Society B: Biological Sciences, 285(1880), 20180598.

Reuzel, E., Embregts, P. J., Bosman, A. M., Cox, R. F., van Nieuwenhuijzen, M., & Jahoda, A. (2014). Verbal interactional dominance and coordinative structure of speech rhythms of staff and clients with an intellectual disability. Nonlinear dynamics, psychology, and life sciences.

Reuzel, E., Embregts, P. J., Bosman, A. M., Cox, R., van Nieuwenhuijzen, M., & Jahoda, A. (2013). Conversational synchronization in naturally occurring settings: A recurrence-based analysis of gaze directions and speech rhythms of staff and clients with intellectual disability. Journal of nonverbal behavior, 37(4), 281-305.

Rutgers, A. H., Bakermans-Kranenburg, M. J., van Ijzendoorn, M. H., & van Berckelaer-Onnes, I. A. (2004). Autism and attachment: a meta-analytic review. Journal of Child psychology and Psychiatry, 45(6), 1123-1134.

Sable, P. (2013). The pet connection: An attachment perspective. Clinical Social Work Journal, 41(1), 93-99

Servais, V. (1999). Some comments on context embodiment in zootherapy: the case of the Autidolfijn project. Anthrozoös, 12(1), 5-15.

Siller, M., & Sigman, M. (2002). The behaviors of parents of children with autism

predict the subsequent development of their children's communication. Journal of autism and developmental disorders, 32(2), 77-89

Silva, K., Correia, R., Lima, M., Magalhães, A., & de Sousa, L. (2011). Can dogs prime autistic children for therapy? Evidence from a single case study. The journal of alternative and complementary medicine, 17(7), 655-659.

Stanton-Chapman TL, Snell ME. Promoting turn-taking skills in preschool children with disabilities: The effects of a peer-based social communication intervention. Early Child Res Q. 2011;26(3):303–19

Steenbeek, H. W., & van Geert, P. L. (2007). A theory and dynamic model of dyadic interaction: Concerns, appraisals, and contagiousness in a developmental context. Developmental Review, 27(1), 1-40.

Steiner, A. M., Gengoux, G. W., Smith, A., & Chawarska, K. (2018). Parent–child interaction synchrony for infants at-risk for autism spectrum disorder. Journal of Autism and Developmental Disorders, 48(10), 3562-3572.

Stivers, T., Enfield, N. J., Brown, P., Englert, C., Hayashi, M., Heinemann, T., ... & Levinson, S. C. (2009). Universals and cultural variation in turn-taking in conversation. Proceedings of the National Academy of Sciences, 106(26), 10587- 10592.

Sterling A. Grammar in Boys With Idiopathic Autism Spectrum Disorder and Boys With Fragile X Syndrome Plus Autism Spectrum Disorder. J Speech Lang Hear Res [Internet]. 2018 Apr 17 [cited 2018 Jun 19];61(4):857. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29541769

Stern D. The issue of vitality. Nord J Music Ther [Internet]. Routledge ; 2010 Sep [cited 2017 Jan 16];19(2):88–102.

Travers B, Klinger M, Klinger L. The Neuropsychology of Autism - Google Boeken [Internet]. attention and working memory in ASD. 2011 [cited 2019 Jun 3]. p. 161–84. Trevarthen, C. (1979). Neuroembryology and the development of perception. In Human Growth (pp. 3-96). Springer, Boston, MA.

Vink R, Wijnants ML, Cillessen AHN, Bosman AMT. Cooperative Learning and Interpersonal Synchrony [Internet]. Nonlinear Dynamics, Psychology, and Life Sciences. 2017.

Volden, J., Coolican, J., Garon, N., White, J., & Bryson, S. (2009). Brief report: Pragmatic language in autism spectrum disorder: Relationships to measures of ability and disability. Journal of Autism and Developmental Disorders, 39(2), 388.

Watt, N., Wetherby, A., & Shumway, S. (2006). Prelinguistic predictors of language outcome at 3 years of age. Journal of Speech, Language, and Hearing Research.

Yoder, P., & Stone, W. L. (2006). Randomized comparison of two communication interventions for preschoolers with autism spectrum disorders. Journal of consulting and clinical psychology, 74(3), 426.

Zbilut, J. P., Giuliani, A., & Webber Jr, C. L. (1998). Recurrence quantification analysis and principal components in the detection of short complex signals. Physics Letters A, 237(3), 131-135.

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Abstract

Dog-assisted therapy (DAT) is hypothesized to help children with Autism Spectrum Disorder (ASD) and Down Syndrome (DS). We compared synchronous movement patterns of these children (n=10) and their therapy dogs during the first and last session of a DAT program, and their post-therapy changes in emotional and behavioral problems. We found a significant increase in synchrony between child and therapy dog over time. Exploratory analyses suggest more synchrony between children with ASD and their therapy dogs, compared to the children with DS. This study is the first to test the synchrony hypothesis, shedding light upon a mechanism that may underlie the effect of DAT and how this may be different for children with ASD and DS.

Keywords

Behavioral Synchrony; Dog-Assisted Therapy; Cross Recurrence Quantification Analysis; Autism Spectrum Disorder; Down Syndrome

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Children with Autism Spectrum Disorder (ASD) show delays and a different developmental course with regard to their cognitive and social-emotional development (e.g. La Malfa, Lassi, Bertelli, Salvini, & Placidi, 2004; McPartland & Volkmar, 2012). Similar delays have been reported for children with Down Syndrome (DS) (Kortenhorst et al., 2005; van Gameren-Oosterom et al., 2011; Weijerman & de Winter, 2010). Both children with ASD and DS commonly have attention problems, social problems, language deficits, and have trouble to engage in social interactions (Eisenhower, Baker, & Blacher, 2005; Weijerman & de Winter, 2010). Although both conditions provide a challenge for caregivers and professionals, the social interaction skills of children with ASD seem more impaired than those of children with DS, especially when it comes to responding to prosocial initiations (Knott, Lewis, & Williams, 1995), joint attention, emotional responsiveness, cooperation, and social engagement (Sigman et al., 1999).

An important part of social interaction is behavioral synchrony, which is generally conceptualized as "an observable pattern of dyadic interaction that is mutually regulated, reciprocal, and harmonious" (Harrist & Waugh 2002, p. 557). Synchrony in dyadic interactions facilitates children's social, emotional, and cognitive growth (Beebe, Sorter, Rustin, & Knoblauch, 2003; Feldman, 2007; Forster & Iacono, 2014; Harrist & Waugh, 2002; Jaffe et al., 2001; Stern, 2010). While most studies on synchrony focus on caregiver-infant interactions (Feldman, 2007; Harrist & Waugh, 2002), the essence of synchrony is a rhythmic pattern of mutual adapta-

tion shared by (at least) two individuals interacting with each other (Fogel, Dedo, & McEwen, 1992). Synchrony is by definition a social phenomenon (Babad et al., 1991; Bernieri & Rosenthal, 1991), and a construct of temporal coordination. This means that synchrony is expressed as a match between the interaction partners' behaviors in time (Feldman, 2007), for example communicative and emotional verbal and non-verbal behaviors such as gestures, movements, postures, vocalizations and gazes between mother and child (Feldman, 2007; Leclère et al., 2014). This results in rhythmic patterns that can be simultaneous and identical, or alternating and mirrored (Fogel et al., 1992).

Previous studies suggest that dyads often fail to achieve synchrony when the child is diagnosed with ASD or DS. Again, this may be more pronounced for children with ASD (Baranek, 1999; Osterling et al., 2002; Sigman et al., 1999). Even before an official diagnosis is made, parents of children with ASD report impaired social interaction, as well as a failure to show joint attention and communicative pointing (Osterling & Dawson, 1994; Trevarthen & Daniel, 2005), difficulties to respond to their own name and to imitate others (Landa, 2007). This makes it hard to achieve the mutual regulation and temporal coordination that characterizes behavioral synchrony. In contrast, although the affective expressions of young children with DS are less lively and they engage more in stereotypical play, researchers have reported more joint attention behaviors and a preference for social stimuli (Baranek, 1999; Kasari & Freeman, 2001). Compared to typically developing children, however, children with DS show more problems when interacting with others (Naess, Nygaard, Ostad, Dolva, & Halaas Lyster, 2017). These problems seem to be related to their language deficits (Næss et al., 2017; Sigman et al., 1999). Moreover, given that children with DS are more prone to sensory problems such as hearing loss and motor difficulties, the timing and flow of their social interactions may be affected, compromising synchrony (Roberts, Price, & Malkin, 2007; Rondal, 2009).

Dog-assisted therapy (DAT) may help children with ASD and DS to build synchronous interaction patterns (Finck, 1993; Myers, 2007; Verheggen, Enders-Slegers, & Eshuis, 2017). This therapy consists of structured one-on-one or small group sessions, offered by trained professionals who use certified therapy dogs. The treatment requires the active involvement of the participant, and has specific therapeutic goals depending on the participant's needs (Perkins et al., 2008). Only a few effect studies on DAT have been conducted involving children with ASD and DS. Their findings indicate an increase in social behavior of children with ASD, such

as initiating contact with the therapist, being more focused, as well as a decrease in autistic symptoms, such as hand-flapping, repetitive behavior and talking about unrelated subjects (Martin & Farnum, 2002; Nimer & Lundahl, 2007; Redefer & Goodman, 1989). Similarly, children with DS had a more sustained focus, performed more cooperative interactions, and showed more positive and less negative social behavior after DAT (Esteves & Stokes, 2008; Limond, Bradshaw & Cormack, 1997).

Whether children with DS and ASD respond differently to dogs compared to typically developing children is still an aspect to be investigated. O'Haire (O'Haire, 2013) showed that children with ASD engaged in more social approach behaviors toward typically developing peers in the presence of animals. In a more recent paper, O'Haire (O'Haire, Mckenzie, Beck, & Slaughter, 2015) described how children with ASD showed lower physical arousal in the presence of animals. Together, these studies might indicate that animals lower the stress in social situations that children with ASD typically experience.

Some studies mention the effects of having a dog at home (pet ownership). (Silva, Correia, Lima, Magalhães, & de Sousa, 2011a), for instance, relate dog ownership to more frequent and longer durations of positive behaviors, such as smiling and physical contacting of children with ASD. This is in line with Carlisle (2015), who reported increased social skills of children with ASD and bonding to their dogs. In addition, positive effects of dog ownership on family functioning and child anxiety and stress are reported by various researchers (Hall, Wright, Hames, & Mills, 2016; Viau et al., 2010; Wright et al., 2015). Lastly, two literature reviews (Berry, Borgi, Francia, Alleva, & Cirulli, 2013; O'Haire, 2017), concluded that animal-assisted interventions increase the social interaction skills of children with ASD. O'Haire's (2017) review included 28 studies over a period from 2012 – 2015, and did find that the most commonly outcome was increased social interaction among children with ASD. Although these studies are encouraging, there is a need for more research to strengthen the clinical use of DAT interventions (Cirulli et al., 2011; O'Haire, 2013), specifically by searching for its underlying mechanism (Berry, Borgi, Francia, Alleva, & Cirulli, 2013a; Melson, 1988; Melson & Fogel, 1989).

Several authors state that movement synchrony is a fundamental condition in human-pet interactions (Beck & Katcher, 1996; Fogel, 1993; Melson & Fogel, 1989; Verheggen, Enders-Slegers, & Eshuis, 2017), and the connection people have to animals can be of similar quality to the bond they have with other people (Martin

& Farnum, 2002; Sable, 2013; Sanders, 2003). Researchers have therefore hypothesized that therapy dogs serve as "transition objects". The clear-cut way in which dogs communicate enables children with ASD and DS to establish synchronous movement patterns they can later extend to human interactions (Martin & Farnum, 2002; Verheggen et al., 2017; Winnicott, 1986). This synchrony hypothesis has, however, never been tested, making the mechanism of the therapeutic effect of DAT unclear. Previous research does show, however, that human-dog couples are able to synchronize. In a recent study focused on dogs' capacity to synchronize with their owners, Duranton, Bedossa, & Gaunet (2017) investigated in a familiar outdoor space how dogs synchronized their movements with their owners and found that dogs generally stayed close to their owners, and moved and gazed in the same direction. In addition, Pirrone and colleagues (Pirrone et al., 2017) examined synchronous behavior in four dog-handler dyads during animal-assisted activities. All dyads showed synchronous behaviors, such as gaze synchrony, touch synchrony, particularly with regard to joint attention. While this shows that human – nonhuman synchronization is possible, research on the mutual attunement between children and (therapy) dogs is still lacking, and may provide more information about the underlying mechanism of DAT.

The current study investigates synchrony between children with ASD or DS and therapy dogs, by comparing their rhythmic patterns of synchronous movement during the first and last therapy session of a six-week DAT program. Our first aim is to respond to the call for more research on DAT interventions (Cirulli et al., 2011; O'Haire, 2013), specifically by investigating the hypothesized mechanism (i.e., synchronous behavioral patterns) that contributes to the effect of this therapy. We expect increased synchrony between child and therapy dog over time. Our second aim is to explore differences between children with ASD and DS in terms of synchrony during the therapy sessions. Here we expect lower synchrony for children with ASD, since their social problems seem qualitatively different from those of children with DS (DiGuiseppi et al., 2010). Third, this study explores post-therapy changes in children's social problems. We expect a post-therapy decrease of children's emotional and behavioral problems as reported by their parents (cf. Verheggen et al., 2017).

Synchrony is a typical nonlinear process (Marwan, Thiel, & Nowaczyk, 2002). Patterns of matching behavior do not always occur at the exact same moment (Stivers et al., 2009), but can be slightly delayed. Research has shown that children

with ASD and DS in particular show a delay in postural reaction and have slower reaction times (Inui et al., 1995; Wallen et al., 2010; Welsh et al., 2001). Hence, a nonlinear approach is essential to capture the rhythmic patterns of mutual adaptation in interactions involving a child with ASD or DS. The current study therefore uses Cross-Recurrence Quantification Analysis (CRQA), a nonlinear time-series technique analyzing the shared dynamics of two coupled systems (e.g., child and dog) (Cox & van Dijk, 2013; Davis et al., 2017; de Graag et al., 2012; Marwan et al., 2007; Shockley et al., 2002; Zbilut et al., 1998).

4.1 METHOD

4.1.1 Participants

Five children with ASD and five children with DS participated in this study, see Table 1 for participant characteristics. All children with ASD were diagnosed by a child psychiatrist. Three children were diagnosed with an autistic disorder and an intellectual disability, one child was diagnosed with pervasive developmental disorder-not otherwise specified (PDD-NOS) and an intellectual disability, and one child was diagnosed with multiple complex developmental disorder (MCDD). All children with DS were diagnosed by a pediatrician, and had no psychiatric co-morbidity.

Participants were recruited through an organization for therapy dogs and a foundation that organizes animal-assisted interventions. Parents signed an informed consent, were informed about the study's procedure, and were notified that they could withdraw their child from the research at any moment.

The Medical Ethics Review Committee of the University of Amsterdam approved the study. Children who showed aggressive behavior against animals, and children who had a fear of dogs, had dog allergies, or severe visual or hearing problems were excluded from participation.

Table 1. Details of the 10 participating children

	DS	ASD
Males/Females	4 males / 1 female	4 males / 1 female
Mean age in years (range)	14 (12-18)	12 (11-13)
Regular primary education	1 male	-
Special education	3 males /1 female	4 males /1 female
Mean total problem score (sd)	35,6 (25.12)	78,2 (20.36)
Mean internalizing probl. (sd)	10 (7.18)	14,6 (10.76)
Mean externalizing probl. (sd)	6,6 (7.86)	23,8 (9.58)

Note. Raw Child Behavior Checklist (CBCL) scores (mean total problem score, mean internalizing problem score and mean externalizing problem score) were obtained at the start of the study and averaged for each group (children with DS and children with ASD). The score for internalizing problems is based on the sum of the Anxious/depressed, Withdrawn-depressed, and Somatic complaints scales of the CBCL; Externalizing problems combines the Rule-breaking and Aggressive behavior scales. From the educational background we can infer that children in this study had an IQ between 40 and 60, based on the eligibility for special education in the Netherlands.

4.1.2 Procedure

The therapy consisted of six weekly sessions of 30 minutes. Each child worked with the same therapist, dog and handler during all six sessions. The handler was responsible for the dog and supervised the behavior and possible stress signals of the dog. Handlers were instructed not to interfere in the interaction between child and dog, unless the situation called for immediate action (e.g., when the dog showed stress signals). Two therapy dogs (1 Labrador male breed and 1 Labradoodle male breed) were selected because of their mild-mannered behavior. The therapy was given by two therapists who were trained to work with therapy dogs. Activities during the sessions were selected from the CTAC Method (Domènec & Ristol, 2012) and adapted to the setting of our study. We selected psycho-motor and socialization activities in particular, for example having the dog follow the child's movements, and letting the child exercise his/her balance and be aware of posture and expression, to align with our outcome measures (movement data and CBCL scores, see below).

The therapist explained what was expected of the child and what gestures and encouraging words were needed to work with the dog. During the first phase of each session, the child and the dog, under supervision of the therapist, performed a number of small exercises or repetitions to get used to the tasks. During the second phase of each session, the child was encouraged to build an obstacle course, and to lead the dog through a series of obstacles and ask the dog to perform certain commands, such as sitting on a mat, walking on a bench, or jumping over a low bar. To complete this obstacle course successfully, the child had to take the lead and give clear instructions to the dog with regard to their moving direction and the tasks the dog needed to perform. Every session an additional obstacle was added to the course, and children were encouraged to suggest obstacles or tasks for the dog themselves.

All sessions were recorded on video, using a HD camcorder, Panasonic type HC-V750, with an external microphone. Video files were imported to the program MediaCoder (Bos & Steenbeek, 2006) to code the child's and dog's moving directions.

4.1.3 Measurements

Coding of behavior

A codebook was written to standardize the coding of movement direction of the participant and the dog (table 2). Four raters completed a training consisting of an explanation of the coding categories and the coding program MediaCoder (Bos & Steenbeek, 2006). This program allows real-time coding of video files and automatically provides a timestamp for each given code. During the training raters coded one therapy session, and compared their codes with those of an expert-rater, who constructed the codebook and training. Each rater focused on movement direction, and either on the dog or on the participant. Inter-rater reliability was considered sufficient when at least 80% of the codes of the rater and expert-rater were similar with regard to both the timing and the chosen category. That is, similar codes given within 2 seconds of each other were considered as agreement, whereas dissimilar codes or similar codes given more than two seconds apart were considered as disagreement. If the 80% agreement was not reached, raters received an additional explanation of the coding rules and coded a second therapy session, after which the percentage of agreement was determined again. All raters reached sufficient inter-rater reliability (> 80%) after coding two sessions and proceeded with coding of the 20 videos.

Video files of the first and last session of the therapy were then coded for all ten participants. Each change in movement direction of the child and dog were coded by means of continuous real-time coding throughout each 30-minute therapy session. Codes were given at the onset of movement, that is, right when the child or therapy dog started to lift a leg. The following categories were used: Moving toward each other (participant to the dog and vice versa), moving to the therapist, moving to a specific object, moving ahead (e.g., to a specific point within the room), and stop of movement/no movement.

Table 2. Coding categories and description

Category	Behavioral description
Moving toward each other	Child takes (a) clear step(s) in the direction of the dog, or vice versa, or they follow each other through the therapy room, without moving toward another specific target, such as an object. Note that child and dog do not have to reach the other.
Moving to handler or therapist	Child or dog takes (a) clear step(s) in the direction of either the therapist or the handler. Note that this target does not have to be reached.
Moving to object	Child or dog takes (a) clear step(s) in the direction of an object in the room that is used during the therapy sessions, such as a mat, cube, or small bench. Note that this target does not have to be reached.
Moving ahead	Child or dog takes (a) clear step(s) within the therapy room, with no apparent target, such as an object, person or each other. This category is also given when the therapist explicitly instructs child or dog to take a certain position within the therapy room.
Stop of movement	Child or dog no longer takes steps in a certain direction. Always use this code to indicate that a certain movement has stopped, even when another movement immediately follows.

Note. All categories were coded separately for the child and the dog and in real time (i.e., continuously throughout the filmed therapy session).

Child Behavior Checklist

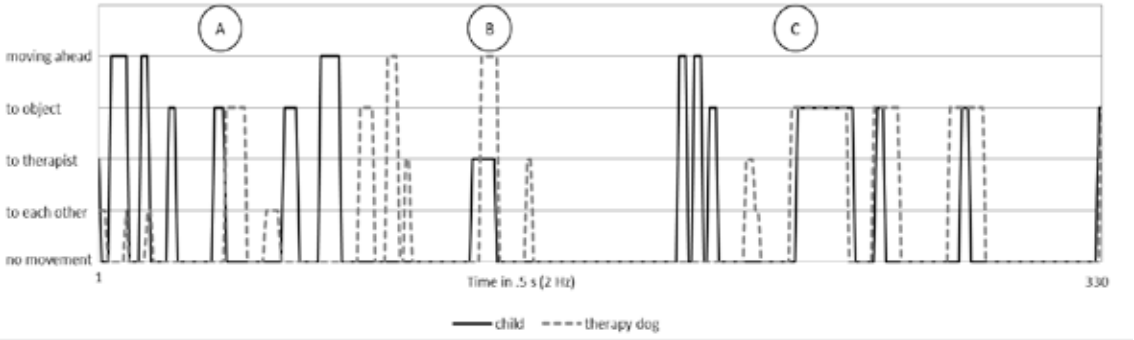
In addition to the analysis of the video's, parents of the ten children completed the Child Behavior Checklist (CBCL; Achenbach et al., 2002) before the first and after the last therapy session. The CBCL is widely used and consists of 120 items that assess the child's emotional and behavioral problems. The sum of all these items is known as the Total problem score. Answers to questions about similar topics can be combined to form the "broad band" scales Internalizing problems (Anxious/depressed symptoms, Withdrawn/depressed symptoms, Somatic complaints) and Externalizing problems (Rule-breaking behavior, Aggressive behavior). There is evidence that the CBCL is sufficiently sensitive to detect emotional and behavioral

problems of children with intellectual disabilities (Dekker, Koot, Ende, & Verhulst, 2002; Einfeld & Tonge, 1995; Pueschel et al., 1991).

4.1.4 Data analysis

We transformed the codes and accompanying times to time series with a sampling rate of 2 Hz. On average, these time series were 2725 data points long (range 1747 – 3609). Figure 1 depicts an excerpt of a time series, as an example. The time series of the participants and dog's movement directions were then subjected to Cross-Recurrence Quantification Analysis (CRQA). CRQA analyzes the shared dynamics of two coupled systems, based on repeatedly occurring 'behavioral matches' between the two time series. These matches are generally called 'recurrences'. In this case, a behavioral match was defined as both participant and dog moving in the same direction. CRQA detects matches across all possible timescales ranging from half a second to the duration of the entire interaction, by repeatedly shifting the two time series with respect to each other and comparing the behavioral states at every shift (for a more elaborate explanation see Cox et al., 2016).

Figure 1. Excerpt of time series of child (M) and dog during the final therapy session.



Note. Three points have been marked to illustrate the meaning of the time series. At point A, the child moves to an object, and the therapy dog follows just when the child stops his movement. At point B, child and therapy dog move in a different direction, when the dog moves to a specific point in the room while the child moves to the therapist. At point C, a series of three movement sequences toward an object start. In all three cases, the therapy dog starts to move first.

In this study, we analyzed the Diagonal Cross-Recurrence Profile (DCRP; (Abney, Paxton, Dale, & Kello, 2015; Abney, Warlaumont, Oller, Wallot, & Kello, 2017; Davis & Pinto, 2017; Griffioen, van der Steen, Cox, Verheggen, & Enders-Slegers, 2019; Richardson & Dale, 2005; De Jonge-Hoekstra et al., 2016; Nomikou et al., 2016; Reuzel et al., 2013). That is, we zoomed in on a 30-second window around the main diagonal (also called line of synchrony, LOS) in the recurrence plot. Several measures that can be derived from the DCRP inform about similarities between the two time series. The Proportion of synchrony represents the proportion of recurrences on the LOS. This is a rather simple measure of synchrony, as behavioral matches on this line reflect instances in which both participant and dog move in a similar direction at the exact same time (i.e., with a lag of zero seconds). The Recurrence rate is the proportion of recurrence across the whole DCRP, which gives a more detailed view of the synchrony between participant and dog. In this case it represents the proportion of behavioral matches of participant and dog in an interval of 15 s on each side of the line of synchrony (30 s in total). RRpeak represents the highest proportion of recurrence in this interval. Lastly, Qlos depicts the amount of recurrent points in the DCRP on the left side of the LOS divided by the amount of recurrent points in the DCRP on the right side of the LOS. A Qlos higher than 1 means that the dog more often temporally leads the interaction, whereas a Qlos smaller than 1 means that the child more often temporally leads. Together, these DCRP measures inform about the synchrony between child and the therapy dog in an interval of 30 s around the LOS (see Figure 2).

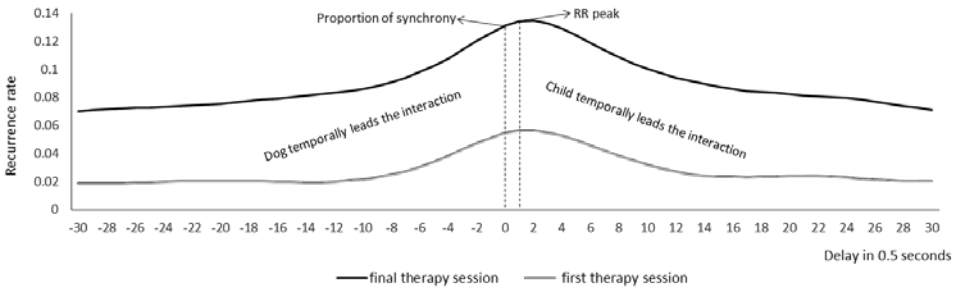
We then performed a Monte Carlo permutation test to assess whether children's observed recurrence rates of the first and last therapy session exceeded chance level, and thus significantly differed from randomly generated recurrence rates (i.e., if a true temporal pattern could be observed). For each child, RRpeak was calculated 1000 times using a random distribution of the original data, that is, without any temporal structure. RRpeak was considered significantly different from chance if the probability that the empirical value occurred in these random samples was small.

To examine whether synchrony between child (n = 10) and therapy dog increased over time, we used a repeated measures ANOVA[1] to compare the DCRP measures *proportion of synchrony, recurrence rate*, RR_{peak} and Q_{los} of the first and last therapy session. We calculated confidence intervals and the generalized eta squared ($_nG^2$) as a measure of effect size (Olejnik & Algina 2003; Lakens 2013).

A value of ${}_nG^2$ of around .02 is considered small, .13 medium, and .26 large (Bakeman, 2005).

We then used descriptive statistics and non-parametric Monte Carlo permutation tests to explore any differences in the DCRP measures between children with DS (n = 5) and ASD (n = 5). To examine whether children's emotional and behavioral problems decreased after the therapy, we calculated differences between the CBCL scores before and after the intervention, for the whole group and separately for the children with DS and ASD.

Figure 2. Average Diagonal Cross-Recurrence Profile (DCRP) plot of this study (n = 10)



Note. The X-axis displays the delay in .5 seconds, and the Y-axis the recurrence rate (the proportion of behavioral matches of participant and dog). The proportion of synchrony represents the proportion of recurrence at the exact same time, while the measure RRpeak represents the highest proportion of recurrence within this plot.

[1] The normality assumption was checked prior to performing the analyses. Nonetheless, because of the small sample size we also performed non-parametric Monte Carlo permutation tests, which confirmed our results.

4.2 RESULTS

We first performed a Monte Carlo permutation test to assess whether children's observed RRpeak in the first and final therapy session significantly differed from randomly generated values. This was the case for all children in our sample (all p-values < .01). We then investigated whether the DCRP measures improved significantly between the first and last session of dog therapy (see Table 2).

Proportion of synchrony

The proportion of synchrony represents instances when both child and dog are moving in the same direction at the exact same time. Nine children had a higher proportion of synchrony during the last therapy session compared to the first one. A repeated measures ANOVA shows this difference is statistically significant, with a high effect size ($F(1,9) = 11.81$, $p = .007$, 90% CI [.03, .10], ${}_nG^2 = .38$).

Recurrence rate

The proportion of recurrence across the DCRP gives a more detailed view of the synchrony between the child's and dog's movements in the 30-second window around the line of synchrony. The recurrence rate increased significantly in the last therapy session, with a high effect size ($F(1,9) = 10.3$, $p = .011$, 90% CI [.02, .06], ${}_nG^2 = .37$).

RRpeak

This measure represents the highest proportion of recurrent points found in the DCRP of the children. The difference in RRpeak between the first and last therapy session was statistically significant ($F(1,9) = 11.62$, $p = .008$, 90% CI [.04, .12]), again with a high effect size (${}_nG^2 = .42$).

Qlos

The Qlos measures show that during both sessions, children more often temporally led the dog than the other way around. During the final session, however, the asymmetry between child and dog appeared to be less ($M_{first\ session} = -.13$, $M_{last\ session} = -.07$). This difference just fell short of significance ($F(1,9) = 2.55$, $p = .07$, 90% CI [-.01, .13], ${}_nG^2 = .11$).

Difference between children with ASD and DS

On average, the five children with ASD showed a greater increase in the DCRP measures over time, apart from the Qlos measure. This indicates more synchrony between children with ASD and their therapy dogs after six sessions, compared to the children with DS. However, none of the differences were statistically significant.

CBCL measures

On average, the children showed a decrease in problem behavior after the therapy sessions, as their parents indicated by lower scores on the CBCL scales internalizing problems, externalizing problems and the total problem scale (see Table 3). None of the differences were statistically significant. The children with DS showed a bigger decrease on the problem scales, compared to the children with ASD. This difference was not statistically significant.

Table 3. DCRP and CBCL measures for each child, and overall

Child	Diagnosis	Session	Prop. Sync	Rec. rate	RR_{peak}	Q_{los}	CBCL intern. problems	CBCLextern. Problems	CBCL total problems
1	DS	first	0.02	0.01	0.05	-0.20	18	5	40
		last	0.06	0.03	0.12	-0.13	17	8	42
2	ASD	first	0.04	0.02	0.09	0.01	4	33	77
		last	0.08	0.04	0.13	0.03	3	32	77
3	DS	first	0.03	0.02	0.07	-0.12	8	6	38
		last	0.06	0.03	0.11	-0.16	4	2	18
4	ASD	first	0.03	0.01	0.06	-0.16	16	33	106
		last	0.01	0.01	0.02	-0.05	16	35	110
5	DS	first	0.02	0.01	0.06	-0.11	2	2	14
		last	0.05	0.01	0.09	-0.14	0	2	10
6	DS	first	0.02	0.01	0.04	-0.10	5	0	12
		last	0.09	0.05	0.16	-0.09	1	0	3
7	ASD	first	0.05	0.01	0.06	-0.15	32	24	90
		last	0.17	0.10	0.23	-0.04	24	24	79
8	DS	first	0.02	0.01	0.04	-0.36	17	20	74
		last	0.05	0.03	0.08	-0.02	4	13	34
9	ASD	first	0.03	0.01	0.06	-0.13	8	18	61
		last	0.14	0.10	0.20	-0.03	16	18	68
10	ASD	first	0.03	0.01	0.04	0.04	13	11	57
		last	0.20	0.09	0.23	-0.04	13	12	62
Mean		first	0.03	0.01	0.06	-0.13	12.30	15.20	56.90
		last	0.09	0.05	0.14	-0.07	9.80	14.60	50.30

4.3 DISCUSSION

This study investigated synchrony between children with ASD or DS and their therapy dogs. We compared patterns of synchronous movements during the first and final session of a six-week Dog-Assisted Therapy (DAT) program. Movement synchrony has been hypothesized as an underlying mechanism of animal-assisted therapies. The clear-cut way in which dogs communicate would enable children with ASD and DS to establish synchronous movement patterns, which they can later extend to human interactions (Martin & Farnum, 2002; Verheggen et al., 2017; Winnicot, 1986). This study is the first to investigate whether synchronous movement patterns between child and therapy dog increase over time during therapy. Given that the social problems of children with ASD seem qualitatively different from those of children with DS (DiGuiseppi et al., 2010), we explored differences between the children in terms of synchrony during the therapy sessions.

We used Cross-Recurrence Quantification Analysis (CRQA), which enabled us to operationalize synchrony between child and dog not only as matching movement patterns at the exact same time, but also across an interval of 30 s to accommodate for the response latencies of children with ASD and DS (Inui et al., 1995; Wallen et al., 2010; Welsh & Elliott, 2001; Torriani-Pasin et al., 2013). Results demonstrate a significant increase in synchrony of the movements of child and therapy dog during the sixth therapy session. Importantly, there was indeed not only an increase in synchrony at the exact same time, but also across an interval of 30 s around this point, and an increase in the highest proportion of recurrent points. The results also suggest an increase in the coupling between child and dog during the final session (lower Qlos measure), meaning that child and dog became more aligned (mutually attuned) in their movements. This last change in synchrony, however, just fell short of significance.

Previous studies on DAT have demonstrated a positive effect on self-esteem, communication and social interaction of children with ASD (Berry et al., 2013; Silva, Correia, Lima, Magalhães, & de Sousa, 2011). Other research has shown that therapy dogs have a calming and de-arousing influence on children with DS (Esteves & Stokes, 2008; Limond et al., 1997). Although synchrony has been proposed as a possible mechanism underlying the positive effects of DAT, this study is the first to demonstrate an increase in synchrony during these therapy sessions.

While we did see the expected decrease in problem behavior after the therapy, this was not statistically significant, which may be due to the small sample size. That said, the link between interventions to increase movement synchrony and adaptive behavior has been established in other areas. For example, synchrony using dance and music has been associated with social bonding (Hagen & Bryant, 2003; Hagen & Hammerstein, 2009), and induced synchrony through movement has a positive effect on the extent to which partners trust each other, resulting in an increase in prosocial behavior (Leclère et al., 2014; Fessler & Holbrook, 2016; Reddish et al., 2013; Stern, 2010; Tarr et al., 2015).

An interesting outcome is that children with ASD showed a bigger increase in synchronous movement behavior during the final therapy session, but a smaller decrease in their emotional and behavioral problems compared to children with DS, as reported by their parents. Although this was not statistically significant, a clear trend in the data could be observed. A reason for this might be that the impairments of children with ASD in social interactions are more severe than those of children with DS (DiGuiseppi et al., 2010). The children with ASD had significantly more problem behavior at the start of the study compared to the children with DS (see table 1). Indeed, research has shown that children with ASD are more 'resistant' to human social interactions than children with DS (Adamson, Deckner, & Bakeman, 2010; Dawson et al., 2004), while other research indicates that children with ASD comprehend animal communication better than human communication (Prothmann, Ettrich, & Prothmann, 2009), which may explain their greater increase in synchrony with the therapy dogs.

4.3.1 Limitations

The number of participants in this study calls for caution with respect to the generalizability of our findings. That said, the smaller number of participants did enable an in-depth investigation of the synchrony process during the therapy. Thorough analyses like these i.e., measuring synchrony across long time series of (coded) behaviors, are crucial to strengthen the clinical use of dog-assisted therapy, as it is not just essential to know if an intervention works, but also how it works (Brazil, Ozer, Cloutier, Levine, & Stryer, 2005). The small sample size of the current study did refrain us from calculating correlations between measures of behavioral problems and

synchrony between child and therapy dog (cf. Schönbrodt & Perugini, 2013; Yarkoni, 2009). Future studies with considerably higher levels of statistical power can reveal important information about the association between child-animal synchrony in animal assisted therapy and behavioral outcomes in daily life.

In this study we did not characterize the children in terms of their cognitive and social functioning and language use other than the scores of the CBCL on problem behaviors (CBCL; Achenbach et al., 2002). Although this questionnaire is widely used and research has shown that parents can adequately assess the behavior of their children (Moretti, Obsuth, Moretti, & Obsuth, 2010; Warnick, Bracken, & Kasl, 2008), researchers have indicated that the three-point Likert scale of the CBCL (not true, sometimes true, often true) may limit the detection of change in behavioral problems over time (McClendon et al., 2011). The CBCL has also been criticized for only measuring children's emotional and behavioral problems, but not the presence or absence of pro-social behavior (Dekker et al., 2002; Verhulst, Koot, & Ende, 1994).

Lastly, our study does not shed light on the minimum number of DAT sessions necessary to yield the most optimal results, while this has been indicated as an important avenue for future research (O'Haire, 2013). In the current study, some measures failed to reach significance, and it is unclear if this is due to the limited number of sessions (six), the sample size, or another unknown factor.

4.3.2 Future directions

Our study is the first to provide preliminary evidence that behavioral synchrony is a key mechanism contributing to the effect of DAT for children with ASD and DS. To further strengthen the knowledge base and to increase the generalizability of our findings, more research is needed. Apart from larger sample sizes, future studies could make use of advanced movement analyzes involving technology such as movement tracking using sensors, or optoelectronic cameras. In addition, an interesting avenue for future studies is to examine differences between typically developing children and children with ASD or DS while interacting with a dog. A comparison of these groups may provide us with more information about the specific patterns of behavioral (movement) synchrony between these children and therapy dogs, which may inform us about how we can improve their communication and social interactional skills.

REFERENCES

Abney, D. H., Paxton, A., Dale, R., & Kello, C. T. (2015). Movement dynamics reflect a functional role for weak coupling and role structure in dyadic problem solving. *Cognitive Processing*, 16(4), 325–332. https://doi.org/10.1007/s10339-015-0648-2

Abney, D. H., Warlaumont, A. S., Oller, D. K., Wallot, S., & Kello, C. T. (2017). Multiple Coordination Patterns in Infant and Adult Vocalizations. *Infancy*, 22(4), 514–539. https://doi.org/10.1111/infa.12165

Achenbach, T. M., Dumenci, L., & Rescorla, L. A. (2002). Ten-Year Comparisons of Problems and Competencies for National Samples of Youth. *Journal of Emotional and Behavioral Disorders*, 10(4), 194–203. https://doi.org/10.1177/10634266020100040101

Adamson, L. B., Deckner, D. F., & Bakeman, R. (2010). Early interests and joint engagement in typical development, autism, and Down syndrome. *Journal of Autism and Developmental Disorders*, 40(6), 665–676. https://doi.org/10.1007/s10803-009-0914-1

Babad, E., Bernieri, F., & Rosenthal, R. (1991). Students as Judges of Teachers' Verbal and Nonverbal Behavior. *American Educational Research Journal*, 28(1), 211–234. https://doi.org/10.3102/00028312028001211

Bakeman, R. (2005). Recommended effect size statistics for repeated measures designs. *Behavior Research Methods*, 37(3), 379–384. https://doi.org/10.3758/BF03192707

Beebe, B., Sorter, D., Rustin, J., & Knoblauch, S. (2003). A Comparison of Meltzoff, Trevarthen, and Stern. *Psychoanalytic Dialogues*, 13(6), 777–804. https://doi.org/10.1080/10481881309348768

Berry, A., Borgi, M., Francia, N., Alleva, E., & Cirulli, F. (2013a). Use of assistance and therapy dogs for children with autism spectrum disorders: a critical review of the current evidence. *J Altern Complement Med.*, 19(2), 73–80. https://doi.org/10.1089/acm.2011.0835

Brazil, K., Ozer, E., Cloutier, M. M., Levine, R., & Stryer, D. (2005). From theory to practice: improving the impact of health services research. *BMC Health Services Research*, 5(1), 1. https://doi.org/10.1186/1472-6963-5-1

Cirulli, F., Borgi, M., Berry, A., Francia, N., & Alleva, E. (2011). Animal-assisted interventions as innovative tools for mental health. *Annali Dell'Istituto*

Superiore Di Sanita, 47(4), 341–348. https://doi.org/DOI: 10.4415/ANN_11_04_04

Cox, R. F. A., van der Steen, S., Guevara, M., de Jonge-Hoekstra, L., & van Dijk, M. (2016). Chromatic and Anisotropic Cross-Recurrence Quantification Analysis of Interpersonal Behavior (pp. 209–225). Springer International Publishing. https://doi.org/10.1007/978-3-319-29922-8_11

Cox, R. F. A., & van Dijk, M. (2013). Microdevelopment in Parent-Child Conversations: From Global Changes to Flexibility. *Ecological Psychology*, 25(3), 304–315. https://doi.org/10.1080/10407413.2013.810095

Davis, T. J., Pinto, G. B., & Kiefer, A. W. (2017). The Stance Leads the Dance: The Emergence of Role in a Joint Supra-Postural Task. *Frontiers in Psychology, 8*. https://doi.org/10.3389/fpsyg.2017.00718

Davis, T., Pinto, G., Psychology, A. K.-F. in, & (2017). The stance leads the dance: the emergence of role in a joint supra-postural task. *Ncbi.Nlm.Nih.Gov*. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5423272/

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early Social Attention Impairments in Autism: Social Orienting, Joint Attention, and Attention to Distress. *Developmental Psychology*, 40(2), 271–283. https://doi.org/10.1037/0012-1649.40.2.271

de Graag, J. A., Cox, R. F. A., Hasselman, F., Jansen, J., & de Weerth, C. (2012). Functioning within a relationship: Mother–infant synchrony and infant sleep. *Infant Behavior and Development*, 35(2), 252–263. https://doi.org/10.1016/j.infbeh.2011.12.006

De Jonge-Hoekstra, L., Van der Steen, S., Van Geert, P., & Cox, R. F. A. (2016). Asymmetric Dynamic Attunement of Speech and Gestures in the Construction of Children's Understanding. *Frontiers in Psychology, 7*, 473. https://doi.org/10.3389/fpsyg.2016.00473

Dekker, M. C., Koot, H. M., Ende, J. van der, & Verhulst, F. C. (2002). Emotional and behavioral problems in children and adolescents with and without intellectual disability. *Journal of Child Psychology and Psychiatry*, 43(8), 1087–1098. https://doi.org/10.1111/1469-7610.00235

DiGuiseppi, C., Hepburn, S., Davis, J. M., Fidler, D. J., Hartway, S., Lee, N. R., … Robinson, C. (2010). Screening for autism spectrum disorders in children with Down syndrome: population prevalence and screening test characteristics. *Journal of Developmental and Behavioral Pediatrics*: JDBP, 31(3), 181–191. https://doi.org/10.1097/DBP.0b013e3181d5aa6d

Duranton, C., Bedossa, T., & Gaunet, F. (2017). The perception of dogs' behavioural synchronization with their owners depends partially on expertise in behaviour. https://doi.org/10.1016/j.applanim.2017.11.004

Einfeld, S. L., & Tonge, B. J. (1995). The Developmental Behavior Checklist: The development and validation of an instrument to assess behavioral and emotional disturbance in children and adolescents with mental retardation. *Journal of Autism and Developmental Disorders,* 25(2), 81–104. https://doi.org/10.1007/BF02178498

Eisenhower, A. S., Baker, B. L., & Blacher, J. (2005). Preschool children with intellectual disability: syndrome specificity, behaviour problems, and maternal well-being. *Journal of Intellectual Disability Research*, 49(9), 657–671. https://doi.org/10.1111/j.1365-2788.2005.00699.x

Esteves, S., & Stokes, T. (2008). Social effects of a dog's presence on children with disabilities. *Anthrozoös*. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/08927936.2008.11425166

Feldman, R. (2007). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *Journal of Child Psychology and Psychiatry,* 48(3–4), 329–354. https://doi.org/10.1111/j.1469-7610.2006.01701.x

Fessler, D. M. T., & Holbrook, C. (2016). Synchronized behavior increases assesments of the formidability and cohesion of coalitions. *Evolution and Human Behavior,* 37(6), 502–509. https://doi.org/10.1016/j.evolhumbehav.2016.05.003

Finck, K. S. (1993). Finck-1993-Children, their pet dogs, and affect attument. pdf.

Fogel, A., Dedo, J. Y., & McEwen, I. (1992). Effect of postural position and reaching on gaze during mother-infant face-to-face interaction. *Infant Behavior and Development,* 15(2), 231–244. https://doi.org/10.1016/0163-6383(92)80025-P

Forster, S., & Iacono, T. (2014). The nature of affect attunement used by disability support workers interacting with adults with profound intellectual and multiple disabilities. *Journal of Intellectual Disability Research, 58* (12), 1105–1120. https://doi.org/10.1111/jir.12103

Griffioen, R., van der Steen, S., Cox, R. F. A., Verheggen, T., & Enders-Slegers, M.-J. (2019). Verbal Interactional Synchronization between Therapist and Children with Autism Spectrum Disorder during Dolphin Assisted Therapy: Five Case Studies. *Animals, 9* (10), 716. https://doi.org/10.3390/ani9100716

Hagen, E. H., & Bryant, G. A. (2003). Music and dance as a coalition signaling system. *Human Nature,* 14(1), 21–51. https://doi.org/10.1007/s12110-003-1015-z

Hagen, E. H., & Hammerstein, P. (2009). Did Neanderthals and other early humans sing? Seeking the biological roots of music in the territorial advertisements of primates, lions, hyenas, and wolves. *Musicae Scientiae,* 13(2_suppl), 291–320. https://doi.org/10.1177/1029864909013002131

Hall, S. S., Wright, H. F., Hames, A., & Mills, D. S. (2016). The long-term benefits of dog ownership in families with children with autism. *Journal of Veterinary Behavior, 13*. https://doi.org/10.1016/j.jveb.2016.04.003

Harrist, A. W., & Waugh, R. M. (2002). Dyadic synchrony: Its structure and function in children's development. *Developmental Review, 22* (4), 555–592. https://doi.org/10.1016/S0273-2297(02)00500-2

Inui, N., Yamanishi, M., & Tada, S. (1995). Simple Reaction Times and Timing of Serial Reactions of Adolescents with Mental Retardation, Autism, and down Syndrome. *Perceptual and Motor Skills, 81* (3), 739–745. https://doi.org/10.2466/pms.1995.81.3.739

Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., Jasnow, M. D., Rochat, P., & Stern, D. N. (2001). Rhythms of Dialogue in Infancy: Coordinated Timing in Development. *Source: Monographs of the Society for Research in Child Development Rhythms of Dialogue in Infancy: Coordinated Timing in Development, 66* (2). Retrieved from http://www.jstor.org/stable/3181589

Kasari, C., & Freeman, S. F. N. (2001). Task-Related Social Behavior in Children With Down Syndrome. *American Journal on Mental Retardation, 106* (3), 253. https://doi.org/10.1352/0895-8017(2001)

Knott, F., Lewis, C., & Williams, T. (1995). Sibling Interaction of Children with Learning Disabilities: A Comparison of Autism and Down's Syndrome. *Journal of Child Psychology and Psychiatry, 36* (6), 965–976. https://doi.org/10.1111/j.1469-7610.1995.tb01343.x

La Malfa, G., Lassi, S., Bertelli, M., Salvini, R., & Placidi, G. F. (2004). Autism and intellectual disability: a study of prevalence on a sample of the Italian population. *Journal of Intellectual Disability Research, 48* (3), 262–267. https://doi.org/10.1111/j.1365-2788.2003.00567.x

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in Psychology, 4*, 863. https://doi.org/10.3389/fpsyg.2013.00863

Landa, R. (2007). Early communication development and intervention for children with autism. *Mental Retardation and Developmental Disabilities Research Reviews, 13* (1), 16–25. https://doi.org/10.1002/mrdd.20134

Leclère, C., Viaux, S., Avril, M., Achard, C., Chetouani, M., Missonnier, S., & Cohen, D. (2014). Why Synchrony Matters during Mother-Child Interactions: A Systematic Review. *PLoS ONE, 9* (12), e113571. https://doi.org/10.1371/journal.pone.0113571

Limond, J., Bradshaw, J., & Cormack, M. (1997). Behavior of children with learning disabilities interacting with a therapy dog. *Anthrozoös*. Retrieved from http://www.tandfonline.com/doi/abs/10.2752/089279397787001139

Marwan, N., Carmenromano, M., Thiel, M., & Kurths, J. (2007). Recurrence plots for the analysis of complex systems. *Physics Reports, 438* (5–6), 237–329. https://doi.org/10.1016/j.physrep.2006.11.001

Marwan, N., Thiel, M., & Nowaczyk, N. R. (2002). Cross recurrence plot based synchronization of time series. *Nonlinear Processes in Geophysics, 9* (3/4), 325–331. https://doi.org/10.5194/npg-9-325-2002

McClendon, D. T., Warren, J. S., M. Green, K., Burlingame, G. M., Eggett, D. L., & McClendon, R. J. (2011). Sensitivity to change of youth treatment outcome measures: a comparison of the CBCL, BASC-2, and Y-OQ. *Journal of Clinical Psychology, 67* (1), 111–125. https://doi.org/10.1002/jclp.20746

McPartland, J., & Volkmar, F. R. (2012). Autism and related disorders. In *Handbook of clinical neurology* (Vol. 106, pp. 407–418). https://doi.org/10.1016/B978-0-444-52002-9.00023-1

Melson, G. F. (1988). Availability of and Involvement with Pets by Children: Determinants and Correlates. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 2* (1), 45–52. https://doi.org/10.2752/089279389787058181

Melson, G. F., & Fogel, A. (1989). Children's Ideas about Animal Young and their Care: A Reassessment of Gender Differences in the Development of Nurturance. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 2* (4), 265–273. https://doi.org/10.2752/089279389787057920

Moretti, M. M., Obsuth, I., Moretti, M. M., & Obsuth, I. (2010). Child Behavior Checklist. In *The Corsini Encyclopedia of Psychology*. Hoboken, NJ, USA: John Wiley & Sons, Inc. https://doi.org/10.1002/9780470479216.corpsy0165

Myers, O. G. (2007). *The significance of children and animals: Social development and our connections to other species*. Purdue University Press.

Naess, K.-A. B., Nygaard, E., Ostad, J., Dolva, A.-S., & Halaas Lyster, S.-A. (2017). Disability and Rehabilitation The profile of social functioning in children with Down syndrome. https://doi.org/10.1080/09638288.2016.1194901

Nimer, J., & Lundahl, B. (2007). Animal-Assisted Therapy: A Meta-Analysis. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 20* (3), 225–238. https://doi.org/10.2752/089279307X224773

Nomikou, I., Leonardi, G., Rohlfing, K. J., & Rączaszek-Leonardi, J. (2016). Constructing Interaction: The Development of Gaze Dynamics. *Infant and Child Development, 25* (3), 277–295. https://doi.org/10.1002/icd.1975

O'Haire, M. E. (2013). Animal-Assisted Intervention for Autism Spectrum Disorder: A Systematic Literature Review. *Journal of Autism and Developmental Disorders, 43* (7), 1606–1622. https://doi.org/10.1007/s10803-012-1707-5

O'Haire, M. E. (2017). Research on animal-assisted intervention and autism spectrum disorder, 2012–2015. *Applied Developmental Science, 21* (3), 200–216. https://doi.org/10.1080/10888691.2016.1243988

O'Haire, M. E., Mckenzie, S. J., Beck, A. M., & Slaughter, V. (2015). Animals may act as social buffers: Skin conductance arousal in children with autism spectrum disorder in a social context. *Developmental Psychobiology*. https://doi.org/10.1002/dev.21310

Olejnik, S., & Algina, J. (2003). Generalized eta and omega squared statistics: measures of effect size for some common research designs. *Psychological Methods*. https://doi.org/10.1037/1082-989X.8.4.434

Perkins, J., Bartlett, H., Travers, C., & Rand, J. (2008). Dog-assisted therapy for older people with dementia: A review. *Australasian Journal on Ageing, 27* (4), 177–182. https://doi.org/10.1111/j.1741-6612.2008.00317.x

Prothmann, A., Ettrich, C., & Prothmann, S. (2009). Preference for, and Responsiveness to, People, Dogs and Objects in Children with Autism. *Anthrozoös, 22* (2), 161–171. https://doi.org/10.2752/175303709X434185

Pueschel, S. M., Louis, S., McKnight, P., JLH, D., WW, I., AW, W., … Orozco CB, S. S. E. C. R. S. (1991). Seizure Disorders in Down Syndrome. *Archives of Neurology, 48* (3), 318–320. https://doi.org/10.1001/archneur.1991.00530150088024

Reddish, P., Fischer, R., Bulbulia, J., Bulbulia, J., & Huici, C. (2013). Let's Dance

Together: Synchrony, Shared Intentionality and Cooperation. *PLoS ONE, 8* (8), e71182. https://doi.org/10.1371/journal.pone.0071182

Redefer, L. A., & Goodman, J. F. (1989). Brief report: Pet-facilitated therapy with autistic children. *Journal of Autism and Developmental Disorders, 19* (3), 461–467. https://doi.org/10.1007/BF02212943

Reuzel, E., Embregts, P. J. C. M., Bosman, A. M. T., Cox, R., van Nieuwenhuijzen, M., & Jahoda, A. (2013). Conversational Synchronization in Naturally Occurring Settings: A Recurrence-Based Analysis of Gaze Directions and Speech Rhythms of Staff and Clients with Intellectual Disability. *Journal of Nonverbal Behavior, 37* (4), 281–305. https://doi.org/10.1007/s10919-013-0158-9

Richardson, D. C., & Dale, R. (2005). Looking To Understand: The Coupling Between Speakers' and Listeners' Eye Movements and Its Relationship to Discourse Comprehension. *Cognitive Science, 29* (6), 1045–1060. https://doi.org/10.1207/s15516709cog0000_29

Roberts, J. E., Price, J., & Malkin, C. (2007). Language and communication development in down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews, 13* (1), 26–35. https://doi.org/10.1002/mrdd.20136

Rondal, J. A. (2009). Spoken Language in Persons with Down Syndrome: A LifeSpan Perspective. *International Journal of Early Childhood Special Education, 1* (2).

Sable, P. (2013). The Pet Connection: An Attachment Perspective. *Clinical Social Work Journal, 41* (1), 93–99. https://doi.org/10.1007/s10615-012-0405-2

Sanders, C. R. (2003). Actions Speak Louder than Words: Close Relationships between Humans and Nonhuman Animals. *Symbolic Interaction, 26* (3), 405–426. https://doi.org/10.1525/si.2003.26.3.405

Schönbrodt, F. D., & Perugini, M. (2013). At what sample size do correlations stabilize? *Journal of Research in Personality, 47* (5), 609–612. https://doi.org/10.1016/j.jrp.2013.05.009

Shockley, K., Butwill, M., Zbilut, J. P., & Webber, C. L. (2002). Cross recurrence quantification of coupled oscillators. *Physics Letters A, 305* (1–2), 59–69. https://doi.org/10.1016/S0375-9601(02)01411-1

Sigman, Marian, Ruskin, E., Arbelle, S., Corona, R., Dissanayake, C., Espinosa, M., … Robinson, B. F. (1999). Continuity and Change in the Social Compe-

tence of Children with Autism, Down Syndrome, and Developmental Delays. *Monographs of the Society for Research in Child Development.* WileySociety for Research in Child Development. https://doi.org/10.2307/3181510

Silva, K., Correia, R., Lima, M., Magalhães, A., & de Sousa, L. (2011a). Can Dogs Prime Autistic Children for Therapy? Evidence from a Single Case Study. *The Journal of Alternative and Complementary Medicine, 17* (7), 655–659. https://doi.org/10.1089/acm.2010.0436

Stern, D. (2010). The issue of vitality. *Nordic Journal of Music Therapy, 19* (2), 88–102. https://doi.org/10.1080/08098131.2010.497634

Stivers, T., Enfield, N. J., Brown, P., Englert, C., Hayashi, M., Heinemann, T., … Levinson, S. C. (2009). Universals and cultural variation in turn-taking in conversation. *Proceedings of the National Academy of Sciences of the United States of America, 106* (26), 10587–10592. https://doi.org/10.1073/pnas.0903616106

Tarr, B., Launay, J., Cohen, E., & Dunbar, R. (2015). Synchrony and exertion during dance independently raise pain threshold and encourage social bonding. *Biology Letters, 11* (10). Retrieved from http://rsbl.royalsociety-publishing.org/content/11/10/20150767

Torriani-Pasin, C., Bonuzzi, G. M., Soares, M. A., Antunes, G. L., Palma, G. C., Monteiro, C. B., … Corrêa, U. C. (2013). Performance of Down syndrome subjects during a coincident timing task. *International Archives of Medicine, 6* (1), 15. https://doi.org/10.1186/1755-7682-6-15

Trevarthen, C., & Daniel, S. (2005). Disorganized rhythm and synchrony: Early signs of autism and Rett syndrome. *Brain and Development, 27*, S25–S34. https://doi.org/10.1016/j.braindev.2005.03.016

Verheggen, T., Enders-Slegers, M.-J., & Eshuis, J. (2017). Enactive Anthrozoology: Toward an integrative theoretical model for understanding the therapeutic relationships between humans and animals - Human-Animal Interaction. *Human-Animal Interaction Bulletin, 5* (2), 13–35.

Verhulst, F. C., Koot, H. M., & Ende, J. (1994). Differential predictive value of parents' and teachers' reports of children's problem behaviors: A longitudinal study. *Journal of Abnormal Child Psychology, 22* (5), 531–546. https://doi.org/10.1007/BF02168936

Viau, R., Arsenault-Lapierre, G., Fecteau, S., Champagne, N., Walker, C.-D., & Lupien, S. (2010). Effect of service dogs on salivary cortisol secretion in autistic children. *Psychoneuroendocrinology, 35* (8), 1187–1193. https://doi.org/10.1016/j.psyneuen.2010.02.004

Wallen, M., & Walker, R. (2010). Occupational therapy practice with children with perceptual motor dysfunction: Findings of a literature review and survey. *Australian Occupational Therapy Journal, 42* (1), 15–25. https://doi.org/10.1111/j.1440-1630.1995.tb01306.x

Warnick, E. M., Bracken, M. B., & Kasl, S. (2008). Screening Efficiency of the Child Behavior Checklist and Strengths and Difficulties Questionnaire: A Systematic Review. *Child and Adolescent Mental Health, 13* (3), 140–147. https://doi.org/10.1111/j.1475-3588.2007.00461.x

Weijerman, M. E., & de Winter, J. P. (2010). Clinical practice. The care of children with Down syndrome. *European Journal of Pediatrics, 169* (12), 1445–1452. https://doi.org/10.1007/s00431-010-1253-0

Welsh, T. N., & Elliott, D. (2001). The Processing Speed of Visual and Verbal Movement Information by Adults with and Without Down Syndrome. *Adapted Physical Activity Quarterly, 18* (2), 156–167. https://doi.org/10.1123/apaq.18.2.156

Wright, H., Hall, S., Hames, A., Hardiman, J., Mills, R., & Mills, D. (2015). Pet dogs improve family functioning and reduce anxiety in children with Autism Spectrum Disorder. *Anthrozoos, 28* (4). https://doi.org/10.1080/08927936.2015.1070003

Yarkoni, T. (2009). Big Correlations in Little Studies: Inflated fMRI Correlations Reflect Low Statistical Power—Commentary on Vul et al. (2009). *Perspectives on Psychological Science, 4* (3), 294–298. https://doi.org/10.1111/j.1745-6924.2009.01127.x

Zbilut, J. P., Giuliani, A., & Webber, C. L. (1998). Detecting deterministic signals in exceptionally noisy environments using cross-recurrence quantification. *Physics Letters A, 246* (1–2), 122–128. https://doi.org/10.1016/S0375-9601(98)00457-5

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CHANGES IN CORTISOL AND HEART RATE VARIABILITY OF CHILDREN WITH DOWN SYNDROME AND CHILDREN WITH AUTISM SPECTRUM DISORDER DURING DOG-ASSISTED THERAPY.

Submitted

Abstract

Background. Dog-assisted therapy (DAT) is hypothesized to lower salivary cortisol levels and increase Heart Rate Variability (HRV) in children with autism spectreum disorder (ASD) and children with Down syndrome (DS).

Method. The authors compared pre- and post-samples of salivary cortisol and HRV of children (n = 20) who followed a Dog-assisted therapy program of six sessions.

Results The authors found a decrease of cortisol levels during single sessions, but no overall effect after 6 sessions (6 weeks). The effect of Dog-assisted therapy on the increase of HRV could not be confirmed.

Conclusion. This study is one of the first to use physiological measurements to test the effects of DAT on children with ASD and children with DS.

Keywords

Animal Assisted Interventions, HRV, Cortisol, Stress

5

CHANGES IN CORTISOL AND HEART RATE VARIABILITY OF CHILDREN WITH DOWN SYNDROME AND CHILDREN WITH AUTISM SPECTRUM DISORDER DURING DOG-ASSISTED THERAPY.

Richard E. Griffioen, Geert J.M. van Boxtel, Steffie van der Steen, Theo Verheggen, Marie-Jose Enders-Slegers.

Children with Down syndrome (DS) and children with Autism Spectrum disorder (ASD), often experience stress due to impaired social interaction and verbalization, e.g., when exposed to a psychosocial stressor like public speaking (Jansen, Gispen-de Wied, van der Gaag, & van Engeland, 2003; Jansen et al., 2006). These children seem more fearful than their typically developing peers (Ramirez & Kratochwill, 1997), use less effective coping strategies in response to stressful situations (Janssen, Schuengel, & Stolk, 2002), and have strong stress reactions to their social environment (Jansen et al., 2003).

Some lines of evidence suggest that interactions with animals, specifically dogs, may be stress-reducing for several populations (Berry, Borgi, Francia, Alleva, & Cirulli, 2013; Silva, Correia, Lima, Magalhães, & de Sousa, 2011). First, various studies have revealed positive effects of dog ownership on family functioning as well as decreased child anxiety and stress (Hall, Wright, Hames, & Mills, 2016; Viau et al., 2010; Wright et al., 2015). Typically developing children who are supported in a stressful situation by their own dog, experience less stress (as measured by children's self-reported feelings of stress and salivary cortisol) than children who are alone in the same situation, or who are supported by their parents (Kertes et al., 2016).

Dogs can also offer support in case of developmental or emotional problems (Motomura et al. 2004; Allen et al. 2001). Beetz and colleagues (Beetz, Julius,

Turner, & Kotrschal, 2012; Beetz, 2017) measured the cortisol levels of children with insecure attachment styles in the presence of dogs. The support by a friendly dog during the study was associated with significantly lower cortisol levels. This effect was strongly correlated with the time the children spent in physical contact with the dog. There is also some evidence that children admitted to a hospital benefit from interactions with dogs, especially with regard to their experienced anxiety and pain (Barker, Knisely, Schubert, Green, & Ameringer, 2015; Germone et al., 2019; Hart, 2006). However, a critical review concluded that most studies on human-animal interactions in hospital settings suffer from weak methodology and flagged construct validity (Chur-Hansen, McArthur, Winefield, Hanieh, & Hazel, 2014).

Research on the effects of having an assistance dog for children with ASD revealed that these children showed significantly lower cortisol levels when the assistance dog was in the house (Viau et al., 2010). Carlisle (Carlisle, 2014; 2015) also reported increased social skills in children with ASD and bonding to their assistance dogs. Lastly, Silva, Correia, Lima, Magalhães, and De Sousa (2011) describe a case report of a child with ASD who displayed more frequent and longer durations of positive interactions in the presence of a dog.

The positive effects of the interactions with dogs on stress symptoms discussed here have mostly been studied in settings in which the children's families were pet owners. Yet, stress reduction has also been an important hypothesized effect of animal-assisted therapy, and specifically dog-assisted therapy (DAT). DAT consists of structured one-on-one sessions, offered by trained professionals who work with certified therapy dogs. Much like other forms of therapy, the child visits the therapist and dog for a number of sessions, in which he/she works on specific therapeutic goals.

For children with DS or ASD, DAT has been found to improve their social interactions and communication with other people (Martin & Farnum, 2002; Redefer & Goodman, 1989), and to cope with stressful situations (Beetz, 2017; O'Haire, 2017; O'Haire, McKenzie, Beck, & Slaughter, 2015). A recent study on DAT (Griffioen, Van der Steen, Verheggen, Enders-Slegers & Cox, 2019) found a positive effect on behavioral synchrony, in children with DS and children with ASD. A recent literature review (O'Haire, 2017), however, found only two case studies in which stress and arousal were physiologically measured in children with ASD during animal-assisted therapy with horses (Tabares et al., 2012) and guinea pigs (O'Haire et al., 2015). To the best of our knowledge, no studies involving physiological measures on children with DS in the DAT-context were found.

Physiological measurements of stress

A relatively inexpensive and easy way to collect a biomarker of stress is salivary cortisol, which can safely be used in research with children. Research shows a relationship between stress and the hormone cortisol: The more stress a child experiences, the higher its cortisol levels become (Almela et al., 2011; Rai, Kaur, & Foing, 2012; Takai et al., 2004). The hypothalamus-pituitary-adrenocortical axis (HPA) is involved in activating the stress response and plays an important role in physiological coping (Hanrahan, McCarthy, Kleiber, Lutgendorf, & Tsalikian, 2006; Takai et al., 2004). As indicated by Hanrahan (Hanrahan et al., 2006), a wide range of factors should be considered while using this measure in research with children, including standardizing the time for sample collection, including baseline samples, using consistent collection materials and methods, controlling for certain drinks, foods, medications, and diagnoses, and establishing sound procedures and protocols.

In addition to cortisol, heart rate variability (HRV) is also a viable physiological indicator of stress (Almela et al., 2011; Rieger, Stoll, Kreuzfeld, Behrens, & Weippert, 2014.; Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012). HRV refers to the variation in intervals between successive heartbeats (IBIs: inter beat interval), and is an indicator of the functioning of the autonomic nervous system. The autonomic nervous system (parasympathetic and sympathetic branches) is the part of the nervous system that controls the visceral functions of the body, including the heart, the movements of the gastrointestinal areas and many other vital activities. Mental and emotional feelings directly influence the autonomic nervous system. Research shows that high HRV is related to rest and relaxation, while low HRV is related to effort and stress (Rieger et al., 2014; Thayer et al., 2012). HRV measurements identify the activity of the parasympathetic system by measuring the beat-to-beat alteration in heart rate, e.g., low HRV is indicative of reduced parasympathetic cardiac control (Boxtel et al, 2018; Evans et al., 2013).

In summary, no studies involving physiological measures to assess stress reduction on children with DS in the DAT-context were found. The two studies taking physiological measures of children with ASD in the DAT context were case studies involving horses (Tabares et al., 2012) and guinea pigs (O'Haire et al., 2015). This research therefore set out to investigate the following two research questions: 1)

To what extent is there a difference in the HRV measurements and cortisol levels of children with DS and ASD after following a 6-week DAT program? And 2) To what extent do HRV measurements and cortisol levels change during DAT sessions (comparing the measurements before and after the session)?

Ethical considerations

In our explorative study we will look at how the execution of various tasks in cooperation with a dog influences the experienced stress of children with DS and ASD. Given that this is an explorative study—the first in which physiological measures are used in a DAT context—and because we work with a vulnerable group of children, we have chosen not to use a (non-intervention) control group at this point.

In this study, twenty children with DS or ASD were followed for six weeks while they received dog-assisted therapy (DAT). At the start of the study, written consent was obtained from the parents of the children. The parents were also informed about the aim of the study, as well as about the protocol of the therapy. It was made clear to them that they were free to stop their participation at any moment.

During the research, the dog's welfare was continually monitored by a handler. All necessary precautions were taken to prevent possible harm to the dogs, such as limiting the time of interacting with the children. The Medical Ethical Review Committee of the University of Amsterdam stated that an official approval of this study was not required concerning the Medical Research Involving Human Subject Act (WMO).

5.1 MATERIALS AND METHODS

5.1.1 Design

The current study investigates the effect of a 6-week DAT program on the salivary cortisol levels and heart rate variability of 20 children with DS and children with ASD who received a weekly one-hour session of Dog-assisted therapy. Before and after every session we collected salivary cortisol and before, and after every session we also recorded the heart rate variability.

5.1.2 Participants

Twenty children volunteered in this study, eight children with Down syndrome (DS) (six males and two females with a mean age of 12, range 10-14 years) and twelve children with autism spectrum disorder (ASD) (eight males and four females with a mean age of 13, range 11-15 years). They all attended education at a school for students with special needs. No allergies and medication use were reported by their parents. The children were recruited through an invitation letter to the parents in the network of the first author, and by referrals from health-care professionals. All parents signed an informed consent and agreed with the procedure. Exclusion criteria were fear of dogs, severe dog allergy, wheel-chair dependency and reported aggression toward animals.

5.1.3 Procedure

The sessions with the dog took place at a gymnasium. The children were accompanied by a therapist. They worked together in a 30 min session, once a week for a period of 6 weeks. Activities during the sessions were selected from the CTAC Method (Domènec & Ristol 2012). We selected psycho-motor and socialization activities in particular, for example having the dog follow the child's movements. During the first phase of each session, the child and the dog, under the care of the therapist and handler, did some exercises to get used to performing the tasks. The second phase of each session was characterized by encouraging the child to build an obstacle course, and to lead the dog through these series of obstacles and ask the dog to perform certain commands, such as sitting and lying on a mat, slalom walk around cones and walking on a bench, or jumping over a low bar (Griffioen et al., 2019).

5.4.1 HRV Measurements

At the beginning of each session, the children were asked to put on a chest belt with heart rate sensor and wear a Polar device V800 wristwatch (Polar Electro Oy, Kempele Finland) to record N-N intervals (Inter beat intervals). The data were read into Polar FlowSync software after the sessions. The HRV of the children (n = 20) were registered during two periods of 3 minutes, before and at the end of each session. During this registration the children were asked to sit on a chair. Based on visual inspection, we chose the two artifact free periods. The artifacts were due to missing beats because of not right fitted chest belt and movements of the children.

Analysis method HRV - Time Domain Analysis. We first analyzed the global indicators of HRV. The analyzed time domain HRV parameters are the following: Average of the N-N intervals (Mnn) and the Standard deviation of the N-N intervals (SDnn) in seconds. The latter is the most straightforward measure of overall HRV. We also calculated the Root mean square of successive differences (RMSSD), which is the standardized average difference between consecutive beats). RMSSD is the most commonly used time domain measure for short (beat-to-beat) variations.

Analysis method HRV - Frequency domain. A more in-depth analysis of HRV was performed using the frequency bands. To be specific, we analyzed the LF (low frequency) band: 0.04 - 0.15 Hz (period of 6.7 - 25 s). This "blood pressure band" is associated with a relatively large contribution from the sympathetic branch of the autonomic nervous system. The HF (high frequency: 0.15 - 0.4 Hz; period of 2.5 - 6.7 s) "respiratory band", associated with a relatively large contribution from the parasympathetic branch of the autonomic nervous system, was also analyzed. Lastly, we used the LF / HF ratio, which is often used as index for the relative activation of the sympathetic versus the parasympathetic nervous system (van Boxtel et al., 2018).

HRV Data preparation. The HRV data was processed in 3 steps: pre-processing, data analysis and statistical analysis. The first step, pre-processing was intended to reach correct files with N-N intervals (IBIs) for each child, for each session and for the intervals within a session. Some children had less sessions because of insufficient artifact-free data, or had missed sessions due to illness. Secondly, the actual data analysis was performed. For the raw N-N intervals artifact correction

was applied. When a particular IBI was outside the range of + or - 3 standard deviations (SD) around the average, it was removed from the series and interpolated by means of a cubic spline interpolation. In total there were 144 measurements and the intervals averaged 209.1 ms (min. 34.6 – max. 319.5 s, SD = 76.5 ms).

HRV Statistical Analysis. The Root Mean Square of Successive Differences (RMSSD), The mean R-R (Mnn) and Standard Deviation of NN intervals (SDnn) were computed in the time domain, and Low Frequency (LF, 0,04 – 0.15 Hz), High Frequency (HF, 0.15 – 0.4 Hz), and the LF/HF ratio were computed from the Lomb-Scargle spectra. The data of SDnn were not normally distributed. We solved this by applying a logarithmic transformation. The log-transformed data was then analyzed. All variables obtained were analyzed using mixed effect (Non Linear Mixed Effects) models. This was done with the R-statistical package version 3.5.2. NLME models are able to handle missing data, and are able to decrease the residual variance in comparison with a regular repeated ANOVA (Pinheiro & Bates, 2019).

Cortisol Measurements. Samples of salivary cortisol were collected from the children prior to and at 10 minutes after sessions were completed for every session, at a similar time of day for each participant during six weeks. The collection was standardized using a Salivette (Sarstedt AG & Co, Numbrecht, Germany), a cotton role packaged in a plastic tube-like container, and the procedure was carried out by the same assistant every time. The child had to chew on the cotton role for 2 minutes. We controlled for foods and drinks for 1 hour before the samples (no caffeinated products, no dairy products and no steroids). In addition, children did not eat or drink for half an hour before each session. The samples were refrigerated within 1 hour after collection. After collecting samples for six weeks, we sent the samples to the laboratory of the Wilhelmina University Children Hospital of Utrecht, the Netherlands for analysis. Cortisol in saliva was measured without extraction using an in-house compe¬titive radio-immunoassay employing a polyclonal anti-cortisol-antibody (K7348). [1,2-3H(N)]-Hydrocortisone (PerkinElmer Inc, Groningen, The Netherlands, NET396250UC) was used as a tracer.

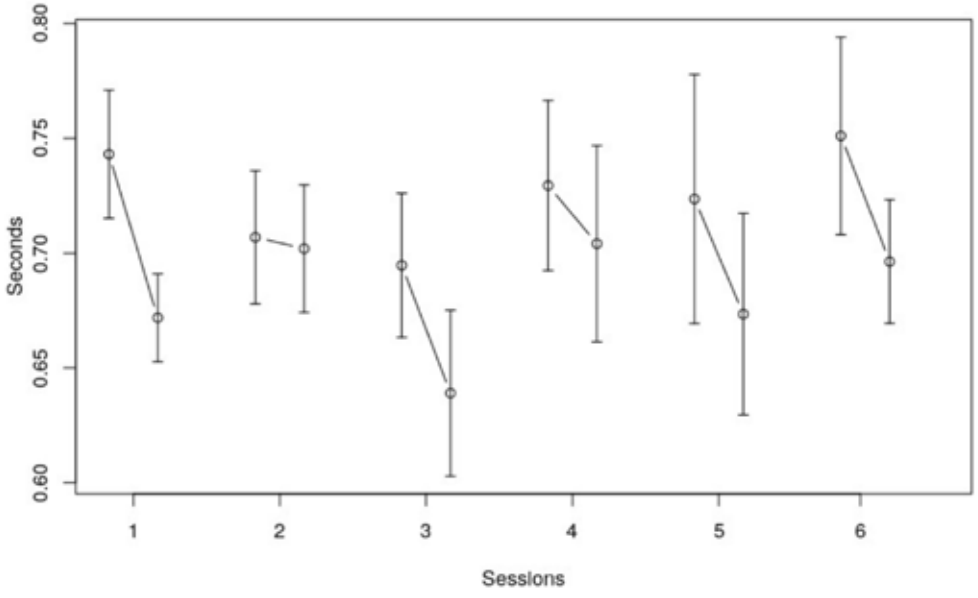
Cortisol Statistical Analysis. The cortisol samples obtained were also analyzed using mixed effect (LME) models with the R-statistical package version 3.5.2.

5.2 RESULTS

5.2.1 Heart Rate Variability, time domain

The overall average length of the N-N intervals (Mnn) was 0.69 s (SE 0.11 s). This corresponds to an average heart rate of 86.30 bpm. The averages were fairly normally distributed. Mnn does seem to decrease slightly in the third session, but a visual inspection of Figure 1 shows no clear trend in Mnn over the course of six sessions. Although there seemed no difference over all sessions, the Mnn before and after a session did vary. Figure 1 shows that the Mnn are somewhat higher at the beginning of each session, meaning that the heart rate is slightly lower at the beginning.

Figure 1. Mean of N-N intervals (Mnn).
The vertical axis displays the mean Mnn of the children in seconds, the horizontal axis represents the session number.



The standard deviations of the R-R intervals (SDnn) provide a global measure for HRV in the time domain. The average SDnn was 0.078 (SE 0.01) Again, no clear trend could be observed over the six sessions, although a visual inspection of Figure 2 shows that the SDnn seemed to decrease from the first to third session, and then increased again to a somewhat stable level over the last three sessions.The SDnn at the end of each session seemed lower than at the beginning of each session, indicating less variability over the course of a single session, see also the RMSSD data in Figure 3.

Figure 2. Standard-deviation of N-N intervals (SDnn).
The vertical axis displays the Standard deviation of N-N intervals of the children in seconds, the horizontal axis represents the session number.

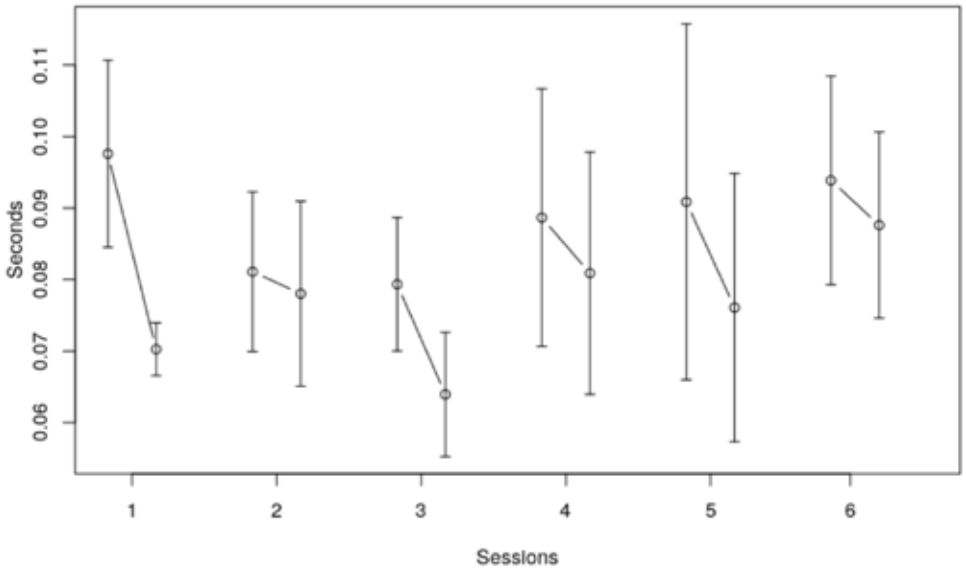
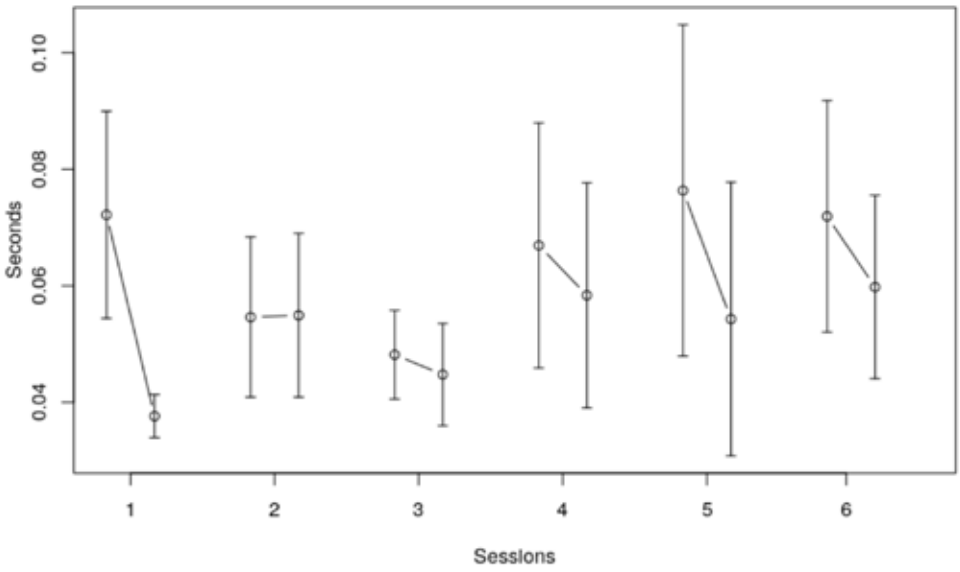


Figure 3. Root mean square of successive differences (RMSSD).
The vertical axis displays RMSSD in seconds, the horizontal axis represents the session number.



The Root mean square of successive differences (RMSSD) shows roughly the same picture, namely no clear trend over sessions, and a decrease of the heart rate variability within a session.

Table 1 shows the NLME model results for the Time domain measures (Mnn, LogSDnn and RMSSD). No significant changes in the Time domain measures were found over the six sessions. However, with regard to measures taken within a session, we found significant changes in Mnn ($F(1,113) = 12.86$, $p < .01$), SDnn ($F(1,113) = 5.45$, $p = .02$) and RMSSD ($F(1,113) = 12.96$, $p < .01$). No interaction effects were found.

Table 1. Mnn, LogSDnn and RMSSD results

		F	df	*p*
Mnn	Session	20.064	5,113	0.0830
	Interval within session	128.576	1,113	0.0005*
	Session*within session	0.6853	5,113	0.6355
SDnn	Session	15.261	5,113	0.1873
	Interval within session	54.518	1,113	0.0213*
	Session*within session	0.2777	5,113	0.9245
RMSSD	Session	11.591.014	5,113	0.1683
	Interval within session	12.959.291	1,113	0.0005*
	Session*within session	1.018.265	5,113	0.4104

5.2.2 Frequency Domain

With regard to the Low Frequency band (LF), no trend could be observed over the course of six sessions, as well as no clear trend within sessions. The High Frequency band (HF) showed a similar pattern as the Time Domain measures, and especially the RMSSD pattern. No clear trend over the six sessions could be observed, but HF seemed to decrease during four out of six sessions (see Figure 4).

Figure 4. HF band data.

The vertical axis displays the HF log-scale in seconds, the horizontal axis represents the session number.

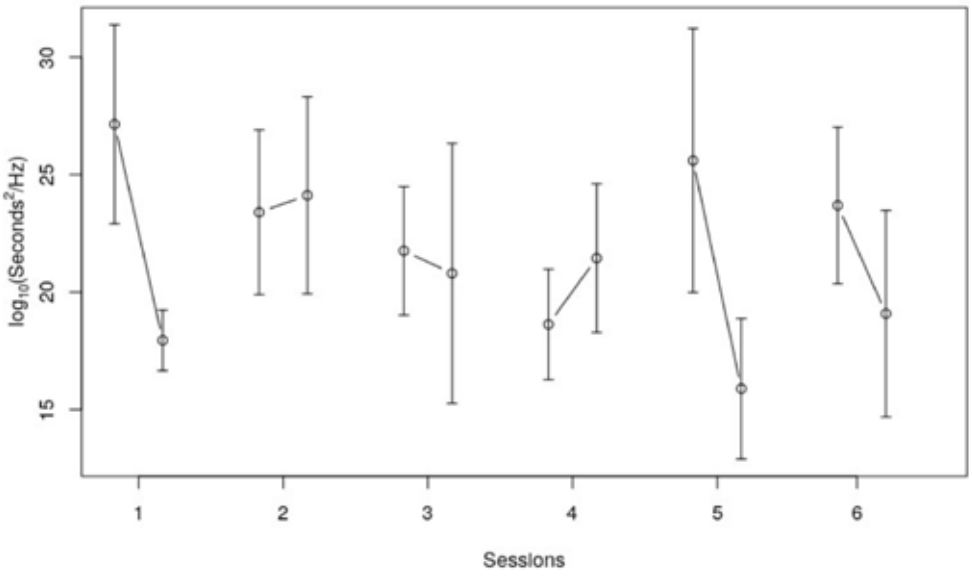
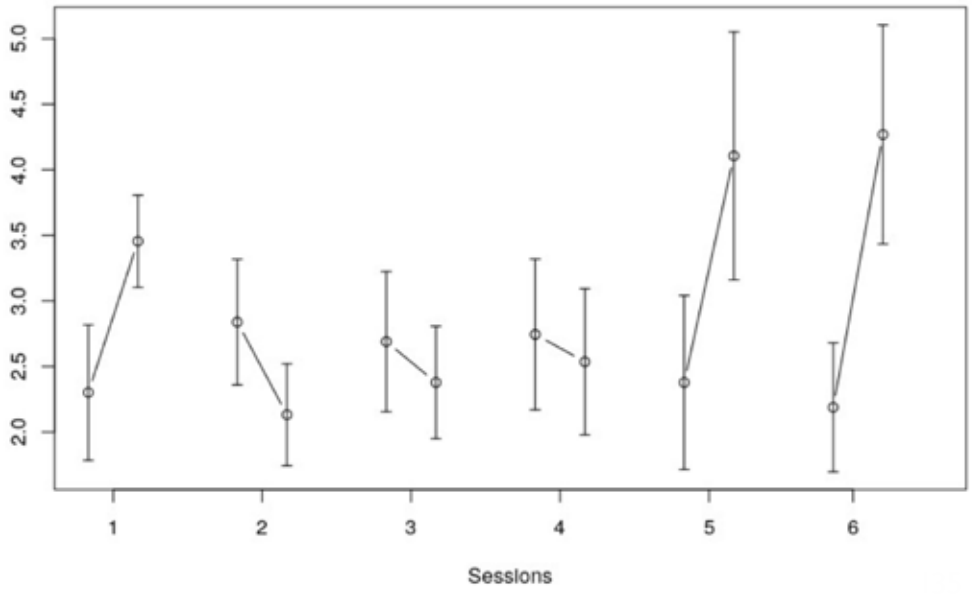


Table 2 shows the NLME model results for the Frequency domain measures (LF band, HF band and LF/HF). No significant findings for the LF band were observed. The within-session trend that could be observed for the HF band fell short of significance ($F(1,113) = 3.38$, $p = .07$). The within-session LF/HF did show a significant change ($F(1,113) = 4.96$, $p = 03$). The session*within session LF/HF also showed a significant change ($F(5,113) = 3.07$, $p = 0.01$) which indicates that the within-session effects of the LF/HF ratio differed across the sessions. This is also visible in Figure 5, that is, the changes in LF/HF ratio within the first, fifth and sixth session were bigger and in a different direction compared to the LF/HF ratio changes within the other sessions.

Table 2. NLME model results for the LF band, HF band, and LF/HF ratio
*p<0.05

		F	df	*p*
LF	Session	0.32508	5,113	0.8970
	Interval within session	0.23844	1,113	0.6263
	Session*within session	167.228	5,113	0.1470
HF	Session	0.51381	5,113	0.7653
	Interval within session	337.757	1,113	0.0687
	Session*within session	106.261	5,113	0.3850
LF/HF	Session	0.82692	5,113	0.5331
	Interval within session	496.285	1,113	0.0279*
	Session*within session	307.045	5,113	0.0123*

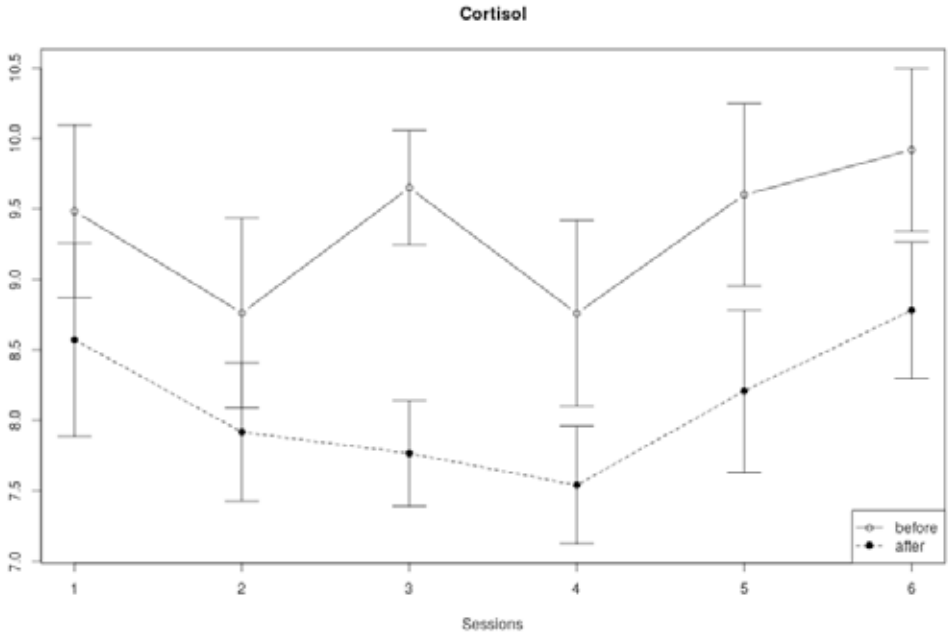
Figure 5. LF/HF ratio.
The vertical axis represents the LF/HF ratio in seconds, the horizontal axis displays the session number.



5.2.3 Cortisol measures

We found no clear trend with regard to the changes in cortisol levels over the six sessions (see Figure 6). Cortisol at the beginning of a session alternately decreased and increased over the course of six weeks, and cortisol levels at the end of a session decreased from the first to fourth session, and then increased again in the last two sessions. Yet, the cortisol levels measured within a session were always lower at the end of each session compared to levels at the start of the session.

Figure 6: Cortisol measures within and across sessions.
The vertical axis displays the cortisol measures in nmol/l, and the horizontal axis represents the session number.



In line with the visual inspection of Figure 6, Table 3 shows no significant effect of cortisol across sessions, but a significant within-session effect ($F(1,159) = 25.36$, $p < .01$). No significant interaction effect was found. (*$p < 0.01$)

		F	df	*p*
Cortisol	Over 6 sessions	1.37	5,159	.24
	Within-session	25.36	1,159	< .0001*
	Interaction	0.42	5,159	.83

5.3 DISCUSSION

In this study, we analyzed physiological changes in 8 children with Down syndrome (SD) and 12 children with Autism Spectrum Disorder (ASD) who took part in a 6-week Dog-Assisted Therapy (DAT) program. To be specific, we measured Heart Rate Variability (HRV) and salivary cortisol at the beginning and end of 6 weekly sessions of DAT. To our knowledge, this is the first study in which these physiological measures are collected during a DAT program, although note that in previous (case) studies on animal-assisted therapy with horses (Tabares et al., 2012) and guinea pigs (O'Haire et al., 2015), physiological data was also used.

Our results show that both HRV (Time and Frequency Domain) and cortisol measures decreased significantly within sessions. Over the course of the full program (6 sessions), however, no significant changes in HRV and salivary cortisol could be found. In addition, the data mostly showed no significant interaction effects, apart from the LF/HF ratio, which showed a different within-session effect across sessions. That is, the changes in LF/HF ratio within the fifth and sixth session were bigger compared to the changes within the first four sessions.

Interestingly, there seems to be a discrepancy between the two types of physiological data. To be specific, the Time-Domain HRV measurements decrease within sessions, which generally indicates a higher level of arousal. At the same time, the cortisol levels decrease within sessions, which corresponds to lower levels of arousal. A reason for this discrepancy might be that during the course of the session, the movement activity of the children increased, which makes the heart rate increase as well. Although the children were seated on a chair when taking the HRV measurements, it takes time for an increased heart rate to return to a baseline level. It is well-known that HRV decreases when the heart rate is increased. (Chamchad, Horrow, Nakhamchik, & Arkoosh, 2007; Marques, Silverman, & Sternberg, 2010). This means that the higher activity levels within DAT sessions confounded the HRV results. From the HF Frequency results it also appears that the children were breathing faster over the course of a session. Yet, since breathing is not directly measured, and since this interpretation of the HF variance is not undisputed (van Boxtel et al., 2018), we cannot state this with confidence. Cortisol levels do not depend on movement, provided that the movement is not caused by a flight reaction (May et al., 2016). Cortisol levels are therefore possibly a more reliable measure of stress reduction during an active form of therapy such as DAT.

To our knowledge, HRV has not previously been measured in similar AAI contexts. Although cortisol was also not measured during DAT, it has been measured in pet owners (Handlin et al., 2011), as well as in a study in which children with insecure attachment styles responded to a stressful situation in presence of a dog (Beetz et al., 2012). The results of those studies are in line with this study, i.e., less arousal in the presence of a dog. Yet, a study on salivary cortisol levels taken from students during their final exams in presence of a dog showed no detectable differences, even though students' own perceptions of their stress levels decreased (Barker, Barker, McCain, & Schubert, 2016). This discrepancy between studies shows that we should be cautious when interpreting cortisol levels in the context of Animal-Assisted Interventions. Based on the current study and previous studies (Handlin et al., 2011; Beetz et al., 2012; Barker et al., 2016), we can cautiously conclude that cortisol levels decrease on the short term (during a session) when interacting with animals.

Contrary to our expectations, there were no significant HRV and cortisol changes over the full course of a 6-week DAT program. This means that this DAT program did not succeed to bring children to lower stress levels on the longer term (6 weeks). Note however, that a DAT program of a longer duration, and/or of a higher intensity (several times a week) could possibly lead to different results. This would correspond to the finding that dog owners (who have frequent interactions with their dogs) appear to have lower cortisol levels (Handlin et al., 2011).

There are some limitations of this study. First, we decided to include no control group for ethical reasons (i.e., we worked with a vulnerable group of children and there was no precedent). However, this limits the generalizability of our results. Second, because we worked with a specific group of children, we also needed profesionally trained therapists to guide these children. This resulted in a relatively small sample size. We therefore recommend to conduct this study in a larger context, possibly combined with a DAT program of a longer duration (see above), as there are some indications from previous studies that prolonged exposure to dogs could influence cortisol levels (Handlin et al., 2011). Lastly, even though we used a HRV chest strap with a special size for children, the artifacts in our recordings could indicate that the fit was not optimal. As mentioned in the method section, we tried to solve this by measuring HRV while children sat in a chair before and at the end of each session. Future studies could overcome this by using wrist devices that register HRV, or other equipment that registers respiratory frequencies and blood

pressure in addition to HRV. Despite these limitations, we believe that this study sets an important precedent for the use of physiological measures in research on Animal Assisted Interventions.

REFERENCES

Allen, K., Shykoff, B. E., & Izzo, J. L. (2001). Pet Ownership, but Not ACE Inhibitor Therapy, Blunts Home Blood Pressure Responses to Mental *Stress. Hypertension, 38*(4).

Almela, M., Hidalgo, V., Villada, C., van der Meij, L., Espín, L., Gómez-Amor, J., & Salvador, A. (2011). Salivary alpha-amylase response to acute psychosocial stress: The impact of age. *Biological Psychology, 87*(3), 421–429. https://doi.org/10.1016/J.BIOPSYCHO.2011.05.008

Barker, S. B., Barker, R. T., McCain, N. L., & Schubert, C. M. (2016). A randomized cross-over exploratory study of the effect of visiting therapy dogs on college student stress before final exams. *Anthrozoos, 29*(1). https://doi.org/10.1080/08927936.2015.1069988

Barker, S. B., Knisely, J. S., Schubert, C. M., Green, J. D., & Ameringer, S. (2015). The Effect of an Animal-Assisted Intervention on Anxiety and Pain in Hospitalized Children. *Anthrozoös, 28*(1), 101–112. https://doi.org/10.2752/089279315X14129350722091

Beetz, A., Julius, H., Turner, D., & Kotrschal, K. (2012). Effects of Social Support by a Dog on Stress Modulation in Male Children with Insecure Attachment. *Frontiers in Psychology, 3*, 352. https://doi.org/10.3389/fpsyg.2012.00352

Beetz, A. M. (2017). Theories and possible processes of action in animal assisted interventions. *Applied Developmental Science*. https://doi.org/10.1080/10888691.2016.1262263

Berry, A., Borgi, M., Francia, N., Alleva, E., & Cirulli, F. (2013). Use of Assistance and Therapy Dogs for Children with Autism Spectrum Disorders: A Critical Review of the Current Evidence. T*he Journal of Alternative and Complementary Medicine, 19*(2), 73–80. https://doi.org/10.1089/acm.2011.0835

Carlisle, G. K. (2014). Pet Dog Ownership Decisions for Parents of Children With Autism Spectrum Disorder. *Journal of Pediatric Nursing*. https://doi.org/10.1016/j.pedn.2013.09.005

Carlisle, G. K. (2015). The Social Skills and Attachment to Dogs of Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 45*(5). https://doi.org/10.1007/s10803-014-2267-7

Chamchad, D., Horrow, J. C., Nakhamchik, L., & Arkoosh, V. A. (2007). Heart rate variability changes during pregnancy: an observational study. *International Journal of Obstetric Anesthesia, 16*(2), 106–109. https://doi.org/10.1016/J.IJOA.2006.08.008

Chur-Hansen, A., McArthur, M., Winefield, H., Hanieh, E., & Hazel, S. (2014). Animal-Assisted Interventions in Children's Hospitals: A Critical Review of the Literature. *Anthrozoös, 27*(1), 5–18. https://doi.org/10.2752/175303714X13837396326251

Evans, S., Seidman, L. C., Tsao, J. C., Lung, K. C., Zeltzer, L. K., & Naliboff, B. D. (2013). Heart rate variability as a biomarker for autonomic nervous system response differences between children with chronic pain and healthy control children. *Journal of Pain Research, 6*, 449–457. https://doi.org/10.2147/JPR.S43849

Finck, K. S. (1993). Children, their pet dogs, and affect attument. pdf, Adelphi University.

Germone, M. M., Gabriels, R. L., Guérin, N. A., Pan, Z., Banks, T., & O'Haire, M. E. (2019). Animal-assisted activity improves social behaviors in psychiatrically hospitalized youth with autism. *Autism, 23*(7), 1740–1751. https://doi.org/10.1177/1362361319827411

Griffioen, R. E., van der Steen, S., Verheggen, T., Enders-Slegers, M., & Cox, R. (2019). Changes in behavioural synchrony during dog-assisted therapy for children with autism spectrum disorder and children with Down syndrome. *Journal of Applied Research in Intellectual Disabilities,* jar.12682. https://doi.org/10.1111/jar.12682

Hall, S. S., Wright, H. F., Hames, A., & Mills, D. S. (2016). The long-term benefits of dog ownership in families with children with autism. *Journal of Veterinary Behavior, 13*. https://doi.org/10.1016/j.jveb.2016.04.003

Handlin, L., Hydbring-Sandberg, E., Nilsson, A., Ejdebäck, M., Jansson, A., & Uvnäs-Moberg, K. (2011). Short-Term Interaction between Dogs and Their Owners: Effects on Oxytocin, Cortisol, Insulin and Heart Rate—An Exploratory Study. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 24*(3), 301–315. https://doi.org/10.2752/175303711X13045914865385

Hanrahan, K., McCarthy, A. M., Kleiber, C., Lutgendorf, S., & Tsalikian, E. (2006). Strategies for salivary cortisol collection and analysis in research with chil-

dren. *Applied Nursing Research, 19*(2), 95–101. https://doi.org/10.1016/j.apnr.2006.02.001

Hart, L. A. (2006). Psychosocial Benefits of Animal Companionship. In *Handbook on Animal-Assisted Therapy* (pp. 59–78). Elsevier. https://doi.org/10.1016/B978-012369484-3/50006-2

Jansen, L. M. C., Gispen-de Wied, C. C., van der Gaag, R.-J., & van Engeland, H. (2003). Differentiation between autism and multiple complex developmental disorder in response to psychosocial stress. *Neuropsychopharmacology : Official Publication of the American College of Neuropsychopharmacology, 28*(3), 582–590. https://doi.org/10.1038/sj.npp.1300046

Jansen, L. M. C., Gispen-De Wied, C. C., Wiegant, V. M., Westenberg, H. G. M., Lahuis, B. E., & Van Engeland, H. (2006). Autonomic and neuroendocrine responses to a psychosocial stressor in adults with autistic spectrum disorder. *Journal of Autism and Developmental Disorders, 36*(7), 891–899. https://doi.org/10.1007/s10803-006-0124-z

Janssen, C. G. C., Schuengel, C., & Stolk, J. (2002). Understanding challenging behaviour in people with severe and profound intellectual disability: a stress-attachment model. *Journal of Intellectual Disability Research, 46*(6), 445–453. https://doi.org/10.1046/j.1365-2788.2002.00430.x

Kertes, D. A., Liu, J., Hall, N. J., Hadad, N. A., Wynne, C. D. L., & Bhatt, S. S. (n.d.). Effect of Pet Dogs on Children's Perceived Stress and Cortisol Stress Response. https://doi.org/10.1111/sode.12203

Marques, A. H., Silverman, M. N., & Sternberg, E. M. (2010). Evaluation of Stress Systems by Applying Noninvasive Methodologies: Measurements of Neuroimmune Biomarkers in the Sweat, Heart Rate Variability and Salivary Cortisol. *Neuroimmunomodulation, 17*(3), 205–208. https://doi.org/10.1159/000258725

Martin, F., & Farnum, J. (2002). Animal-Assisted Therapy for Children with Pervasive Developmental Disorders. *Western Journal of Nursing Research, 24*(6), 657–670. https://doi.org/10.1177/019394502320555403

May, D. K., Seivert, N. P., Cano, A., Casey, R. J., Johnson, A., & May, D. (2016). Animal-assisted therapy for youth: A systematic methodological critiqu. *Human-Animal Interaction Bulletin, 4*(1), 1–18.

Motomura, N., Yagi, T., & Ohyama, H. (2004). Animal assisted therapy for people with dementia. *Psychogeriatrics, 4*(2), 40–42. https://doi.org/10.1111/j.1479-8301.2004.00062.x

O'Haire, M. E. (2017). Research on animal-assisted intervention and autism spectrum disorder, 2012–2015. *Applied Developmental Science, 21*(3), 200–216. https://doi.org/10.1080/10888691.2016.1243988

O'Haire, M. E., McKenzie, S. J., Beck, A. M., & Slaughter, V. (2015). Animals may act as social buffers: Skin conductance arousal in children with autism spectrum disorder in a social context. *Developmental Psychobiology, 57*(5), 584–595. https://doi.org/10.1002/dev.21310

Pinheiro, J., & Bates, D. (2019). Linear and Nonlinear Mixed Effects Models. Retrieved from https://bugs.r-project.org

Rai, B., Kaur, J., & Foing, B. H. (2012). Salivary amylase and stress during stressful environment: Three Mars analog mission crews study. *Neuroscience Letters, 518*(1), 23–26. https://doi.org/10.1016/J.NEULET.2012.04.034

Ramirez, S. Z., & Kratochwill, T. R. (1997). Self-Reported Fears in Children With and Without Mental Retardation. *Mental Retardation, 35*(2), 83–92. https://doi.org/10.1352/0047-6765(1997)

Redefer, L. A., & Goodman, J. F. (1989). Brief report: Pet-facilitated therapy with autistic children. *Journal of Autism and Developmental Disorders, 19*(3), 461–467. https://doi.org/10.1007/BF02212943

Rieger, A., Stoll, R., Kreuzfeld, S., Behrens, K., & Weippert, M. (n.d.). Heart rate and heart rate variability as indirect markers of surgeons' intraoperative stress. https://doi.org/10.1007/s00420-013-0847-z

Silva, K., Correia, R., Lima, M., Magalhães, A., & de Sousa, L. (2011a). Can Dogs Prime Autistic Children for Therapy? Evidence from a Single Case Study. *The Journal of Alternative and Complementary Medicine, 17*(7), 655–659. https://doi.org/10.1089/acm.2010.0436

Tabares, C., Vicente, F., Sánchez, S., Aparicio, A., Alejo, S., & Cubero, J. (2012). Quantification of hormonal changes by effects of hippotherapy in the autistic population. *Neurochemical Journal, 6*(4), 311–316. https://doi.org/10.1134/S1819712412040125

Takai, N., Yamaguchi, M., Aragaki, T., Eto, K., Uchihashi, K., & Nishikawa, Y. (2004). Effect of psychological stress on the salivary cortisol and amylase levels in healthy young adults. *Archives of Oral Biology, 49*(12), 963–968. https://doi.org/10.1016/j.archoralbio.2004.06.007

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience &*

Biobehavioral Reviews, 36(2), 747–756. https://doi.org/10.1016/J.NEUBIOREV.2011.11.009

van Boxtel, G. J. M., Cluitmans, P. J. M., Raymann, R. J. E. M., Ouwerkerk, M., Denissen, A. J. M., Dekker, M. K. J., & Sitskoorn, M. M. (2018). Heart Rate Variability, Sleep, and the Early Detection of Post-traumatic Stress Disorder. In *Sleep and Combat-Related Post Traumatic Stress Disorder* (pp. 253–263). New York, NY: Springer New York. https://doi.org/10.1007/978-1-4939-7148-0_22

Viau, R., Arsenault-Lapierre, G., Fecteau, S., Champagne, N., Walker, C.-D., & Lupien, S. (2010). Effect of service dogs on salivary cortisol secretion in autistic children. *Psychoneuroendocrinology, 35*(8), 1187–1193. https://doi.org/10.1016/j.psyneuen.2010.02.004

Wright, H., Hall, S., Hames, A., Hardiman, J., Mills, R., & Mills, D. (2015). Pet dogs improve family functioning and reduce anxiety in children with Autism Spectrum Disorder. *Anthrozoos, 28*(4). https://doi.org/10.1080/08927936.2015.1070003

SUMMARY & GENERAL DISCUSSION

6
SUMMARY & GENERAL DISCUSSION

This dissertation focuses on the influence of Animal Assisted Therapy (AAT) on the development of children with Down syndrome (DS) and children with autism spectrum disorder (ASD). The studies in this dissertation were specifically designed to explore children's social development while working with an animal, using the theoretical frameworks of synchrony (Feldman, 2007; Leclère et al., 2014) and attunement (Baerveldt & Verheggen, 2012; Verheggen & Baerveldt, 2001; Verheggen, Enders-Slegers, & Eshuis, 2017).

More specifically, we first looked at whether the results from previous research (Nathanson, 1998; Nathanson, de Castro, Friend, & McMahon, 1997) could be replicated. We then carried out two AAT studies to test the overarching framework of synchrony, in which in the first study behavioral synchrony in movement between child and dog during Dog-Assisted Therapy was studied, and in the second study verbal synchrony (turn-taking behavior) in interactions between therapist and child during Dolphin-Assisted Therapy. Finally, in addition, the influence of Dog-Assisted Therapy on salivary cortisol levels and heart rate variability as measures of perceived stress were studied.

In the research field of Anthrozoology, or Human-Animal Interactions (HAI), many different theoretical approaches to understand the effects of Animal-Assisted Interventions (AAI) have been proposed, yet a coherent overarching framework was lacking so far. By focusing on behavioral synchrony, as part of the proposed larger framework of Enactive Anthrozoology (Verheggen et al., 2017), it is possible to connect the beneficial effect of human-animal interactions to a sound theoretical frame focusing on dyadic interactions. This framework indicates that human-animal interactions are by essence embodied and mutually synchronized, and that synchrony between humans and animals in an AAT setting increases the possibility of positive outcomes by a possible transfer to human interactions.

From the broader concept of behavioral attunement, we chose synchrony as its main operationalization (Bernieri & Rosenthal, 1991; Duranton, Bedossa, & Gaunet, 2017; Feldman, 2007; Forster & Iacono, 2014; Harrist & Waugh, 2002; Leclère et al., 2014; Reddish, Bulbulia, & Fischer, 2014; Reuzel et al., 2013;

Trevarthen & Daniel, 2005). Behavioral attunement consists of a multi-modal coordination between two interaction partners. In this case, multi-modal means that similar messages can be sent through different modes of communication, such as verbal expressions, body language, or touch. Synchrony forms its behavioral operationalization in the shape of a temporal pattern in e.g., coordinated movements, verbalizations and turn-taking behavior between two interaction partners (Delaherche & Chetouani, 2010; Flom & Bahrick, 2007).

The theoretical construct synchrony can unite all or most existing theories about the positive effects of human-animal interactions, including the social learning theory, social support, social capital and social catalyst, biophilia hypothesis and biopsychosocial model (see also the introduction of this dissertation). As proposed by the biophilia hypothesis, the tendency of humans to affiliate with other life forms explains why animals attract us and hold our attention, which implies mutually attuned behavior. The social support and attachment theory show that high levels of mother-child synchrony contribute to the attachment of children to their caregivers, otherwise said, synchrony forms the basis for social support and attachment.
The practice of social skills benefits from synchronized behavior, which is also proposed in social cognitive theory on AAI (Van der Steen, 2018). Lastly, the biopsychosocial model gives insight into the physiological mechanism that has an effect on social behavior, namely a decrease in cortisol levels and therefore a positive effect on social behavior during human-animal interactions (Beetz, Uvnäs-Moberg, Julius, & Kotrschal, 2012; O'Haire, McKenzie, Beck, & Slaughter, 2013), similar to what researchers have found in case of caregiver-child interactions.

Different traditions propagate the same principle of synchrony/attunement behavior. For example, the mutual and continuous influence and coordination of behavior is a central theme from the dynamic systems point of view in developmental psychology (Fogel, Dedo, & McEwen, 1992; Smith & Thelen, 2003; Thelen & Smith, 2007; van Geert, 1998). In psychiatry and developmental psychology, Fogel and Stern (Fogel, 1993; Jaffe et al., 2001; Stern, 2010; Stern, 2018), assume that the quality of the relationship depends on a healthy development in which there is optimal behavioral attunement, co-regulation, or a fluid interaction in the dyad. Co-regulation (Fogel, 1993), in which behaviors of two interaction partners match, requires sensitivity and is the result of changes in the body, in particular the nervous system that arise from the constant interaction with others. Affect attunement as Stern (2018) describes it refers to the similarities and differences between behavior of

individuals in terms of intensity, rhythm, form and use of space or direction of movement. Lastly, the concept of enactivism in biology, specifically under the name of autopoietic theory, (Maturana & Varela, 1987) and the theory of cognition (Varela, Thompson, & Rosch, 1992; Maturana, Poerksen, Koeck, & Koeck, 2004) is a relational perspective on cognition, affectivity and embodiment. Interactively, a behavioral pattern such as synchronization (e.g. rhythm, tempo, direction) will arise between organisms (such as human- human or human-animal). This does not necessarily require words while new behavior patterns are created (e.g. non-verbal mother-child synchronization).

Although the account above shows that synchrony and attunement can unite many of the theories on the effect of human-animal interactions, the empirical research base from this perspective is still limited. The only two empirical studies known that used the framework of attunement in child-animal interactions are by Finck (1993) and Myers (2007). In the study of Finck (1993) child/pet interactions were video-taped for 10 minutes and then scored for the occurence of affective attunement. Attunement behavior did occur in the interactions of these children and their dogs. Not only did it occur, but it was a bi-directional feature of the interactions, with both the children and the dogs participating in this specific type of behavior. For example, the children were requested to bring one or two favorite play items of the dogs and were allowed to play for 10 minutes with the dog. The attunement events were identified using the following criteria: whenever the dog displayed any affect that represented a marked change over immediately preceding behavior and then the child displayed behavior which gave the impression of imitating, mirroring, matching or attuning in any way to the dogs behavior. Myers (2007), concluded in his observational studies of typically developing children in a classroom that animals are not regarded by children as objects but as subjects with feelings, intentions and autonomous behavior, and that interactions are not solely dependent on linguistic exchanges, but that the attunement with an animal as a non-verbal other can contribute to the development of the human self.

Synchrony and attunement are important in human interactions. It signals similarities in meaning and intentions conveyed between two interaction partners. Moreover, the experience of synchronous caregiver-child interactions early in life can stimulate children's social skills (Harrist & Waugh, 2002). Literature indicates that an increased synchronization in caregiver-child dyads leads to a greater sense

of security and attachment (Feldman, 2007), and is associated with positive social outcomes (Leclère et al., 2014). In other fields of study, synchronized movements, such as during a dance, have been postulated as an effective bonding activity (Tarr, Launay, & Dunbar, 2014) and promote prosocial behavior (Fischer, Callander, Reddish, & Bulbulia, 2013; Reddish et al., 2014; Reddish, Fischer, Bulbulia, & Huici, 2013).

However, when there are congenital abnormalities, intellectual disabilities or difficult social circumstances, synchronization with the interaction partner can be hampered and the development of the child can become disturbed (Bosman, 2010). In AAI settings, the child learns to read and "tune in" on the animal's behavior, which is nonverbal and therefore possibly simpler to attune to. The hypothesis is that the child eventually learns to transfer this newly acquired way of attuning to human interactions, which results in improved social skills. This hypothesis has, so far, never been studied. Although more research in this area is needed, this dissertation makes a first attempt.

6.1 SUMMARY OF RESULTS

Of all studies in this dissertation, chapter 2 is mostly focused on the social effects (and hence, the outcome) of AAT. The empirical study discussed in this chapter shows an increase in the verbalization and social interaction skills of children with DS after following a 6-week Dolphin-Assisted Therapy program. Compared to two control groups (one in which the children were placed on a waiting list and the other in which the children received a swimming pool program), children in the therapy program showed an increase in verbalization and recognition of persons, as indicated by their parents using the Messier questionnaire. Follow-up measurements revealed that even after 5 months these improvements were still (somewhat) visible. Although a slight decrease could be observed, the results of the group receiving Dolphin-Assisted Therapy were still above the baseline value.

Chapter 3 is more specifically focused on verbal interactional synchronization between therapist and children with ASD during Dolphin-Assisted Therapy. In this study, videos of the interaction between child and therapist during the first and final session of Dolphin-Assisted Therapy were observed. We operationalized

verbal synchrony as effective turn-taking during the interaction. To give a detailed view of the interaction between therapist and child in the context of Dolphin-Assisted Therapy, we used Cross-Recurrence Quantification Analysis (CRQA) on the observational data of these five children. This relatively new technique provides insight into the dynamic organization of behavior in a dyad. In other words, this technique looks at the behavior of the child and the therapist as two separate but linked systems that together form a dyad. These two time series (of child and therapist) are compared to see where they approach each other for the purpose of determining the degree of synchrony. The results show turn-taking behavior (increased verbal synchronization) in all dyads, nevertheless not all children improved equally, which may be due to a delayed reaction time of some children, or their level of speech/language development. However, the total time of spoken language increased during the final session for three out of five children while the total time of spoken language of the therapist decreased. Some authors (e.g., Yoder & Stone, 2006) suggest that adequate turn-taking is dependent on a reasonable vocabulary and that children with disabilities mostly lack such skills. A few parents, prior to, this study reported that their children were only able to speak using supportive gestures (frequent use of pointing instead of verbalization).

In chapter 4, changes in behavioral synchrony during Dog-Assisted Therapy for children with ASD and children with DS were investigated. The synchronous movement patterns of these children (n = 10) and the therapy dogs were compared during the first and last session of a six-week program. In addition their post-therapy changes in behavioral problems were measured. A significant increase in synchrony of the movements of child and therapy dog during the sixth session was demonstrated. Children with ASD showed a bigger increase, although not significant, in synchronous behavior than children with DS. Compared to children with DS, children with ASD showed a smaller decrease in behavioral problems, although this was also not statistically significant. This was, as far as we know, the first study with children and their therapy dogs to shed light upon synchrony as a mechanism.

As introduced by the biopsychosocial model, synchronous interactions (in this study child-dog dyads) elicit physiological responses in our bodies, such as a decrease in cortisol levels and an increase in oxytocin release (Feldman, Gordon, & Zagoory-Sharon, 2011; Handlin et al., 2011). Chapter 5 therefore describes a study designed to measure the salivary cortisol levels and the heart rate variability

(HRV) of children with DS (n=8) and children with ASD (n=12) during a dog-assisted therapy program. We compared the pre- and post-samples of salivary cortisol of six sessions and the pre- and post therapy HRV measures. The results show a significant decrease of cortisol levels at every end of a session, but no overarching effect over the course of the full program. Also the HRV results show no significant increase over time. The Time-Domain HRV measurements decrease within a session, indicating a higher level of arousal while the lower cortisol levels indicate less arousal within a session. This discrepancy may be due to the fact that the movements of the children increased towards the end of a session, which makes the heart rate increase (and as a result HRV decreases). However, the lower cortisol levels do indicate that the children experienced lower stress at the end of every session. Lower stress will possibly enable the children to increase their social interaction and communication.

Although it should be noted that in some case studies on Animal-Assisted Therapy with horses (Tabares et al., 2012) and guinea pigs (O'Haire, McKenzie, Beck, & Slaughter, 2015), physiological data were used, this is the first study in which these physiological measures are collected during a Dog-Assisted Therapy program for children with DS and children with ASD.

6.2 CONCLUSIONS

To conclude from the results about synchronization in AAT:

A) Synchrony seems to play a role in child-animal and child-therapist interactions during AAT. Chapter 3 and chapter 4 show that there is some kind of development in synchrony. The results of Dog-Assisted therapy for children with DS and children with ASD demonstrate a significant increase in synchrony of the movements of child and dog during the final therapy session. The results from the research on verbal turn-taking behavior between child and therapist during Dolphin Assisted therapy are partially in line with our expectations that synchronization of verbalizations (turn-taking) would improve during Dolphin-Assisted therapy.

B) In line with previous research (Beetz, Julius, Turner, & Kotrschal, 2012; Nathanson, 1998; Nathanson et al., 1997; Viau et al., 2010), we also found

an improvement in social skills and verbalization in Dolphin Assisted therapy (chapter 2) and a decrease in cortisol levels within every session as an indication of a decrease in perceived stress during Dog-Assisted therapy (chapter 4).

C) However, what we do not know after these studies is whether synchrony indeed underlies all other theories on the beneficial effects of AAI. This remains an assumption. Although it is likely that synchrony plays a role, it could also work the other way around, meaning that synchrony could also be a consequence of the other theories proposed in the literature. For example, the stress reduction reported in chapter 5 might enable children to focus more on the dog, and as a result show more synchronization with the dog (chapter 4). It is also conceivable that a child first builds a bond with the animal (attachment), which then ensures more synchronization. Note, however, that researchers from fields like developmental psychology, dance, cognitive psychology and biology assume that the synchronization of behavior comes in before the attachment (Duranton et al., 2017; Feldman, 2007; Fessler & Holbrook, 2016; Harrist & Waugh, 2002; Leclère et al., 2014; Tarr, Launay, Cohen, & Dunbar, 2015).

D) Finally, we do not know whether synchronization with an animal is indeed transferable to synchronization with other people. We observed both human-animal and human-human synchrony during AAT in this thesis, but in a different setting (synchronization with people during dolphin-assisted therapy in chapter 2 and synchronization with a therapy dog in chapter 3). This dissertation therefore does not prove the transfer of synchrony from human-animal interactions to human-human interactions. The improvement in social skills of the children in chapter 3 after increasing synchronization with the dog during the program can be an indication of such a transfer, but this result was not statistically significant. A follow-up study with larger groups, in which the possible transfer from human-animal synchrony to human-human synchrony within the same participants is examined, is therefore desirable. This could be combined with control groups in which less synchronization is possible, for example by using a robotic dog (van der Steen, 2018). In addition, future studies are necessary to determine the optimal duration of the program and the frequency of the sessions.

6.3 GENERAL DISCUSSION

An interesting point of discussion is the apparent difference in the outcomes of AAT in children with DS and children with ASD. Although more research is needed, chapter 4 seems to indicate that children with ASD show a bigger increase in movement synchrony with a therapy dog than children with DS. At the same time, the behavioral problems of children with DS seem to decrease more after the therapy program in comparison to children with ASD, although the latter result was not statistically significant. Although children with ASD show less behavioral change in chapter 4, which seems to contradict the synchrony hypothesis, this could be explained by the large degree of variability of disabilities in social skills.

Children with ASD are more resistant to human social interactions than children with DS (Adamson, Bakeman, Deckner, & Romski, 2009), and according to earlier research (Prothmann, Ettrich, & Prothmann, 2009) they comprehend non-verbal animal communication better than human communication. To further explore this, more comparative research is needed in which larger numbers of children participate. Moreover, it would be advised to measure the baseline of problem behavior differently. Researchers have indicated that the three-point Likert scale of the Child Behavior CheckList (not true, sometimes true and often true) may limit the detection of change in behavioral problems over time (McClendon et al., 2011).

Another important point of discussion is that an improvement in turn-taking behavior may depend on the baseline skills of verbal communication of the children. In chapter 3 it was found that some children who had more trouble speaking (as reported by their parents) did not increase in their turn-taking behavior. This may also be due to the fact that the therapists were not fully aware of the delayed reaction times of the children and that the therapists could receive more extensive instructions with regard to what they say. As a result this is an important clinical recommendation for working with these children in an AAI setting. It could also be that longer programs provide better results due to the great variation in language development in children with ASD. To take an active role as a speaker, it requires sufficient communication skills while children with disabilities lack such skills. Especially for children who have more trouble speaking, it might take a longer time to practice this.

A third discussion point is that the expectant attitude (Breitenbach, Stumpf, Fersen, & Ebert, 2009; Walsh, 2009) of the parents regarding the therapy

can influence the success of the therapy. The design of the first study included two control groups, but the parents knew in which group their child was enrolled. A response bias (Furnham, 1986), that is, when parents provide socially desirable answers, is therefore not unlikely and could have influenced the outcomes of the study in chapter 2 and also partly in chapter 4. Other outcome measures in chapter 3 and 4 were gathered by structured observations by Master's students. Before the observations were done, sufficient interrater reliability first had to be achieved, which reduces (although does not completely rule out) confirmation bias in which there is a tendency to interpret the observations in a way that confirms preconceptions. Although the study with the biological markers is not confronted with similar biases, note that no control group was used in this study, which means that we cannot be absolutely sure about the influence of this AAT program on stress reduction. Although the methodological weaknesses of this dissertation are a vulnerable point, note that the studies were mostly of an exploratory nature, and among the first (chapter 3 and 4) to assess the role of synchrony in the AAT context, as well as the use of biomarkers in AAT with dogs and children (chapter 4). The aim of the studies is therefore not to provide a definitive conclusion about the synchrony-hypothesis, but to shed light on this possible underlying mechanism.

6.4 FINAL THOUGHTS

The main aim of this dissertation was to shed light on the underlying mechanism supposed to explain the effects of Animal assisted Interventions and to take a first step in looking at whether the theoretical constructs of synchrony can be found in an Animal Assisted Therapy setting.

Our results show for the first time a significant increase in behavioral synchrony and verbal synchrony (turn-taking) during Animal Assisted Interventions. The proposed overarching framework of synchrony in this dissertation therefore proves to be of importance to (partially) explain the effects of Animal-Assisted Therapy. We advocate taking greater account of synchronization in human-animal interactions in order to further explore the precise nature of human-animal interactions, and to more lucidly and coherently explain the wide variety of effects attributed to AAI.

REFERENCES

Adamson, L. B., Bakeman, R., Deckner, D. F., & Romski, M. (2009). Joint engagement and the emergence of language in children with autism and Down syndrome. *Journal of Autism and Developmental Disorders, 39*(1), 84–96. https://doi.org/10.1007/s10803-008-0601-7

Baerveldt, C., & Verheggen, T. (2012). Enactivism. In *The Oxford Handbook of culture and psychology* (pp. 165–190). Oxford University Press.

Beetz, A., Julius, H., Turner, D., & Kotrschal, K. (2012). Effects of Social Support by a Dog on Stress Modulation in Male Children with Insecure Attachment. *Frontiers in Psychology, 3*, 352. https://doi.org/10.3389/fpsyg.2012.00352

Beetz, Uvnäs-Moberg, K., Julius, H., & Kotrschal, K. (2012, July 9). Psychosocial and psychophysiological effects of human-animal interactions: The possible role of oxytocin. *Frontiers in Psychology*. Frontiers. https://doi.org/10.3389/fpsyg.2012.00234

Bernieri, F., & Rosenthal, R. (1991). Interpersonal coordination: Behavior matching and interactional synchrony. Retrieved from http://psycnet.apa.org/record/1991-98576-011

Bosman, A. (Radboud U. N. (2010). Bosman, A. (Radboud U. N. (2010). De interpersoonlijke wereld van het kind The Unfolding Worlds of a Baby's Life, 1–19.

Breitenbach, E., Stumpf, E., Fersen, L. V., & Ebert, H. (2009). Dolphin-Assisted Therapy: Changes in Interaction and Communication between Children with Severe Disabilities and Their Caregivers. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 22*(3), 277–289. https://doi.org/10.2752/175303709X457612

Delaherche, E., & Chetouani, M. (2010). Multimodal coordination. In *Proceedings of the 2nd international workshop on Social signal processing - SSPW '10* (p. 47). New York, New York, USA: ACM Press. https://doi.org/10.1145/1878116.1878131

Duranton, C., Bedossa, T., & Gaunet, F. (2017). Interspecific behavioural synchronization: dogs exhibit locomotor synchrony with humans. *Scientific Reports, 7*(1), 12384. https://doi.org/10.1038/s41598-017-12577-z

Feldman, R. (2007). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *Journal of Child Psychology and Psychiatry, 48*(3–4), 329–354. https://doi.org/10.1111/j.1469-7610.2006.01701.x

Feldman, R., Gordon, I., & Zagoory-Sharon, O. (2011). Maternal and paternal plasma, salivary, and urinary oxytocin and parent-infant synchrony: Considering stress and affiliation components of human bonding. *Developmental Science, 14*(4), 752–761. https://doi.org/10.1111/j.1467-7687.2010.01021.x

Fessler, D. M. T., & Holbrook, C. (2016). Synchronized behavior increases assessments of the formidability and cohesion of coalitions. *Evolution and Human Behavior, 37*(6), 502–509. https://doi.org/10.1016/j.evolhumbehav.2016.05.003

Finck, K. S. (1993). Children, their pet dogs, and affect attument. pdf. Adelphi University.

Flom, R., & Bahrick, L. E. (2007). The development of infant discrimination of affect in multimodal and unimodal stimulation: The role of intersensory redundancy. *Developmental Psychology, 43*(1), 238–252. https://doi.org/10.1037/0012-1649.43.1.238

Fogel, A. (1993). *Developing through relationships: Origins of communication, self, and culture.* University of Chicago Press.

Fogel, Alan, Dedo, J. Y., & McEwen, I. (1992). Effect of postural position and reaching on gaze during mother-infant face-to-face interaction. *Infant Behavior and Development, 15*(2), 231–244. https://doi.org/10.1016/0163-6383(92)80025-P

Forster, S., & Iacono, T. (2014). The nature of affect attunement used by disability support workers interacting with adults with profound intellectual and multiple disabilities. *Journal of Intellectual Disability Research, 58*(12), 1105–1120. https://doi.org/10.1111/jir.12103

Furnham, A. (1986). Response bias, social desirability and dissimulation. *Personality and Individual Differences, 7*(3), 385–400. https://doi.org/10.1016/0191-8869(86)90014-0

Handlin, L., Hydbring-Sandberg, E., Nilsson, A., Ejdebäck, M., Jansson, A., & Uvnäs-Moberg, K. (2011). Short-Term Interaction between Dogs and Their Owners: Effects on Oxytocin, Cortisol, Insulin and Heart Rate—An Exploratory Study. *Anthrozoos: A Multidisciplinary Journal of The Interactions*

of People & Animals, 24(3), 301–315. https://doi.org/10.2752/175303711X13045914865385

Harrist, A. W., & Waugh, R. M. (2002). Dyadic synchrony: Its structure and function in children's development. *Developmental Review, 22*(4), 555–592. https://doi.org/10.1016/S0273-2297(02)00500-2

Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., Jasnow, M. D., Rochat, P., & Stern, D. N. (2001). Rhythms of Dialogue in Infancy: Coordinated Timing in Development. Source: *Monographs of the Society for Research in Child Development Rhythms of Dialogue in Infancy: Coordinated Timing in Development, 66*(2).

Leclère, C., Viaux, S., Avril, M., Achard, C., Chetouani, M., Missonnier, S., & Cohen, D. (2014). Why Synchrony Matters during Mother-Child Interactions: A Systematic Review. *PLoS ONE, 9*(12), e113571. https://doi.org/10.1371/journal.pone.0113571

Maturana, H. R., & Poerksen, B. (2004). *From being to doing: The origins of the biology of cognition*. Carl-Auer Verlag.

Maturana, H. R., & Varela, F. J. (1987). *The tree of knowledge: The biological roots of human understanding*. New Science Library/Shambhala Publications.

Myers, O. G. (2007). *The significance of children and animals: Social development and our connections to other species*. Purdue University Press.

Nathanson, D. E. (1998). Long-Term Effectiveness of Dolphin-Assisted Therapy for Children with Severe Disabilities. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 11*(1), 22–32. https://doi.org/10.2752/089279398787000896

Nathanson, D. E., de Castro, D., Friend, H., & McMahon, M. (1997). Effectiveness of Short-Term Dolphin-Assisted Therapy for Children with Severe Disabilities. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 10*(2), 90–100. https://doi.org/10.2752/089279397787001166

O'Haire, M. E., McKenzie, S. J., Beck, A. M., & Slaughter, V. (2013). Social behaviors increase in children with autism in the presence of animals compared to toys. *PloS One, 8*(2), e57010. https://doi.org/10.1371/journal.pone.0057010

O'Haire, M. E., McKenzie, S. J., Beck, A. M., & Slaughter, V. (2015). Animals may act as social buffers: Skin conductance arousal in children with autism spectrum disorder in a social context. *Developmental Psychobiology, 57*(5), 584–595. https://doi.org/10.1002/dev.21310

Prothmann, A., Ettrich, C., & Prothmann, S. (2009). Preference for, and Responsiveness to, People, Dogs and Objects in Children with Autism. *Anthrozoös, 22*(2), 161–171. https://doi.org/10.2752/175303709X434185

Reddish, P., Bulbulia, J., & Fischer, R. (2014). Does synchrony promote generalized prosociality? *Religion, Brain & Behavior, 4*(1), 3–19. https://doi.org/10.1080/2153599X.2013.764545

Reuzel, E., Embregts, P. J. C. M., Bosman, A. M. T., Cox, R., van Nieuwenhuijzen, M., & Jahoda, A. (2013). Conversational Synchronization in Naturally Occurring Settings: A Recurrence-Based Analysis of Gaze Directions and Speech Rhythms of Staff and Clients with Intellectual Disability. *Journal of Nonverbal Behavior, 37*(4), 281–305. https://doi.org/10.1007/s10919-013-0158-9

Smith, L. B., & Thelen, E. (2003). Development as a dynamic system. *Trends in Cognitive Sciences, 7*(8), 343–348. https://doi.org/10.1016/S1364-6613(03)00156-6

Stern. (2018). *The interpersonal world of the infant: A view from psychoanalysis and developmental psychology. The Interpersonal World of the Infant: A View from Psychoanalysis and Developmental Psychology.* https://doi.org/10.4324/9780429482137

Stern, D. (2010). The issue of vitality. *Nordic Journal of Music Therapy, 19*(2), 88–102. https://doi.org/10.1080/08098131.2010.497634

Steen, van der S. (2018). Theory and research methods in Animal-Assisted Interventions (Key-note). Symposium, One health in AAI: current trends and future collaborations in research and practice. Amsterdam

Tabares, C., Vicente, F., Sánchez, S., Aparicio, A., Alejo, S., & Cubero, J. (2012). Quantification of hormonal changes by effects of hippotherapy in the autistic population. *Neurochemical Journal, 6*(4), 311–316. https://doi.org/10.1134/S1819712412040125

Tarr, B., Launay, J., Cohen, E., & Dunbar, R. (2015). Synchrony and exertion during dance independently raise pain threshold and encourage social bonding. *Biology Letters, 11*(10). Retrieved from http://rsbl.royalsocietypublishing.org/content/11/10/20150767

Thelen, E., & Smith, L. B. (2007). Dynamic Systems Theories. In *Handbook of Child Psychology*. Hoboken, NJ, USA: John Wiley & Sons, Inc. https://doi.org/10.1002/9780470147658.chpsy0106

Trevarthen, C., & Daniel, S. (2005). Disorganized rhythm and synchrony: Early signs of autism and Rett syndrome. *Brain and Development, 27*, S25–S34. https://doi.org/10.1016/j.braindev.2005.03.016

van Geert, P. (1998). A dynamic systems model of basic developmental mechanisms: Piaget, Vygotsky, and beyond. *Psychological Review, 105*(4), 634–677. https://doi.org/10.1037/0033-295X.105.4.634-677

Varela, F. J., Thompson, E., & Rosch, E. (1993). *The embodied mind: cognitive science and human experience.* MIT Press.

Verheggen, T., & Baerveldt, C. (2001). From Shared Representations to Consensually Coordinated Actions: Toward an Intrinsically Social Psychology. In *Theoretical Issues in Psychology* (pp. 59–67). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4757-6817-6_6

Verheggen, T., Enders-Slegers, M.-J., & Eshuis, J. (2017). Enactive Anthrozoology: Toward an integrative theoretical model for understanding the therapeutic relationships between humans and animals - Human-Animal Interaction. *Human-Animal Interaction Bulletin, 5*(2), 13–35.

Viau, R., Arsenault-Lapierre, G., Fecteau, S., Champagne, N., Walker, C.-D., & Lupien, S. (2010). Effect of service dogs on salivary cortisol secretion in autistic children. *Psychoneuroendocrinology, 35*(8), 1187–1193. https://doi.org/10.1016/j.psyneuen.2010.02.004

Walsh, F. (2009). Human-animal bonds I: The relational significance of companion animals. *Family Process*. https://doi.org/10.1111/j.1545-5300.2009.01296.x

Yoder, P., & Stone, W. L. (2006). Randomized Comparison of Two Communication Interventions for Preschoolers With Autism Spectrum Disorders. https://doi.org/10.1037/0022-006X.74.3.426

NEDERLANDSE SAMENVATTING (SUMMARY IN DUTCH)

7

NEDERLANDSE SAMENVATTING

Dit proefschrift richt zich op de invloed van Animal Assisted Therapy (AAT) op de ontwikkeling van kinderen met het syndroom van Down (DS) en kinderen met een autismespectrumstoornis (ASD). De studies in dit proefschrift zijn specifiek ontworpen om de sociale ontwikkeling van kinderen te onderzoeken tijdens het werken met een dier, gebruikmakend van de theoretische kaders van synchronisatie (Feldman, 2007; Leclère et al., 2014) en afstemming (Baerveldt & Verheggen, 2012; Verheggen & Baerveldt, 2001; Verheggen, Enders-Slegers, & Eshuis, 2017).

Meer specifiek hebben we eerst gekeken (hoofdstuk 2) of de resultaten van eerder onderzoek (Nathanson, 1998; Nathanson, de Castro, Friend, & McMahon, 1997) konden worden gerepliceerd. Vervolgens hebben we twee AAT-onderzoeken uitgevoerd om het overkoepelende raamwerk van synchronie te testen, waarbij in de tweede studie (hoofdstuk 4) gedragssynchronisatie in beweging tussen kind en hond tijdens Dog-Assisted Therapy werd bestudeerd, en in de eerste studie (hoofdstuk 3) verbale synchronie (turn-taking gedrag) in interacties tussen therapeut en kind tijdens Dolphin-Assisted Therapy. Ten slotte werd ook de invloed van Dog-Assisted Therapy op de cortisol spiegels en de hart ritme variabiliteit onderzocht als maatstaven voor waargenomen stress (hoofdstuk 5).

In het onderzoeksgebied van de Antrozoology of Human-Animal Interactions (HAI) zijn veel verschillende theoretische benaderingen voorgesteld om de effecten van Animal-Assisted Interventions (AAI) te begrijpen, maar tot dusver ontbrak een coherent overkoepelend kader. Door te focussen op gedrags-synchronisatie, als onderdeel van het voorgestelde grotere raamwerk van Enactive Anthrozoology (Verheggen et al., 2017), is het mogelijk om het gunstige effect van interacties tussen mens en dier te koppelen aan een degelijk theoretisch raamwerk dat zich richt op dyadische interacties. Dit raamwerk geeft aan dat interacties tussen mens en dier in wezen belichaamd en onderling gesynchroniseerd zijn, en dat synchronisatie tussen mens en dier in een AAT-setting de kans op positieve resultaten vergroot door een mogelijke overdracht naar menselijke interacties.

Vanuit het bredere concept van gedragsafstemming kozen we synchronie als belangrijkste operationalisatie (Bernieri & Rosenthal, 1991; Duranton, Bedossa,

& Gaunet, 2017; Feldman, 2007; Forster & Iacono, 2014; Harrist & Waugh, 2002; Leclère et al., 2014; Reddish, Bulbulia, & Fischer, 2014; Reuzel et al., 2013; Trevarthen & Daniel, 2005).

Het theoretische construct van synchronisatie kan alle of de meeste bestaande theorieën over de positieve effecten van mens-dier interacties verenigen, waaronder de social learning theory, social support, social capital en social catalyst, biophilia hypothese en biopsychosociaal model (zie ook de introductie van dit proefschrift) . Zoals de biophilia-hypothese suggereert, verklaart de neiging van mensen om zich te verbinden met andere levensvormen, waarom dieren ons aantrekken en onze aandacht vasthouden, wat een wederzijds afgestemd gedrag impliceert.
De theorie van sociale ondersteuning en hechting laat zien dat een hoge mate van moeder-kindsynchronie bijdraagt aan de hechting van kinderen aan hun verzorgers, anders gezegd, synchronie vormt de basis voor sociale steun en gehechtheid. Het synchroniseren van gedrag heeft een positieve invloed op sociale vaardigheden, zoals ook wordt voorgesteld in de sociaal-cognitieve theorie over AAI (Van der Steen, 2018). Ten slotte geeft het biopsychosociale model inzicht in het fysiologische mechanisme dat effect heeft op sociaal gedrag, namelijk een afname van cortisolspiegels en daarmee een positief effect op sociaal gedrag tijdens mens-dier interacties (Beetz, Julius, Turner, & Kotrschal, 2012; O'Haire, McKenzie, Beck, & Slaughter, 2013), vergelijkbaar met wat onderzoekers hebben gevonden in het geval van interacties tussen zorgverleners en kinderen.

Verschillende tradities propageren hetzelfde principe van synchronie/gedrags-afstemming. Zo is de wederzijdse en continue beïnvloeding en coördinatie van gedrag een centraal thema vanuit het oogpunt van dynamische systemen in de ontwikkelingspsychologie (Alan Fogel, Dedo, & McEwen, 1992; Smith & Thelen, 2003; Thelen & Smith, 2007; van Geert, 1998). In de psychiatrie en ontwikkelingspsychologie gaan Fogel en Stern (A Fogel, 1993; Jaffe et al., 2001; Stern, 2018, 2010) ervan uit dat de kwaliteit van de relatie afhangt van een gezonde ontwikkeling waarin er een optimale gedragsafstemming is, co-regulatie (A Fogel, 1993) of een vloeiende interactie in de dyade. Affect-afstemming zoals Stern (2018) het beschrijft, verwijst naar de overeenkomsten en verschillen tussen gedrag van individuen in termen van intensiteit, ritme, vorm en gebruik van ruimte of bewegingsrichting. Ten slotte het concept van enactivisme in de biologie, specifiek onder de naam autopoietische theorie (Maturana & Varela, 1987) en de cognitietheorie (Maturana, Poerksen, Koeck, & Koeck, 2004; Varela, Thompson, & Rosch, 1993)

wat een relationeel perspectief biedt op cognitie, affectiviteit en belichaming. Interactief ontstaat er een gedragspatroon zoals synchronisatie (bijv. ritme, tempo, richting) tussen organismen (zoals mens-mens of mens-dier). Hiervoor zijn niet per se woorden nodig terwijl er nieuwe gedragspatronen worden gecreëerd (bijv. non-verbale synchronisatie van moeder en kind).

Hoewel uit het bovenstaande blijkt dat synchronisatie en afstemming veel theorieën over het effect van mens-dierinteracties kunnen verenigen, is het empirische onderzoek vanuit dit perspectief nog steeds beperkt. De enige twee empirische studies die het afstemmingskader bij interacties tussen kinderen en dieren gebruikten, zijn van Finck (Finck, 1993) en Myers (Myers, 2007). In de studie van Finck (1993) werden interacties tussen kinderen en huisdieren gedurende 10 minuten op video opgenomen en vervolgens gescoord op het optreden van affectieve afstemming. Afstemmingsgedrag kwam voor bij de interacties van deze kinderen en hun honden. Het kwam niet alleen voor, maar het was een bi-directioneel kenmerk van de interacties, waarbij zowel de kinderen als de honden deelnamen aan dit specifieke type gedrag. Zo werd de kinderen gevraagd één of twee favoriete speel-items van de honden mee te nemen en mochten ze 10 minuten met de hond spelen.
De afstemmingsgebeurtenissen werden geïdentificeerd aan de hand van het volgende criterium: telkens wanneer de hond een affect vertoonde dat een duidelijke verandering ten opzichte van onmiddellijk voorafgaand gedrag betekende, en vervolgens het kind gedrag vertoonde dat de indruk wekte van imiteren, spiegelen, matchen of afstemmen op welke manier dan ook op het gedrag van de hond. Myers (2007) concludeerde in zijn observationele studies van normaal ontwikkelende kinderen in een klaslokaal dat dieren door kinderen niet worden beschouwd als objecten, maar als subjecten met gevoelens, intenties en autonoom gedrag, en dat interacties niet alleen afhankelijk zijn van taaluitwisselingen, maar dat de afstemming met een dier als non-verbale ander kan bijdragen aan de ontwikkeling van een 'zelf'.

Synchronie en afstemming zijn belangrijk bij menselijke interacties. Het signaleert overeenkomsten in betekenis en intenties die worden overgedragen tussen twee interactiepartners. Bovendien kan de ervaring van synchrone interacties tussen verzorger en kind in het vroege leven de sociale vaardigheden van kinderen stimuleren (Harrist & Waugh, 2002). In de literatuur wordt aangegeven dat een verhoogde synchronisatie in de dyades van verzorger-kind leidt tot een groter gevoel van veiligheid en gehechtheid (Feldman, 2007) en wordt geassocieerd met positieve sociale

resultaten (Leclère et al., 2014). In andere studiegebieden zijn gesynchroniseerde bewegingen, zoals tijdens een dans, gepostuleerd als een effectieve hechtingsactiviteit (Tarr, Launay, & Dunbar, 2014) en bevorderen ze sociaal gedrag (Fischer, Callander, Reddish, & Bulbulia, 2013; Reddish et al., 2014; Reddish, Fischer, Bulbulia, Bulbulia, & Huici, 2013).

Als er echter aangeboren afwijkingen, verstandelijke beperkingen of moeilijke sociale omstandigheden zijn, kan de synchronisatie met de interactiepartner worden belemmerd en kan de ontwikkeling van het kind worden verstoord (Bosman, 2010). In AAI-programma's leert het kind lezen en 'afstemmen' op het gedrag van het dier, dat non-verbaal is en daarom mogelijk eenvoudiger op af te stemmen. De hypothese is dat het kind uiteindelijk leert deze nieuw verworven manier van afstemmen over te dragen op menselijke interacties, wat resulteert in verbeterde sociale vaardigheden. Deze hypothese is tot nu toe nooit onderzocht. Omdat meer onderzoek op dit gebied nodig is, doet dit proefschrift een eerste poging.

7.1 SAMENVATTING VAN DE RESULTATEN

Van alle studies in dit proefschrift is hoofdstuk 2 vooral gericht op de sociale effecten (en dus de uitkomst) van AAT. De empirische studie die in dit hoofdstuk wordt besproken, laat een toename zien van de verbalisatie en sociale interactievaardigheden van kinderen met DS na het volgen van een 6 weken durende Dolphin-Assisted Therapy-programma. In vergelijking met twee controlegroepen (één waarin de kinderen op een wachtlijst werden geplaatst en de andere waarin de kinderen een zwembad-programma kregen), vertoonden kinderen in het therapieprogramma een toename in verbalisatie en herkenning van personen, zoals blijkt uit de door hun ouders ingevulde Messier-vragenlijst. Vervolgmetingen lieten zien dat deze verbeteringen zelfs na 5 maanden nog (enigszins) zichtbaar waren. Hoewel een lichte daling kon worden waargenomen, lagen de resultaten van de groep die Dolphin-Assisted Therapy kreeg nog steeds boven baseline.

Hoofdstuk 3 is meer specifiek gericht op verbale interactiesynchronisatie (turn-taking) tussen therapeut en kinderen met ASD tijdens Dolphin-Assisted Therapy.

In deze studie werden video's van de interactie tussen kind en therapeut tijdens de eerste en laatste sessie van Dolphin-Assisted Therapy geanalyseerd. Om een gedetailleerd beeld te geven van de interactie tussen therapeut en kind in de context van Dolphin-Assisted Therapy, hebben we Cross-Recurrence Quantification Analysis (CRQA) gebruikt voor de observationele gegevens van deze vijf kinderen. Deze relatief nieuwe techniek geeft inzicht in de dynamische organisatie van gedrag in een dyade. Met andere woorden, met deze techniek kijken wij naar het gedrag van het kind en de therapeut als twee afzonderlijke maar gekoppelde systemen die samen een dyade vormen. Deze twee tijdreeksen (van kind en therapeut) worden vergeleken om te zien waar ze naar elkaar toe komen om de mate van synchronie te bepalen. De resultaten laten het gedrag van de beurt-neming zien (verhoogde verbale synchronisatie) in alle dyades, maar niet alle kinderen verbeterden gelijkelijk, wat te wijten kan zijn aan een vertraagde reactietijd van sommige kinderen of hun niveau van spraak/taalontwikkeling. De totale tijd van de gesproken taal nam tijdens de laatste sessie echter toe voor drie van de vijf kinderen, terwijl de totale tijd van de gesproken taal van de therapeut afnam. Sommige auteurs (bijv.(Yoder & Stone, 2006) suggereren dat een goede turn-taking afhankelijk is van een redelijk vocabulaire en dat kinderen met een handicap dergelijke vaardigheden meestal niet hebben. Enkele ouders in deze studie meldden dat hun kinderen alleen konden praten met ondersteunende gebaren (veelvuldig gebruik van wijzen in plaats van verbaliseren).

In hoofdstuk 4 werden veranderingen in gedragssynchronisatie tijdens Dog-Assisted Therapy onderzocht voor kinderen met ASD en kinderen met DS. De synchrone bewegingspatronen van deze kinderen (n = 10) en de therapiehonden werden vergeleken tijdens de eerste en laatste sessie van een programma van zes weken. Daarnaast werden hun post-therapie veranderingen in gedragsproblemen gemeten. Tijdens de zesde sessie werd een significante toename in synchronisatie van de bewegingen van kind en therapiehond aangetoond. Kinderen met ASD vertoonden een grotere toename, hoewel niet significant, in synchroon gedrag dan kinderen met DS. In vergelijking met kinderen met DS vertoonden kinderen met ASD een kleinere afname van gedragsproblemen, hoewel dit ook niet statistisch significant was. Dit was, voor zover we weten, de eerste studie met kinderen en hun therapiehonden om licht te werpen op synchronie als mechanisme.

Zoals geïntroduceerd door het biopsychosociale model, wekken synchrone interacties (in dit onderzoek dyades van kinderen en honden) fysiologische reacties

in ons lichaam op, zoals een afname van de cortisolspiegels en een toename van de oxytocine-afgifte (Feldman, Gordon, & Zagoory-Sharon, 2011; Handlin et al., 2011).

Hoofdstuk 5 beschrijft daarom een studie die is ontworpen om de cortisolspiegel in het speeksel en de hartslagvariatie (HRV) van kinderen met DS (n = 8) en kinderen met ASS (n = 12) te meten tijdens Dog-Assisted Therapy. We vergeleken de pre- en post-samples van speekselcortisol van zes sessies en de HRV-metingen voor en na de therapie sessies. De resultaten tonen een significante afname van de cortisolspiegels aan het einde van een sessie, maar geen overkoepelend effect in de loop van het volledige programma. Ook de HRV-resultaten laten over het gehele verloop van de sessies geen significante toename zien. De HRV-metingen in het tijddomein nemen af binnen een sessie, wat wijst op een hogere mate van opwinding, terwijl de lagere cortisolspiegels duiden op minder opwinding binnen een sessie. Deze discrepantie kan te wijten zijn aan het feit dat de bewegingen van de kinderen tegen het einde van een sessie zijn toegenomen, waardoor de hartslag toeneemt (en daardoor de HRV afneemt). De lagere cortisolspiegels geven echter aan dat de kinderen aan het einde van elke sessie minder stress ervoeren. Lagere stress zal de kinderen mogelijk in staat stellen hun sociale interactie en communicatie te vergroten.

Hoewel moet worden opgemerkt dat in sommige casestudies over Animal-Assisted Therapy met paarden (Tabares et al., 2012) en cavia's (O'Haire, McKenzie, Beck, & Slaughter, 2015) fysiologische gegevens werden gebruikt, is dit de eerste studie waarin deze fysiologische metingen worden verzameld tijdens een Dog-Assisted Therapy-programma voor kinderen met DS en kinderen met ASD.

7.2 CONCLUSIES

A) Synchronie lijkt een rol te spelen in interacties tussen kind en dier en kind en therapeut tijdens AAT (hoofdstuk 3 en 4). De resultaten van Dog-Assisted therapie voor kinderen met DS en kinderen met ASD laten een significante toename zien in synchrone bewegingen van kind en hond tijdens de laatste therapiesessie. De resultaten van het onderzoek naar verbaal gedrag bij het nemen van beurten tussen kind en therapeut tijdens Dolphin Assisted-therapie zijn gedeeltelijk in lijn met onze verwachtingen dat synchronisatie van verbalisaties (turn-taking) zou verbeteren tijdens Dolphin-Assisted-therapie.

B) In lijn met eerder onderzoek (Beetz et al., 2012; Nathanson, 1998; Nathanson et al., 1997; Viau et al., 2010), vonden we ook een verbetering in sociale vaardigheden en verbalisatie in Dolphin Assisted Therapy (hoofdstuk 2) en een verlaging van de cortisolspiegels binnen elke sessie als een indicatie van een afname van waargenomen stress tijdens therapie met honden (hoofdstuk 5).

C) Wat we na deze studies echter nog niet weten, is of synchronie inderdaad alle andere theorieën over de gunstige effecten van AAI onderbouwt. Dit blijft een aanname. Hoewel waarschijnlijk is dat synchronie een rol speelt, kan het ook andersom werken, wat betekent dat synchronie ook een gevolg kan zijn van de effecten die andere theorieën in de literatuur beschrijven. De stressvermindering die in hoofdstuk 5 wordt gerapporteerd, kan bijvoorbeeld komen doordat de kinderen meer focus op de hond hebben en daardoor meer synchronisatie met de hond (hoofdstuk 4). Het is ook denkbaar dat een kind eerst een band opbouwt met het dier (gehechtheid), wat dan voor meer synchronisatie zorgt. Echter dient opgemerkt op dat onderzoekers uit vakgebieden als ontwikkelingspsychologie, dans, cognitieve psychologie en biologie aannemen dat de synchronisatie van gedrag plaatsvindt vóór de gehechtheid (Duranton et al., 2017; Feldman, 2007; Fessler & Holbrook, 2016; Harrist & Waugh, 2002; Leclère et al., 2014; Tarr, Launay, Cohen, & Dunbar, 2015).

D) Ten slotte weten we niet of synchronisatie met een dier inderdaad overdraagbaar is op synchronisatie met andere mensen. We hebben zowel mens-dier als mens-mens synchronie waargenomen tijdens AAT in dit proefschrift, maar in

een andere setting (synchronisatie met mensen tijdens Dolphin-Assisted Therapy in hoofdstuk 3 en synchronisatie met een therapiehond in hoofdstuk 4). De verbetering van de sociale vaardigheden van de kinderen in hoofdstuk 4 na toenemende synchronisatie met de hond tijdens het programma kan een indicatie zijn van een dergelijke overdracht, maar dit resultaat was niet statistisch significant. Een vervolgstudie met grotere groepen, waarbij de mogelijke transfer van mens-dier synchronie naar mens-mens synchronie binnen dezelfde deelnemers wordt onderzocht, is daarom wenselijk. Dit kan worden gecombineerd met controlegroepen waarin minder synchronisatie mogelijk is, bijvoorbeeld door gebruik te maken van een robothond (van der Steen, 2018). Daarnaast zijn toekomstige studies nodig om de optimale duur van het programma en de frequentie van de sessies te bepalen.

7.4 DISCUSSIE

Een interessant discussiepunt is het duidelijke verschil in de uitkomsten van AAT bij kinderen met DS en kinderen met ASD. Hoewel er meer onderzoek nodig is, lijkt hoofdstuk 4 erop te wijzen dat kinderen met ASD een grotere toename in bewegingssynchronisatie vertonen met een therapiehond dan kinderen met DS. Tegelijkertijd lijken de gedragsproblemen van kinderen met DS na het therapieprogramma meer af te nemen in vergelijking met kinderen met ASD, hoewel dit laatste resultaat niet statistisch significant was. Hoewel kinderen met ASD minder gedragsverandering vertonen in hoofdstuk 4, wat in tegenspraak lijkt te zijn met de synchronie hypothese, zou een verklaring hiervoor kunnen zijn dat de grote mate van variabiliteit van beperkingen in de sociale vaardigheden hiervoor verantwoordelijk is.

Kinderen met ASD hebben meer weerstand voor menselijke sociale interacties dan kinderen met DS (Adamson, Bakeman, Deckner, & Romski, 2009), en volgens eerder onderzoek (Prothmann, Ettrich, & Prothmann, 2009) begrijpen ze non-verbale communicatie tussen dieren beter dan menselijke communicatie. Om dit verder te onderzoeken is meer vergelijkend onderzoek nodig waaraan grotere aantallen kinderen deelnemen. Bovendien wordt geadviseerd om de basis van probleemgedrag

anders te meten. Onderzoekers hebben aangegeven dat de driepunts-Likert-schaal van de Child Behavior CheckList (niet waar, soms waar en vaak waar) vaak niet sensitief genoeg is om de detectie van verandering in gedragsproblemen in de tijd te meten (McClendon et al., 2011).

Een ander belangrijk discussiepunt is dat een verbetering van het gedrag bij het nemen van beurten afhankelijk kan zijn van de basisvaardigheden van verbale communicatie van de kinderen. In hoofdstuk 3 werd gevonden dat sommige kinderen die meer moeite hadden met praten (zoals gerapporteerd door hun ouders) geen toename van turn-taking lieten zien. Dit kan ook komen doordat de therapeuten zich niet volledig bewust waren van de vertraagde reactietijden van de kinderen en dat de therapeuten uitgebreidere instructies zouden moeten krijgen met betrekking tot wat ze zeggen. Daarom is dit een belangrijke klinische aanbeveling voor het werken met deze kinderen in een AAI-setting. Het kan ook zijn dat langere programma's betere resultaten opleveren door de grote variatie in taalontwikkeling bij kinderen met ASD. Om een actieve rol als spreker op zich te nemen, zijn voldoende communicatieve vaardigheden vereist, terwijl kinderen met een handicap dergelijke vaardigheden niet hebben. Vooral voor kinderen die meer moeite hebben met spreken, kan het wat langer duren om dit te oefenen.

Een derde discussiepunt is dat de houding (Breitenbach, Stumpf, Fersen, & Ebert, 2009; Walsh, 2009) van de ouders over de therapie het succes van de therapie kan beïnvloeden. Het ontwerp van de eerste studie omvatte twee controlegroepen, maar de ouders wisten in welke groep hun kind was ingeschreven. Een responsbias (Furnham, 1986), dat wil zeggen, wanneer ouders sociaal wenselijke antwoorden geven, is daarom niet onwaarschijnlijk en zou de uitkomsten van de studie in hoofdstuk 2 en ook gedeeltelijk in hoofdstuk 4 kunnen hebben beïnvloed. Andere uitkomstmaten in hoofdstuk 3 en 4 werden verzameld door gestructureerde observaties door masterstudenten. Voordat de waarnemingen werden gedaan, moest eerst voldoende inter-beoordelaars betrouwbaarheid worden bereikt, wat (hoewel dit niet volledig uitsluit) een vertekening om de waarnemingen te interpreteren op een manier die vooroordelen bevestigt, vermindert.

Hoewel in het onderzoek met de biologische markers geen sprake is van response bias of confirmation, is er bij dit onderzoek geen gebruik gemaakt van een controle

groep, wat betekent dat we niet absoluut zeker kunnen zijn van de invloed van dit AAT-programma op stressvermindering. Hoewel de methodologische zwakheden van dit proefschrift een kwetsbaar punt zijn, willen wij benadrukken dat de studies meestal van verkennende aard waren en als eerste uitgevoerd (hoofdstuk 3 en 4) om de rol van synchronie in de AAT-context te beoordelen, evenals het gebruik van biomarkers in AAT met honden en kinderen (hoofdstuk 5). Het doel van de studies is dan ook niet om een definitieve conclusie te geven over de synchronie-hypothese, maar om licht te werpen op dit mogelijke onderliggende mechanisme.

Het voornaamste doel van dit proefschrift was om licht te werpen op het onderliggende mechanisme dat de effecten van Animal Assisted Interventions zou kunnen verklaren en om een eerste stap te zetten om te kijken of de theoretische constructen van synchronie te vinden zijn in een Animal Assisted Therapy-setting.

Onze resultaten tonen voor het eerst een significante toename van gedragssynchronisatie en verbale synchronie (turn-taking) tijdens Animal Assisted Therapy. Het voorgestelde overkoepelende synchronie raamwerk in dit proefschrift blijkt daarom van belang om de effecten van Animal Assisted Therapy (gedeeltelijk) te verklaren. We pleiten ervoor om meer rekening te houden met synchronisatie in mens-dierinteracties om de precieze aard van deze interacties verder te onderzoeken en om de grote verscheidenheid aan effecten die aan AAI worden toegeschreven, meer helder en coherenter te verklaren.

REFERENCES

Adamson, L. B., Bakeman, R., Deckner, D. F., & Romski, M. (2009). Joint engagement and the emergence of language in children with autism and Down syndrome. *Journal of Autism and Developmental Disorders, 39*(1), 84–96. https://doi.org/10.1007/s10803-008-0601-7

Baerveldt, C., & Verheggen, T. (2012). Enactivism. In *The Oxford Handbook of culture and psychology* (pp. 165–190). Oxford University Press.

Beetz, A., Julius, H., Turner, D., & Kotrschal, K. (2012). Effects of Social Support by a Dog on Stress Modulation in Male Children with Insecure Attachment. *Frontiers in Psychology, 3*, 352. https://doi.org/10.3389/fpsyg.2012.00352

Bernieri, F., & Rosenthal, R. (1991). Interpersonal coordination: Behavior matching and interactional synchrony. Retrieved from https://psycnet.apa.org/record/1991-98576-011

Bosman, A. (Radboud U. N. (2010). Bosman, A. (Radboud U. N. (2010). De interpersoonlijke wereld van het kind The Unfolding Worlds of a Baby 's Life, 1–19.

Breitenbach, E., Stumpf, E., Fersen, L. V., & Ebert, H. (2009). Dolphin-Assisted Therapy: Changes in Interaction and Communication between Children with Severe Disabilities and Their Caregivers. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 22*(3), 277–289. https://doi.org/10.2752/175303709X457612

Duranton, C., Bedossa, T., & Gaunet, F. (2017). Interspecific behavioural synchronization: dogs exhibit locomotor synchrony with humans. *Scientific Reports, 7*(1), 12384. https://doi.org/10.1038/s41598-017-12577-z

Feldman, R. (2007). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *Journal of Child Psychology and Psychiatry, 48*(3–4), 329–354. https://doi.org/10.1111/j.1469-7610.2006.01701.x

Feldman, R., Gordon, I., & Zagoory-Sharon, O. (2011). Maternal and paternal plasma, salivary, and urinary oxytocin and parent-infant synchrony: Considering stress and affiliation components of human bonding. *Developmental Science, 14*(4), 752–761. https://doi.org/10.1111/j.1467-7687.2010.01021.x

Fessler, D. M. T., & Holbrook, C. (2016). Synchronized behavior increases assess-

ments of the formidability and cohesion of coalitions. *Evolution and Human Behavior, 37*(6), 502–509. https://doi.org/10.1016/j.evolhumbehav.2016.05.003

Finck, K. S. (1993). Children, their pet dogs, and affect attument.pdf, Adelphi University

Fischer, R., Callander, R., Reddish, P., & Bulbulia, J. (2013). How Do Rituals Affect Cooperation? *Human Nature, 24*(2), 115–125. https://doi.org/10.1007/s12110-013-9167-y

Fogel, A. (1993). *Developing through relationships: Origins of communication, self, and culture.* University of Chicago Press.

Fogel, Alan, Dedo, J. Y., & McEwen, I. (1992). Effect of postural position and reaching on gaze during mother-infant face-to-face interaction. *Infant Behavior and Development, 15*(2), 231–244. https://doi.org/10.1016/0163-6383(92)80025-P

Forster, S., & Iacono, T. (2014). The nature of affect attunement used by disability support workers interacting with adults with profound intellectual and multiple disabilities. *Journal of Intellectual Disability Research, 58*(12), 1105–1120. https://doi.org/10.1111/jir.12103

Furnham, A. (1986). Response bias, social desirability and dissimulation. *Personality and Individual Differences, 7*(3), 385–400. https://doi.org/10.1016/0191-8869(86)90014-0

Handlin, L., Hydbring-Sandberg, E., Nilsson, A., Ejdebäck, M., Jansson, A., & Uvnäs-Moberg, K. (2011). Short-Term Interaction between Dogs and Their Owners: Effects on Oxytocin, Cortisol, Insulin and Heart Rate—An Exploratory Study. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 24*(3), 301–315. https://doi.org/10.2752/175303711X13045914865385

Harrist, A. W., & Waugh, R. M. (2002). Dyadic synchrony: Its structure and function in children's development. *Developmental Review, 22*(4), 555–592. https://doi.org/10.1016/S0273-2297(02)00500-2

Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., Jasnow, M. D., Rochat, P., & Stern, D. N. (2001). Rhythms of Dialogue in Infancy: Coordinated Timing in Development. *Source: Monographs of the Society for Research in Child Development Rhythms of Dialogue in Infancy: Coordinated Timing in Development, 66*(2). Retrieved from http://www.jstor.org/stable/3181589

Leclère, C., Viaux, S., Avril, M., Achard, C., Chetouani, M., Missonnier, S., & Cohen, D. (2014). Why Synchrony Matters during Mother-Child Interactions: A Systematic Review. *PLoS ONE, 9*(12), e113571. https://doi.org/10.1371/journal.pone.0113571

Maturana, H. R., Poerksen, B., Koeck, W. K., & Koeck, A. R. (2004). *From being to doing : the origins of the biology of cognition.* Carl Auer Verlag.

Maturana, H. R., & Varela, F. J. (1987). *The tree of knowledge: the biological roots of human understanding.* New Science Library.

McClendon, D. T., Warren, J. S., M. Green, K., Burlingame, G. M., Eggett, D. L., & McClendon, R. J. (2011). Sensitivity to change of youth treatment outcome measures: a comparison of the CBCL, BASC-2, and Y-OQ. *Journal of Clinical Psychology, 67*(1), 111–125. https://doi.org/10.1002/jclp.20746

Myers, O. G. (2007). *The significance of children and animals: Social development and our connections to other species.* Purdue University Press.

Nathanson, D. E. (1998). Long-Term Effectiveness of Dolphin-Assisted Therapy for Children with Severe Disabilities. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 11*(1), 22–32. https://doi.org/10.2752/089279398787000896

Nathanson, D. E., de Castro, D., Friend, H., & McMahon, M. (1997). Effectiveness of Short-Term Dolphin-Assisted Therapy for Children with Severe Disabilities. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 10*(2), 90–100. https://doi.org/10.2752/089279397787001166

O'Haire, M. E., McKenzie, S. J., Beck, A. M., & Slaughter, V. (2013). Social behaviors increase in children with autism in the presence of animals compared to toys. *PloS One, 8*(2), e57010. https://doi.org/10.1371/journal.pone.0057010

O'Haire, M. E., McKenzie, S. J., Beck, A. M., & Slaughter, V. (2015). Animals may act as social buffers: Skin conductance arousal in children with autism spectrum disorder in a social context. *Developmental Psychobiology, 57*(5), 584–595. https://doi.org/10.1002/dev.21310

Prothmann, A., Ettrich, C., & Prothmann, S. (2009). Preference for, and Responsiveness to, People, Dogs and Objects in Children with Autism. *Anthrozoös, 22*(2), 161–171. https://doi.org/10.2752/175303709X434185

Reddish, P., Bulbulia, J., & Fischer, R. (2014). Does synchrony promote generalized prosociality? *Religion, Brain & Behavior, 4(*1), 3–19.

Reddish, P., Fischer, R., Bulbulia, J., Bulbulia, J., & Huici, C. (2013). Let's Dance Together: Synchrony, Shared Intentionality and Cooperation. *PLoS ONE, 8*(8), e71182. https://doi.org/10.1371/journal.pone.0071182

Reuzel, E., Embregts, P. J. C. M., Bosman, A. M. T., Cox, R., van Nieuwenhuijzen, M., & Jahoda, A. (2013). Conversational Synchronization in Naturally Occurring Settings: A Recurrence-Based Analysis of Gaze Directions and Speech Rhythms of Staff and Clients with Intellectual Disability. *Journal of Nonverbal Behavior, 37*(4), 281–305. https://doi.org/10.1007/s10919-013-0158-9

Smith, L. B., & Thelen, E. (2003). Development as a dynamic system. *Trends in Cognitive Sciences, 7*(8), 343–348. https://doi.org/10.1016/S1364-6613(03)00156-6

Stern. (2018). *The interpersonal world of the infant: A view from psychoanalysis and developmental psychology. The Interpersonal World of the Infant: A View from Psychoanalysis and Developmental Psychology.* https://doi.org/10.4324/9780429482137

Stern, D. (2010). The issue of vitality. *Nordic Journal of Music Therapy, 19*(2), 88–102. https://doi.org/10.1080/08098131.2010.497634

Steen, van der S. (2018). Theory and research methods in Animal-Assisted Interventions (Key-note). Symposium, One health in AAI: current trends and future collaborations in research and practice. Amsterdam

Tabares, C., Vicente, F., Sánchez, S., Aparicio, A., Alejo, S., & Cubero, J. (2012). Quantification of hormonal changes by effects of hippotherapy in the autistic population. *Neurochemical Journal, 6*(4), 311–316. https://doi.org/10.1134/S1819712412040125

Tarr, B., Launay, J., Cohen, E., & Dunbar, R. (2015). Synchrony and exertion during dance independently raise pain threshold and encourage social bonding. *Biology Letters, 11*(10). Retrieved from http://rsbl.royalsocietypublishing.org/content/11/10/20150767

Tarr, B., Launay, J., & Dunbar, R. I. M. (2014). Music and social bonding: â€œself-otherâ€ merging and neurohormonal mechanisms. *Frontiers in Psychology, 5*, 1096. https://doi.org/10.3389/fpsyg.2014.01096

Thelen, E., & Smith, L. B. (2007). Dynamic Systems Theories. In *Handbook of Child Psychology.* Hoboken, NJ, USA: John Wiley & Sons, Inc. https://doi.org/10.1002/9780470147658.chpsy0106

Trevarthen, C., & Daniel, S. (2005). Disorganized rhythm and synchrony: Early signs of autism and Rett syndrome. *Brain and Development, 27*, S25–S34. https://doi.org/10.1016/j.braindev.2005.03.016

van Geert, P. (1998). A dynamic systems model of basic developmental mechanisms: Piaget, Vygotsky, and beyond. *Psychological Review, 105*(4), 634–677. https://doi.org/10.1037/0033-295X.105.4.634-677

Varela, F. J., Thompson, E., & Rosch, E. (1993). *The embodied mind: cognitive science and human experience.* MIT Press.

Verheggen, T., & Baerveldt, C. (2001). From Shared Representations to Consensually Coordinated Actions: Toward an Intrinsically Social Psychology. In *Theoretical Issues in Psychology* (pp. 59–67). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4757-6817-6_6

Verheggen, T., Enders-Slegers, M.-J., & Eshuis, J. (2017). Enactive Anthrozoology: Toward an integrative theoretical model for understanding the therapeutic relationships between humans and animals - Human-Animal Interaction. *Human-Animal Interaction Bulletin, 5*(2), 13–35.

Viau, R., Arsenault-Lapierre, G., Fecteau, S., Champagne, N., Walker, C.-D., & Lupien, S. (2010). Effect of service dogs on salivary cortisol secretion in autistic children. *Psychoneuroendocrinology, 35*(8), 1187–1193. https://doi.org/10.1016/j.psyneuen.2010.02.004

Walsh, F. (2009). Human-animal bonds I: The relational significance of companion animals. *Family Process*. https://doi.org/10.1111/j.1545-5300.2009.01296.x

Yoder, P., & Stone, W. L. (2006). Randomized Comparison of Two Communication Interventions for Preschoolers With Autism Spectrum Disorders. https://doi.org/10.1037/0022-006X.74.3.426

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LIST OF PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Griffioen, R. E., Enders-Slegers, M.J. (2014) "The Effect of Dolphin-Assisted Therapy on the Cognitive and Social Development of Children with Down Syndrome", *Anthrozoos: A Multidisciplinary Journal of The Interactions of People & Animals, 27* (4), pp. 569–580. doi: 10.2752 / 089279314X14072268687961580.

Griffioen, R.E., van der Steen, S., Cox, R., Verheggen, T., Enders-Slegers, M.J. (2019) Changes in Behavioral Synchrony during Dog-Assisted Therapy for Children wit Autism Spectrum Disorder and Children with Down Syndrome. *Journal of Applied Research in Intellectual Disabilities (JARID*), 2019; 00:1-11

Griffioen, R.,* van der Steen, S., Cox, R., Verheggen, T., Enders-Slegers, M.J. (2019) Verbal interactional synchronization between therapist and children with Autism Spectrum Disorder during Dolphin Assisted Therapy: Five case studies. *Animals 2019, 9*, 716

Griffioen, R.E., van Boxtel, G. J.M., van der Steen, S., Verheggen, T., Enders-Slegers, M.J. (2020) Changes in Cortisol and Heart Rate Variability of children with Down syndrome and children with Autism spectrum disorder during Dog-assisted therapy. Submitted

Griffioen, R., en Maurer, C. (2018). Dierondersteunde programma's voor kinderen met Downsyndroom en/of autismespectrumstoornis. *Jeugdbeleid, 12*(2), 113-119.

Pradhapan, P., Griffioen, R., Clerx, M., & Mihajlović, V. (2017). Personalized characterization of sustained attention/vigilance in healthy children. In *eHealth 360°* (pp. 271-281). Springer, Cham.

Gelsomini, M., Garzotto, F., Riva, C., Griffioen, R., Clerx, M. A smart Dolphin for Children with Neurodevelopmental Disorders. Conference paper. 2016.

PRESENTATIONS

Oral presentation IAHAIO Triennial Conference at Green Chimneys, New York, April 2019, Behavioral synchrony during Dolphin-Assisted Therapy for Children with Down syndrome and Children with Autism Spectrum Disorder.

Keynote lecture; Mini Symposium, 20 years of Animal Supported Therapy in the Netherlands, Ouwehands Zoo, March 11, 2017. Animal Assisted Therapy in the Netherlands, 1997-2017, an overview and presentation of results from research.

Keynote lecture; Hypotherapy conference Konya Turkye, 6-10 April 2016. The effect of animal assisted interventions on attunement behavior, verbalization and social interaction of children with Down syndrome and children with autism spectrum disorder.

Oral presentation ISAZ (International Society for Antrozoology) Conference Chicago, July 2013. The effect of Dolphin assisted therapy on the speech/ language development of children with down syndrome.

Oral presentation symposium Open University, (inauguration Prof. Dr. M.J. Enders-Slegers), Effect of animal assisted interventions on the development of children with Down syndrome and children with autistic behavior, December 6, 2013.

Workshops at the IAHAIO / AAIZOO Symposium, October 2018, Amsterdam. "Live better with animals" and "Virtual reality Dolphin therapy"

Workshop at the IAHAIO conference 11-13 July 2016, Paris. Theoretical framework in Human-Animal Interactions and Methodology. (Th. Verheggen, R. Griffioen, MJ. Enders-Slegers and R. Zink).

Poster presentation. The effect of Dog Assisted Therapy on attunement behavior and stress reduction of Children with Down Syndrome and Children with Autism Spectrum Disorder, IAHAIO conference 11-13 July 2016, Paris.

Poster presentation. Effects of serious game intervention and dog assisted interventions on brain activity of children, a feasibility study. IAHAIO conference, 11-13 July, 2016, Paris.

Poster presentation and pitch, Antrozoology symposium, Animal Impact, Open University, The effect of Dolphin assisted therapy on the development of social interactions of Children with Down syndrome and Children with Autism Spectrum Disorder, November 2015.

ABOUT RICHARD GRIFFIOEN

Richard Griffioen was born on November 12th, 1957 in Amsterdam. He spent his childhood in Amsterdam, where he attended primary and secondary school.
He graduated at the Physical Therapy Academy, the Manual Therapy Academy and obtained a master degree in Psychology. Richard is married to Angela and they have a son, Sam and a daughter, Juna. He fulfilled various functions within primary care, health center and sports medical center.

He is an experienced health care professional, coach and trainer. In 1992 he started Medical Center IBIS (Integrated Biomedical Institute and Sports Health Care), with a multidisciplinary team of 13 people, (e.g. sports physiotherapists, athletic coaches, hapto-therapists, acupuncturists, sports doctor, exercise physiologist and massage therapists).

From 1997 till present, he works together with Bert Terpstra and Marjolein Rovers at The Human academy, as trainer/coach responsible for individual coaching processes, non-verbal bodywork and guiding training groups on personal growth and leadership.

In 1997 he started a foundation for Animal Assisted Interventions (SAM Foundation) and initiated research on the development of children with Down syndrome and children with autism spectrum disorder.

He is also the founder of a Care Farm Foundation Het Boerenparadijs (2011-2017) with the objective to facilitate daytime activities for children with disabilities. From 2013 till now he is a board member of AAIZOO, Animal Assisted Interventions in care, education and research.

In 2011 he accepted the challenge to start a PhD research program at the Graduate school of the Open University, Faculty of Psychology and Educational Sciences, chair of Antrozoology, under supervision of Prof. dr. Dr. Marie-Jose Enders-Slegers.

He currently works in his own practice and, together with Carmen Maurer (Leer-dier.nl) and the board of the SAM Foundation provides various animal-assisted intervention programs for children with special needs.