Diplomarbeit

Autism Spectrum Disorders: Early signs and their implications

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eingereicht von

Eva Sigmund

zur Erlangung des akademischen Grades

Doktorin der gesamten Heilkunde

(Dr. med. univ.)

an der

Medizinischen Universität Graz

ausgeführt am

Institut für Physiologie

unter der Anleitung von Betreuer

Assoz. Prof. Priv.-Doz. Mag. Dr.phil. Dr.scient.med Peter Marschik

und

ao.Univ.-Prof.^{in}Dr.^{in}phil. Christa Einspieler

Graz, 02.12.2016

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Danksagung

An dieser Stelle möchte ich all jenen danken, die mich im Rahmen dieser Diplomarbeit begleitet haben.

Ganz besonders möchte ich Assoz. Prof. Priv.-Doz. Mag. Dr.phil. Dr.scient.med Peter Marschik, ao.Univ.-Prof.in Dr.in phil. Christa Einspieler, Mag.a phil. Katrin Daniela Bartl-Pokorny, Mag.a rer.nat. Magdalena Krieber und dem ganzen Research Unit iDN interdisciplinary Developmental Neuroscience – Team, die mich bei meiner Arbeit durch ihre fachliche und persönliche Unterstützung begleitet haben.

Darüber hinaus möchte ich mich bei meinen Eltern bedanken, die mir durch ihre Unterstützung mein Studium ermöglicht haben.

Ein besonderer Dank gilt meinen Kommilitonen und Freunden, durch deren Anregungen meine Arbeit kontinuierlich verbessert wurde und die mich mit viel Geduld moralisch unterstützt haben.

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Abstract

Background: The core features of autism spectrum disorder (ASD), a neurodevelopmental disorder, are impairment in social behaviour, communication behaviour and repetitive behaviours. Experts recommend starting intervention as early as possible although ASD is commonly not diagnosed before the age of 3.

Objective: We hypothesized that the ability to respond when being called might be impaired in children with ASD. Therefore our aim was to define response rates to name calls at the age of 9 to 24 months in three groups of children (i.e. children with ASD, children with Transient Autistic Behaviour 'TAB' or Typically Developing 'TD' children) in order to explore whether a failure to respond to name calling could be serve as one of the early markers for ASD.

Methods: We retrospectively assessed home videos of individuals with ASD, TAB and TD children in order to observe response rates to name calls in the prodromal period of ASD. Furthermore, we established clear cut definitions of name calls and we aimed to assess the mode of response and to highlight whether age has an influence on the expected differences.

Results: The results indicated that children with ASD and TAB showed a response rate of 45% each, TD children had a response rate of 64% at 9 to 12 months of age. At 13 to 18 months, children with ASD responded in 52%, TAB in 44% and TD in 30%. At 19 to 24 months the response rate was 18% for ASD, 39% for TAB; and 65% for TD children. Eye contact was the preferred mode of response. In addition, the number of calls observed in children with ASD was considerably higher compared to TD children across all ages.

Conclusion: We were able to demonstrate that at the second half of the second year children with ASD and TAB reacted less frequently when called compared to TD children. Hence, the results of our study are in line with findings from previous studies and confirm that "response to name" could be part of a complex screening tool for ASD that includes behaviour and biological biomarkers.

Zusammenfassung

Hintergrund: Autismus-Spektrum-Störung (ASS) ist eine neurologische Entwicklungsstörung, deren Hauptsymptome sich als Beeinträchtigungen in der sozialen Interaktion, der verbalen und non-verbalen Kommunikation sowie in begrenzten, repetitiven und stereotypen Verhaltensmustern zeigen. ASS wird kaum vor dem dritten Lebensjahr diagnostiziert, doch wird angenommen, dass frühzeitige Intervention den Verlauf der Erkrankung positiv beeinflussen kann und damit von zentraler Bedeutung ist.

Zielsetzung: Das Ziel dieser Studie war herauszufinden, ob es Unterschiede gibt zwischen Kindern mit ASS, Kindern mit transientem autistischem Verhalten (Transient Autistic Behaviour, TAB) und sich normal entwickelnden Kindern (TD, „typical developing“) hinsichtlich ihrer Fähigkeit auf das Rufen des eigenen Names („response to name“) zu reagieren. Unsere Hypothese war es, dass Kinder mit ASS seltener, als sich normal entwickelnde Kinder, auf das Rufen ihres Namens reagieren.

Methode: Die Studie wurde mit Hilfe von retrospektiver Videoanalyse privater Familienvideos durchgeführt; diese Filmsequenzen von den Probanden wurden in deren Alter von 9 bis 24 Monaten aufgenommen. Dabei wurde verglichen, wie oft Kinder mit ASS, TAB oder TD auf den Ruf ihres Namens reagierten. Zusätzlich wurden die möglichen Reaktionen auf den Ruf des Namens (‚name call‘) definiert.

Ergebnisse: Die Ergebnisse zeigten, dass Kinder mit ASS und TAB im Alter von 9 bis 12 Monate in 45% der Fälle positiv auf das Rufen reagierten, wohingegen TD- Kinder in dieser Alterskategorie zu 64% reagierten. Im Alter von 13 bis 18 Monate reagierten Kinder mit ASS zu 52%, mit TAB zu 44% und TD zu 30%. Mit 19 bis 24 Monaten reagierten Kinder mit ASS auf das Rufen zu 18%, Kinder mit TAB zu 39% und TD-Kinder zu 65%. Die Mehrheit der untersuchten Kinder aus allen Gruppen und Alterklassen reagierten mit Augenkontakt auf das Rufen ihrer Bezugspersonen. Zusätzlich wurde in diesen Untersuchungen deutlich, dass Kinder mit ASS erheblich öfter gerufen wurden als TD-Kinder.

Schlussfolgerung: Diese Ergebnisse bestätigen, dass die Fähigkeit auf den Namensruf zu reagieren, bei Kindern mit ASS im Vergleich zu sich normal entwickelnden Kindern eingeschränkt ist, und dies vor allem im zweiten Halbjahr des zweiten Lebensjahres.

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Table 1: List of abbreviations

ABA	Applied Behavioural Analysis
ABC	Autistic Behaviour Checklist
ADHD	Attention deficit hyperactivity disorder
ADIR	Autism Diagnostic Interview-Revised
ADOS	Autism Diagnostic Observation Schedule
ASD	Autism Spectrum Disorder
CARS	Childhood Autism Rating Scale
Chat	Checklist for Autism Toddlers
DSM	Diagnostic and Statistical Manual of Mental Disorders
EIBI	Early Intensive Behavioural Intervention
ESDM	Early Start Denver Model
HFA	High functioning autism
ICD	International Statistical Classification of Diseases and Related Health Problems
IQ	Intelligence Quotient
M-Chat	Modified- Checklist for Autism Toddlers
nc	Name calls
OCD	Obsessive–compulsive disorder
PDDs	Pervasive developmental disorder
SCQ	Social communication questionnaire
SD	Standard deviation
TAB	Transient Autistic Behaviour
TD	Typically Developing
ToM	Theory of Mind
vl	Video length

1 Introduction

Until recently the trait of autism and outcome of children showing autistic behaviour was considered unchangeable. Consequently, only little attention was paid to early detection of autism. More recent evidence suggests a prevalence of autism of about 1% in general population. Hence, autism is not a rare disease anymore. (Baird et al., 2006; ADDM Network, 2012) As a result to the increasing attention paid on autism some insights regarding the aetiology, pathology and new perspectives on the prognosis emerged. Experts suggest that intervention, and even more so, early intervention, could improve quality of life of children and their families and support functional independence of people with autism. (e.g. Bölte & Hallmayer, 2011; Koegel, 2014) Therefore, it is of major importance to identify and diagnose autism as early as possible in order to facilitate the support of children with autism.

1.1 Classification

To date there are two manuals available for the standardised diagnosis of autism, firstly, the International Statistical Classification of Diseases and Related Health Problems (ICD-10) and, secondly, the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). Both manuals are similar in their understanding of autism. The DSM-5 introduced a new term describing autism as “Autism Spectrum Disorders” (ASD). This new understanding of autism as a spectrum, in contrast to the former classification of distinct forms of autism, enables a more appropriate, individual diagnosis and a rating of the severity of the disease. For a better understanding, both the ICD-10 and DSM-5 criteria for diagnosis are outlined in the section below.

1.1.1 ICD-10

In the ICD-10 autism is listed within the group of diseases classified as Pervasive Developmental Disorders (PDDs). PDDs are defined as: “a group of disorders characterized by qualitative abnormalities in reciprocal social interactions and in patterns of communication, and by a restricted, stereotyped, repetitive repertoire of interests and activities. These qualitative abnormalities are a pervasive feature of the individual's functioning in all situations.” (World Health Organization, 1992 p. 344-346)

According to the ICD-10 classification on forms of autism, the Childhood Autism, which is the one we have dealt with in the present study, belongs also to the PDDs. Criteria for childhood autism defined in ICD-10 (World Health Organization, 1992 p. 344-346) are:

1. "The occurrence of symptoms of autism before the age of three, and
2. The impairment in the three core behaviours describing autism, which are
    a. reciprocal social interaction
    b. communication, and
    c. restricted, stereotyped, repetitive behaviour "

In addition to these core symptoms, phobias, sleeping and eating disturbances, temper tantrums, and aggression are common comorbidities (Sinzig, 2011; World Health Organization, 1992). Besides Childhood Autism, the DSM-5 includes other forms of PDDs in the category of ASD. Therefore, the term "atypical autism" is used if a child does not meet all autistic core behaviours or if these behaviours occur after the third year of life (Sinzig, 2011; World Health Organization, 1992). Furthermore, Rett syndrome, Other Childhood Disintegrative Disorders, Overactive Disorders associated with mental retardation and stereotyped movements, Asperger Syndrome, High Functioning Autism, Pervasive Developmental Disorder-unspecified, are also categorised as PDDs. (World Health Organization, 1992)

1.1.2 DSM-5

As mentioned above, in contrast to the ICD-10, the DSM-5 introduced the term Autism Spectrum Disorders (ASD), which includes all disorders previously referred to as "early infantile autism, childhood autism, Kanner's autism, high-functioning autism, atypical autism, pervasive developmental disorder not otherwise specified, childhood disintegrative disorder, and Asperger disorder" (American Psychiatric Association, 2013 p. 64-76).

The diagnostic criteria in DSM-5 of ASD are similar to those used in the ICD-10 to diagnose PPDs (American Psychiatric Association, 2013 p. 64-76) and are the following:

1. "Persistent deficits in social communication and social interaction including deficits in social-emotional reciprocity, deficits in nonverbal communication and deficits in developing, maintaining and understanding relationships.

2. Restricted, repetitive patterns of behaviour, interests or activities including stereotyped or repetitive movements, insistence on sameness, inflexible adherence to routines or ritualized patterns which leads, for example, to difficulties in transition, highly restricted and fixated interests that are abnormal in intensity and focus, and unusual interest in sensory aspects.
3. Symptoms must be present in the early developmental period.
4. The symptoms need to cause clinically significant impairment in social, occupational or other important areas of current functions.
5. The impairment is not better explained by intellectual disability or developmental delay."

According to DSM-5 (American Psychiatric Association, 2013), the severity of ASD is confined to three levels of support a person requires in the fields of social communication and restricted, repetitive behaviours.

In level 1, the patient requires support. Autistic people do have noticeable impairments in social communication as well as difficulties initiating social interactions. In addition inflexibility is interfering with everyday functioning. In level 2, defined as "requiring substantial support" (American Psychiatric Association, 2013 p. 64-76), patients show deficits in verbal and non-verbal communication. Impairments are visible even if the patient receives support. The response to social overtures is reduced or abnormal. In level 3, patients show severe deficits in verbal and non-verbal communication and require substantial support. This inflexibility interferes in all aspects of life. (American Psychiatric Association, 2013)

The classification of autism as a spectrum introduced by the DSM-5 (American Psychiatric Association, 2013) not only allows the gradual assessment of severity but also takes the developmental level and the chronological age of the patient into account. As ASD is not a degenerative disorder and its severity and outcome are always influenced by additional factors such as learning and compensation, the level of severity is alterable within the spectrum of autism. That is why a classification according to the DSM-5 is able to reflect reality most closely. (American Psychiatric Association, 2013)

In this study we referred to the criteria of the DSM-5, therefore from now on we will use the term ASD.

1.1.3 Core symptoms in detail

To understand how the core symptoms of ASD affect the daily life of children and their families, I will outline some features of children with ASD. One core feature for the early diagnosis is lack of imitation (Sinzig, 2011). Children with ASD imitate social behaviour less often than typically developing children. This lack of imitation interferes with the development of social skills. A defect in the mirror neuron system of children with ASD is assumed to be responsible for the impairment of social learning (Dapretto, 2013). Among other phenomena, mirror neurons enable us to experience the same emotion while watching a situation as if we would have carrying out the respective situation. This is one way of how humans learn to interact with others. The lack of social learning might be the reason why children with ASD do not properly develop a so-called Theory of Mind (e.g. Sinzig, 2011; Bölte, 2009; Volkmar, 2014). The Theory of Mind (ToM) is a concept which enables the imagination and prediction of another person's feelings, needs, ideas, intentions, expectations or opinions in order to empathize with that person. Consequently, the ability to play 'If...-games' or imitation games, is often reduced or absent in children with ASD. (e.g. Bölte, 2009; Volkmar, 2014; Sinzig, 2011) Interestingly, the pre-stage of the above mentioned ToM is the ability of a child to keep eye contact or to react to his/her name when addressed (Kampe et al., 2003). Furthermore, it was reported that the same brain areas are activated while responding to the own name as are during the processes related to the ToM.

Consequently, children with ASD have shortcomings and impairments in reciprocal social interaction. This includes the inability to use and understand language and body language, such as gestures, facial expressions, eye contact and posture as an instrument to regulate social interactions. Furthermore, children with ASD show limitations in building up relationships, sharing and understanding interests or emotions of others. The lack of social emotional reciprocity makes it difficult for children with ASD to understand and react adequately to emotions of other people; that is to recognize and understand feelings or to behave adequately in a social context (Sinzig, 2011; Bölte, 2009; Volkmar, 2014).

Joint attention, which is the ability to share attention on something with another person, is often restricted in children with ASD. One example for joint attention is the so called index finger pointing: a person wants to guide the child's attention into the direction of a subject of interest by pointing with the finger. Usually, typically developing children look into the

direction the other person pointed to. Children with ASD, however, have problems in understanding this request to share attention and to follow the pointing finger. (e. g. Sinzig, 2011)

Moreover, the development of speech/language and communication plays a central role in diagnosing ASD as children with ASD are often impaired in these domains. In children with ASD language development is delayed or even absent and cannot be compensated by means of other modalities of nonverbal communication. As any other language development disorder would be accompanied by other modes to communicate, children with ASD do not use alternative ways of communication. Furthermore, children with ASD often have problems to use pragmatic language and semantic aspects of language. That is, to use language appropriately and understand the meaning of what is being said. (Sinzig, 2011; Bölte, 2009; Volkmar, 2014; Libertus, 2015) Additionally, it is difficult for children with ASD to start a conversation and to maintain it, as language is often confined to restricted, repetitive and stereotyped patterns.

Although, stereotyped and repetitive language behaviour is a substantial characteristic of ASD, it is the least reliable marker for diagnosis, as typically developing children of young age show similar preferences for repetition and imitation of language (American Psychiatric Association, 2013). Stereotyped and repetitive behaviour can also manifest in stereotyped motor mannerisms, narrow and unusual strange fields of interests and hypo- or hyperactivity in response to sensory stimuli. Furthermore, an obsessive need to follow special rituals is common. (Sinzig, 2011;American Psychiatric Association, 2013; Bölte, 2009; Volkmar, 2014) The excessive adherence to routines, rituals and restricted patterns of behaviours might cause considerable stress in situations of alterations, for example, when asked to suddenly walk on the opposite site of the road. .

Another determining factor in the behaviour of individuals with ASD is impairment in action planning. From a neuropsychiatric perspective this is defined as impairment in executive functions. Executive function is the ability to plan actions and to solve different tasks or problems.

Furthermore, children with ASD might be outstanding in perceiving details but are often unable to understand the holistic view.

Eventually, it has to be mentioned that 50% of children with ASD are intellectually impaired, with intelligence quotients ranging from 50-70 (Sinzig, 2011).

1.1.4 Transient autistic behaviour (TAB)

In 2007, Turner and colleagues (Turner & Stone, 2007), reported that the diagnostic stability for Childhood Autism (defined by DSM- IV criteria) was only 63%. This suggests, that there was a decent number of children who first met the diagnosis criteria for ASD but "lost that diagnosis later on". Children who lost the diagnosis differed from children with persistent ASD in the following aspects (Turner & Stone, 2007):

1) age of initial diagnosis: 30 months or younger at initial evaluation

2) severity of symptoms: milder symptoms of autism, particularly in the social domain, and

3) cognitive abilities: higher cognitive scores at 2 years of age.

Due to a lack of studies in this field, no effect of interventions could be linked to children whose ASD diagnosis was reversible compared to children with persistent ASD. In the study of Turner and Stone (2007) almost all children with TAB continued to develop some abnormalities in respect to language and cognition although they improved in their socio-communication.

These findings support the following assumption: "What is apparently at play with those children who are able to escape the unfortunate fate of persistent autism is related to the nature of the underlying disorder which allows a positive outcome and possibly an appropriate intervention" (Zappella, 2012 p.116). In 2012, Zappella spent a number of studies and observations on Reversible Autism or TAB. Autistic behaviours are usually present from 2.5 to 3.5 years of age and fade away afterwards. According to Zappella (2012) the most common reason for TAB is "early institutionalization, Landau and Kleffner syndrome, early onset epilepsies, intrauterine rubella, or blindness". However, these explanations do not hold true for other children with early autistic behaviours. What these children have in common are similar comorbidities such as Developmental Disorders, Attention Deficit Hyperactivity Disorder (ADHD) and Tic Disorder. Most of these children were reported by their parents to have developed normally until a regression

or loss of abilities, co-occurring with autistic features, observed during the second year of life. Tics also emerged at that time. Zappella concluded that Tic Disorders could be relevant for the identification of TAB. (Zappella, 2012)

1.2 Epidemiology

As mentioned above, ASD has a prevalence of 1% in the general population (Baird et al., 2006; ADDM Network, 2012). Referring to Sinzig (2011) 10 to 16 out of 10.000 children are affected by early childhood autism. In Austria 48.500 people are presently diagnosed with autism, among them 13.600 with early childhood autism (Dachverband Österreichische Autistenhilfe, 2015). The gender ratio is 4 males : 1 female (American Psychiatric Association, 2013). Studies on the heritability of ASD showed that in 18% siblings of a child diagnosed with ASD are also affected (Ozonoff et al., 2011). In monozygotic twins the percentage of affected siblings amounts even to 58% (Hallmayer et al,. 2011), suggesting a high heritability of ASD.

1.3 Pathogenesis

To date many researchers focus on the pathogenesis and aetiology of ASD although no universal answer on the cause of ASD could be determined yet. As the phenotype of ASD is heterogeneous, its aetiology seems to be inconsistent. Neurophysiology, neuropsychology, genetics, brain growth and structure, neurotransmitter and pre- and perinatal factors influence the genesis of ASD (Sinzig, 2011; Bölte, 2009).

Genetic deviations causing symptoms of ASD (1) refer to co-morbidities of genetic syndromes (5-10% of ASD); (2) are inherited or non-inherited de novo mutations on hundreds of ASD risk genes; (3) are a dysregulation of epigenetic mechanism; or (4) are based on environmental conditions (Bölte, 2014). Sinzig (2011) also suggests that findings on genetics are inconsistent. Consequently, although the high heritability among siblings indicates reproductive genetic changes, Sinzig emphasised that genetics are not sufficient to explain ASD. Nevertheless, ASD is associated with genetic syndromes like Tuberous sclerosis, Fragile-X-syndrome and Neurofibromatosis and 10-20% of the cases are caused by chromosomal mutations, during meiosis. Epigenetics also influences the emergence of ASD. Therefore, cell regulation of expression patterns could be influenced by external factors such as intrauterine exposure to Valproat, an anti-epileptic drug.

Neurotransmitters, such as serotonin and dopamine are also involved in the pathogenesis of ASD. Sixty per cent of the patients with ASD have decreased levels of serotonin in the brain. (Sinzig, 2011) Abnormalities in the balance of oxytocin, a hormone, which also effects emotional stability, were additionally found in patients with ASD (Husarova et al., 2016; Sinzig, 2011).

Another abnormality in children with ASD is an enlarged head circumference. Functional imaging studies revealed structural and functional differences in the brain of children with ASD (Bölte, 2014; Yirmiya & Charman, 2010). Sinzig (2011) reported that at the age of 2 to 4 years the brain volume, especially white matter volume, of children with ASD was increased. Experts assume dysfunctional orientation of nervous cell connections to cause a compensatory growth of white matter. (Sinzig, 2011)

Pre- and perinatal influences, such as Rubella infection or maternal alcohol abuse during pregnancy, the age of the parents, the use of certain drugs during pregnancy, low birth weight and respiratory distress are further risk factors for ASD (Sinzig, 2011).

1.4 Detection and diagnosis of ASD

As outlined above ASD is a neurodevelopmental disorder of complex origins. State of the art diagnosis of ASD relies on neuropsychiatric markers (Bölte, 2014).

Commonly, ASD is not diagnosed before the age of 3 (Shattuck et al., 2009). The most common parental concerns leading to a medical consultation are abnormalities in the speech/language domain (Hess & Landa, 2012) although parents might have also earlier more common concerns (Saint-Georges et al., 2011).

The diagnostic procedure of ASD includes the following steps: (1) a general medical history with the parents (i.e. questions related to abnormalities at birth; the behaviour during the first year of life; problems with regulation of crying, sleeping, and eating; impairment of language development and playing behaviour; family history with respect to PDDs or behavioural abnormalities even back to three generations); (2) a suspicion of a diagnosis of ASD as a result of the anamnestic information; (3) screening/specific diagnostics, with the help of clinical behavioural exploration of social interaction, communication and stereotyped behaviour; (4) defining differential diagnosis and co-morbidities, like problems in regulation or reactive depressions and aggressions such as Obsessive Compulsive Disorder (OCD), Attention Deficit Hyperactivity Disorder

(ADHD), Tic Disorder, Aggression and Conduct Disorder; (5) assessment of severity (see section about DSM-5). (for an overview see Sinzig, 2011)

The most frequently used standardized psychological assessments for the early detection of ASD are the SCQ-questionnaire (Social Communication Questionnaire) (Rutter et al. n.d.), the Checklist for Autism in Toddlers (Chat) (Baron-Cohen et al,. 1992), and the Modified-Checklist for Autism in Toddlers (M-Chat) (Robins et al., 2001), the ADOS (Early Detection of Autism) and ADI-R (Autism-Revised) (Allison et al., 2012).

The SCQ is a parental questionnaire used for the detection of ASD and focuses on social communication after an age of 3 to 4 years. The Chat and M-Chat are commonly used by the age of 3 years. The ADOS can be applied from 18 months onwards and assesses communication, social interaction and play. It is widely accepted as the gold standard for diagnosing ASD (Lord et al., 2000; Allison et al., 2012; Sinzig, 2011) and was enhanced with a new module, the ADOS Toddler Module (or Module T), to improve its utility with very young children under 30 months of age (Luyster et al., 2009).

However, it still remains a challenge to identify early and reliable features pinpointing ASD.

1.5 Treatment/Intervention

If and how ASD is treatable is a highly debated topic. As ASD is considered to be incurable, interventions generally focus on the optimization of individual outcomes. Bölte (2014) is convinced that only 15% of individuals with ASD are able to live independently. The main goal for a child with ASD is to reach as much functional independence as possible. The age when intervention begins is assumed to influence the outcome. Therefore experts recommend starting intervention as early as possible (Bölte & Hallmayer, 2011; Koegel et al., 2014).

In 2011, Sinzig reported about the effectiveness of the Early Intensive Behavioural Interventions (EIBI) and Applied Behaviour Analysis (ABA) (Rogers & Vismara 2008; Sinzig 2011). The results on the effectiveness of the Early Start Denver Model (ESDM), a behavioural treatment starting at the age of 2 years, suggest the same as Sinzig, namely the following: Participants scored better with respect to intelligence and adaptive behaviour after a 2-years-period with intensive ESDM-therapy compared to common treatment (Dawson et al., 2010).

It has been criticized that these interventions did not affect the core symptoms of ASD but mainly influenced intellectual abilities and language development (Sinzig, 2011). Nevertheless, intelligence and language are seen as the most reliable prognostic factors for the outcome of ASD (American Psychiatric Association, 2013). Therefore, an increase in IQ and intensive language training might influence the outcome remarkably.

One reason for supporting early intervention is related to neuroplasticity of the brain. The language domain should be well established when entering school. Consequently, intervention focusing on speech-language development should start well in advance and this is just one example for many processes improving social learning (e.g.: joint attention, ToM… see section 1.1.3 Core symptoms in detail) (Knudsen, 2004; Libertus, 2015). Toddler age is thought to be the best starting point for intervention related to social learning. By mitigating the cascade of autistic symptoms and supporting social learning, early intervention increases the chances for integration in the society and the ability to live an independent life later on. (Bölte & Hallmayer, 2011)

Another benefit of early intervention might be to avoid negative experience in social interaction, for both children and their families. Additionally, early intervention enables parents to acquire strategies to interact appropriately with their child. (Sinzig, 2011)

1.6 Scientific background of my study

In this Chapter, I shall (a) emphasise on current trends of early identification of ASD and (b) focus on the ability to react socially when being called.

As the phenotype of ASD is quite heterogeneous the detection of one single and distinctive sign or symptom might be insufficient to indicate ASD reliably (Yirmiya & Charman; 2010; Bölte, 2014; Tager-Flusberg et al., 2016). A useful approach to overcome the difficulties of reliable identification might be to search for "both the presence of unusual behaviours (e.g. stereotypes) as well as the absence of typically developing behaviours" (Baranek, 1999 p. 215-224). Besides focusing on early pathological signs, attention should also be paid to the absence of a range of age specific behaviours present in typically developing (TD) children (e.g. index finger pointing, joint attention, responding to name, verbal language) (e.g. Maestro et al., 2001).

We hypothesized that the ability to respond when being called ("response to name") might be impaired or absent in children later diagnosed with ASD.

TD infants at the age of 4.5 months are able to recognize the sound patterns of their own names when being called (Mandel et al., 2012). Werner and colleagues emphasized that: "orienting to name involves aspects of both; the social and communication domains, as well as attention, so it taps nearly all the domains known to be impaired in autism" (Werner, Dawson, Osterling, & Dinno, 2000 p. 997-1003).

Saint-Georges and colleagues (2010) also considered the disability to respond to name as a very robust early sign to detect deficits in communication. Furthermore it is an easy discriminative and reproducible sign for ASD and represents dysfunction of all fields of communication in children with ASD. This is in line with Baranek (1999) who raised the question if an impairment in response to name calling might reflect more general problems in responsive behaviour (attention/orientation).

Clifford and Dissanayake (2008) suggest that deficits in dyadic behaviours such as lack of eye contact and early affective impairments are precursors of deficits in joint attention and hence, of more complex social interactions. Focusing on dysfunctional response to name and peculiarities in an additional set of behaviours including interest in peers and quality of eye contact, 79% of the infants later diagnosed with ASD could be correctly identified (Clifford & Dissanayake, 2008).

Retrospective audio-video analysis is a popular tool to study early human behaviour. In studies on ASD the core features of ASD (i.e. social behaviour, communication behaviour and repetitive behaviours) are often used to explore early behaviours. In the study of Werner and colleagues (2000), the category "social behaviours" included features like "looking at others, looking at the face of another while smiling, and orienting to name". When focusing on response to name calling, these authors calculated the proportion of responses to the total number of name calls.

To get an idea how coding was done in other studies (for our study see Methods 2.4.1Coding), I will give an example how Clifford et al. (2007) defined eye contact and respond to name. Eye contact was scored when "the infant directs his/her visual attention to a person and looks directly into the person's face and into the eyes; or looks directly at the camera when a person is standing behind the camera" (Clifford et al., 2007 p.311). A child was considered to respond adequately to his/her name if "the child turns his/her head and looks at the caregiver's face when being called" (Clifford et al., 2007 p.311). The authors suggested that not just the presence or absence of distinctive behaviours was

important but also the quality and form of early nonverbal communicative behaviour should be taken in consideration.

Several studies suggest that impairments in response to name can be detected from 8 to 10 months onwards (e.g. Werner et al., 2000). Differences in the response rate can be used to discriminate infants with ASD from typically developing children, and developmentally delayed children (Werner et al., 2000; Clifford et al., 2007; Saint-Georges et al., 2010; Baranek, 1999).

Infants with ASD were found to need significantly more prompts to react when being called (Baranek, 1999). Although a low response rate is specific for ASD its sensitivity is rather low resulting in a high number of children who remaining undetected (Nadig et al., 2007; Yirmiya & Charman, 2010).

In their study Werner et al. (2000) found that 8 to 10 months old children with ASD responded to 37% of the name calls, while the response rate for their typically developing peers was 75%.

Baranek (1999) compared children with ASD, developmentally delayed children and typically developing children at the age of 9 to 12 months. She found, among other results, the ASD group to respond to name calls less frequently, than either typically developing children or children with a developmental delay.

Yirmiya and Charman (2010) concluded that early social communicative impairments (i.e. “shows interest in people”, “smiles directly”, “reacts when spoken to”) are the most reliable indicators for ASD.

Although, retrospective audio-video analysis has a number of limitations, findings from prospective studies on ASD emphasise its reliability: at the end of the first year the frequency of looking at or orienting towards others was decreased and the response rate to name calls was low for children with ASD. During the second year looking at people was even more reduced (Nadig et al., 2007)

Nadig et al. compared response to name in an at-risk group (i.e. siblings from children with ASD) to a group of siblings of TD children. At the age of 12 months all siblings TD children responded to either the first or second call of their name. In contrast the reaction rate of siblings from children with ASD was 86%. Seventy-five per cent of the high risk

group, who failed to respond to their name at 12 months of age, were diagnosed with ASD (n=5) or with other developmental delays (n=4) at the age of 24 months. (Nadig et al., 2007; Yirmiya & Charman, 2010)

1.7 Our research questions

In this study we focused on one specific aspect of early socio-communicative behaviour, the child's ability to respond to his or her name when being addressed. Our aim was to define response rates to name calls at the age of 9 to 24 months in three groups of children (i.e. children with ASD, children with TAB or TD children). Trying to define differences between the three groups we hypothesised that children with ASD have lower response rates than children with TAB or TD children. Furthermore, we aimed to highlight whether age has an influence on the expected differences, and we assessed the mode of response and established clear cut definitions of name calls (for details please see Methods section).

2 Methods

Building on the methodological footsteps of many social reciprocity studies in ASD, we used a retrospective approach to observe orienting/response to name in the prodromal period of infants later diagnosed with ASD.

In this study we retrospectively assessed home videos recorded between 9 and 24 months of age of participants with ASD, TAB and TD toddlers.

2.1 Participants

In this study fifteen male children diagnosed with ASD (Cases 1-15) and 12 male children (Cases 16-27) diagnosed with TAB were included. In addition, seven TD children from Austria (2 male, 5 female), were included as control group for this pilot study. All videos have been taken by their parents; in case of ASD or TAB at a time when parents did not know about the presence of a neurodevelopmental disorder. All parents reported normal early development and no suspicion of developmental delay in the first year of life. The participants of the ASD and TAB group were born in Italy between 2004 and 2010 at term age with an appropriate birth weight.

Table 2 provides additional data about the age of onset of autistic behaviours and details on examination and outcome. The neuropsychiatric diagnoses were made according to ICD-10 (World Health Organization, 1992). The participants were diagnosed with ASD between 18 and 24 months of age. As cases 16 to 27 did not show autistic behaviours after the last examination they were categorised as TAB. Five individuals with TAB were later diagnosed with, Gilles de la Tourette syndrome (Cases 16-21); Tic Disorders and Gilles de la Tourette syndrome also occurred as co-morbidity in four individuals diagnosed with ASD (Cases 1, 10, 12, and 14). Attention Deficit Hyperactivity Disorder (ADHD) occurred as co-morbidity to ASD in cases 8, 10 and 13 and was found in six individuals with TAB (Cases 14, 15, 19, 20, 22, and 27). Ten cases (Cases 1, 2, 3, 4, 6, 9, 10, 11, 12, and 14) out of the ASD group and three cases (Cases 16, 18, and 20) of the TAB group had cognitive impairments (ranging from -1 SD to -2 SD; Table 2). Some of these individuals participated also in a retrospective study on motor and socio-communicative behaviours from birth to 6 months of age (Zappella et al., 2015).

Table 2: Age and examination at the onset of autistic behaviours and further neuropsychiatric development of the 27 participants (15 ASD, 12 TAB) (Zappella et al., 2015)

	Age; onset	First examination	Age; last examination	Last examination	Cognitive status	Tic Disorder	ADHD
case 1	18	Clin eval	3;7	CARS=15	-1	+	
case 2	18	Clin eval	5;6	ASD	-1		
case 3	24	Clin eval	6;0	ASD	-2		
case 4	18	Clin eval	4;9	ADOS=28	-2		
case 5	18	ADOS=20	3;10	ASD	not testable		
case 6	12-24	Clin eval	3;6	ASD	-1		
case 7							
case 8	12-24	CARS=32.5	5;10	ADOS=18	not testable		+
case 9	18	Clin eval	4;0	ASD	-1		
case 10	12-24	CARS=37	7;0	ABC=48	-2	+ (f)	+
case 11	15	Clin eval	3;0	CARS=33	-2		
case 12	14	Clin eval	4;6	ASD	-1	+	
case 13	12-24	Clin eval	4;3	ASD	Normal		+
case 14	15	CARS=36	7;1	ASD	-1	+(f)	+
case 15	18	ADOS=10	7;1	HFA	Normal	-	-
case 16	18	Clin eval	9;0	CARS=15	-1	+	+
case 17	20	CARS=33	5;9	CARS=16	Normal	+(f)	+
case 18	15	CARS=36	4;0	CARS=20	-2	+	-
case 19	18	ADOS=8	7;0	CARS=15.5	Normal	+(f)	-
case 20	18	ADOS=16	5;6	CARS=15	-1	+	-
case 21	18	ABC=47	9;7	CARS=18	Normal	+	+

	Age; onset	First examination	Age; last examination	Last examination	Cognitive status	Tic Disorder	ADHD
case 22							
case 23	24	Clin eval	5;8	CARS=16	Normal	-	+
case 24	15	CARS=36	5;1	CARS=15	Normal	-	-
case 25	24	ADOS=19	5;4	CARS=16	Normal	-	-
case 26	18	Clin eval	7;4	CARS=15	Normal	-	-
case 27	18	Clin eval	6;8	CARS=21	Normal	-	+

Key: ADHD= Attention Deficit hyperactivity Disorder; ABC= Autistic Behaviour Checklist; ADOS= Autistic Diagnostic Observation Schedule, subcategory communication and interaction (cut-off value= 6); ASD= Autism Spectrum Disorder; CARS= Childhood Autism Rating Scale (cut-off value= 30) (Chlebowski, Green, Barton, & Fein, 2013); HFA= High-Functioning Autism; SD= standard deviation; += present; −= absent; (f)= familial; Clin eval= Clinical evaluation according to ICD-10. (Zappella et al., 2015)

2.2 Ethical approval

The study was approved by the local research ethics committee and the parents gave their informed consent to retrospective video-analyses and to the publication of the results. The Institutional Review Board of the Medical University of Graz approved the method of retrospective video analyses.

2.3 Data base

2.3.1 Footage

In total, 1472 min of recorded footage was available for analysis across all participants. We observed 388 minutes of footage of children later diagnosed with ASD, 504 minutes of footage of children with TAB and 552 minutes for TD children. .

Referring to the article by Townend et al. (2015) the videos were divided into three distinct age categories. The first category summarizes all videos of children from 9 to 12 months; the second group refers to 13 to 18 months; and the third group contains videos of children aged 19 to 24 months. Details are given in Figure 1.

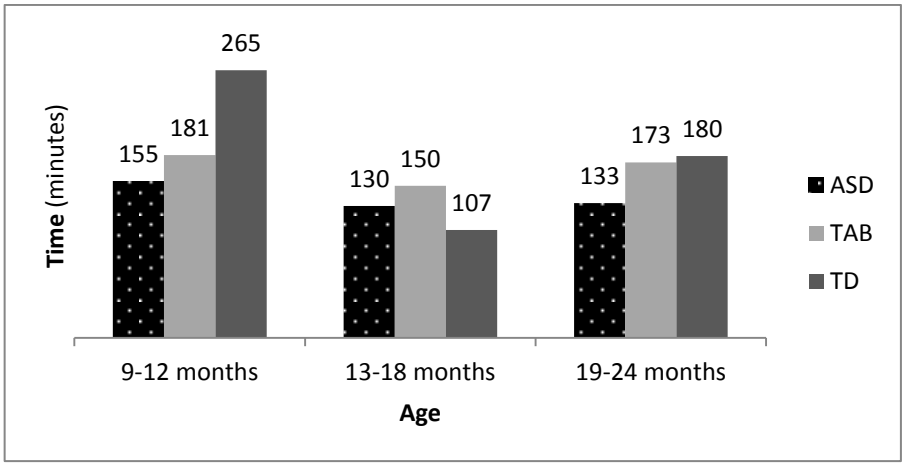

Figure 1: Available video recordings in minutes according to the three age categories

2.3.2 Case/Calls/Footage-Overview

The following Tables (Table 3Table 4Table 5) give an overview on the duration of video recordings, the number of name calls per individual observed in our study.

Table 3: Number of name calls ("nc") and video length in minutes ("vl") for each individual in the age categories 9-12 months, 13-18 months, and 19-24 months in the ASD group

ASD	**9-12 months**		**13-18 months**		**19-24 months**	
	nc	vl	nc	vl	nc	vl
case 1	7	8	1	3	0	0
case 2	11	19	16	16	3	7
case 3	4	5	4	4	0	0
case 4	7	9	30	18	6	9
case 5	8	4	5	5	0	0
case 6	1	1	0	0	0	0
case 7	5	14	5	5	25	20
case 8	6	6	1	2	13	10
case 9	1	1	0	0	0	0
case 10	12	22	7	6	0	0
case 11	24	224	70	58	0	0
case 12	0	0	3	7	8	44
case 13	3	3	1	1	15	29
case 14	25	27	1	2	3	9
case 15	12	9	9	6	8	5
Sum						
Number of cases:	14		13		8	
Number of calls:	126		153		81	
Video length:	352		132		133	

Table 4: Number of name calls (‘nc’) and video length in minutes (‘vl’) for each individual in the age categories 9-12 months, 13-18 months, and 19-24 months in the TAB group

TAB	**9-12 months**		**13-18 months**		**19-24 months**	
	nc	vl	nc	vl	nc	vl
case 14	19	26	52	46	8	14
case 15	0	0	16	18	38	35
case 16	9	13	0	0	6	15
case 17	1	0	5	2	0	0
case 18	15	17	12	14	11	18
case 19	25	48	17	31	26	67
case 20	7	13	0	0	0	0
case 21	14	22	0	0	2	5
case 22	11	27	1	17	17	34
case 23	11	9	0	0	0	0
case 24	1	2	2	3	5	4
case 25	4	4	12	19	0	0
Sum						
Number of cases:	11		8		8	
Number of calls:	117		117		113	
Video length:	181		150		192	

Table 5: Number of name calls (‘nc’) and video length in minutes (‘vl’) for each individual in the age categories 9-12 months, 13-18 months, and 19-24 months in the TD group

TD		**9- 12 months**		**13-18 months**		**19-24 months**	
		nc	vl	nc	vl	nc	vl
	case 1	24	60	7	48	2	43
	case2	4	36	0	0	0	0
	case 3	25	149	2	7	0	0
	case 4	2	19	0	0	7	34
	case 6	0	0	2	2	9	103
	case 7	0	0	1	20	0	0
	case 8	0	0	1	29	0	0
Sum							
Number of cases:		4		5		3	
Number of calls:		55		13		18	
Video length:		265		107		180	

2.3.3 Recording Situations

Certainly, and one of the methodological problems when dealing with retrospective video analysis, is the non-standardised video material. Our video recordings displayed the child during the course of typical daily activities such as feeding or bathing as well as on special occasions such as birthday parties, Christmas or carnival. We analysed (a) situations in which the child was playing alone with certain objects such as a ball, a rattle, a toy or a stuffed animal as well as (b) situations in which the child interacted with other individuals , for example during feeding or playing with the parents or other children. We distinguished between (1) low communicative settings, like interacting with one person, as it was often the case in feeding situations or (2) complex communicative settings, i.e. scenes in which the child was surrounded by other people. This was for example the case during family

celebrations, carnival or at the playground. In these scenes the child was exposed to many different distractions. Background noises, different simultaneous conversations, music, visual stimulants or children dressed up for carnival built the context of these videos. Therefore we tried to balance between (1) and (2) and did not preselect specific situations.

2.3.4 Coding software

We used 'The Observer XT' (www.nodlus.com), which is a manual event recorder for the collection, management, analysis and presentation of observational data, in our case, obtained from family videos. The software is used to record any aspects of human or animal behaviour like activities, postures, movements, positions, social interactions. 'The Observer XT' enables to code distinct behaviours and to measure time intervals between these coded events. Any event, for example a specific behaviour, can be marked in the video and defined by a unique describing code. Furthermore it is possible to install several individually defined modifiers to specify the coded behaviour. For example one can define the reaction of the participant; in our study we coded details on how the child reacted (e.g. eye contact, vocalisation, etc. see 2.4.1 Coding).

The program memorizes the coded events in regard to the timeline of the observational data. Therefore any scene showing the coded event can be replayed just by clicking on it. Furthermore the analyst function of "The ObserverXT" allows producing lists, tables, graphical representations and statistical calculations. Figure 2 gives an example for the coding scheme in "The ObserverXT" used in our study.

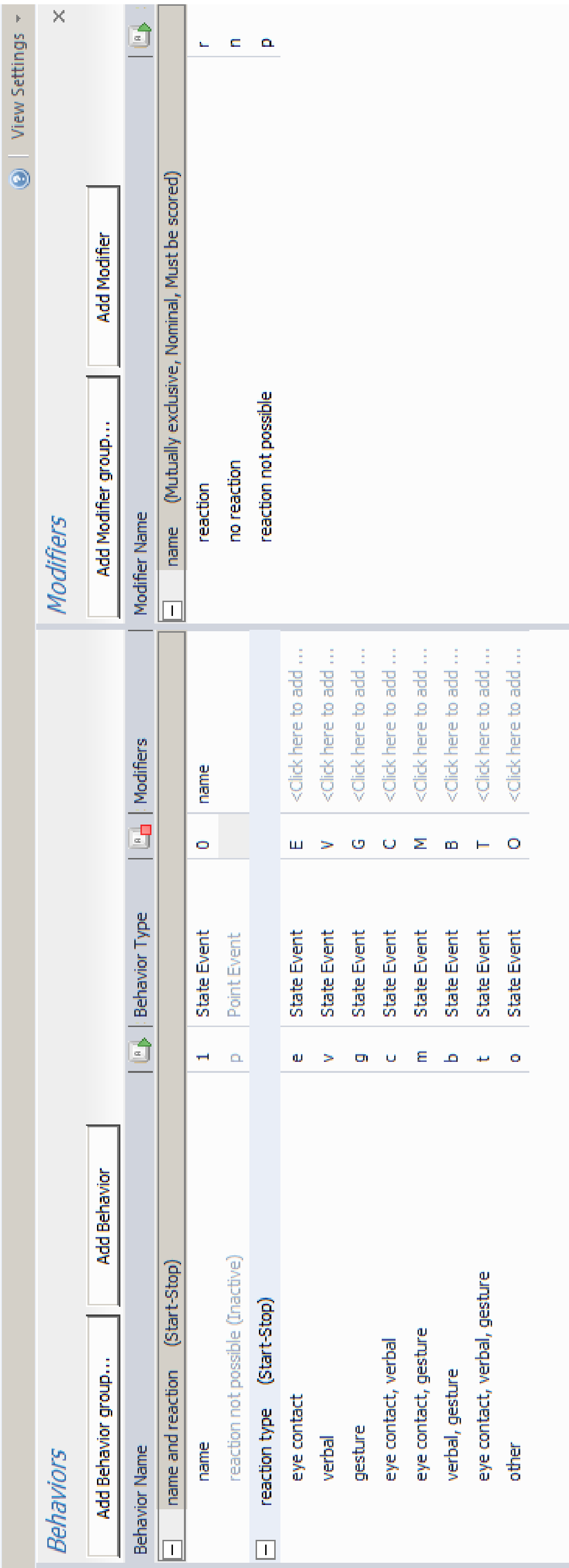

Figure 3: Coding scheme

2.4 Procedure

The observer of this study was blind to the children's diagnoses. The study was carried out at the iDN Lab *braintegrity* and supervised by Assoz. Prof. Priv.-Doz. Mag. Dr.phil. Dr.scient.med Peter Marschik, ao.Univ.-Prof.in Dr.in phil. Christa Einspieler, Mag.a phil. Katrin Daniela Bartl-Pokorny and Mag.a rer.nat. Magdalena Krieber.

2.4.1 Coding

As outlined before, we assigned different behaviours to a unique identifier in 'The Observer XT' program. The procedure of coding the videos started with identifying calls by name. We defined a 'name call' as a situation in which the caregiver called the child to get his/her attention. Our aim was to find out if the child was able to react socially adequate when called by the name. Besides calling the child by its given name we included all verbal approaches with calling intonation of the caregiver (e.g., nicknames, whistling). Questions or admonition were excluded. A reaction to a name call was noted when a child reacted within three seconds after being called and answered after maximal two prompts. We categorized possible behaviours (see Table 6) as a reaction/response to a name call.

Table 6: Behaviours related to specify reactions

(1)	Eye contact: Eye contact with the caregiver who called the child by the name, including head movement (turning, looking up....) towards the caregiver.
(2)	Verbal: The child was responding to the name by using vocalisations.
(3)	Gesture: The child responded by using gestures like waving.
(4)	Eye contact + verbal [(1)+(2)]
(5)	Eye contact + gesture [(1)+(3)]
(6)	Eye contact+ verbal+ gesture [(1)+(2)+(3)]
(7)	Other: This category includes all other possible behaviours of the child which expressed a reaction towards its name being called.

No reaction to a call was annotated if (i) the child did not show any response behaviour, (ii) it took the child longer than three seconds to react, or (iii) the caregiver needed to use more than two prompts to elicit a response.

In some occasions it was not possible to score reactions. Examples for this can be situations in which the child was already looking at the caregiver and a reaction to the call was not possible because they were already interacting; or, situations in which the child was unable to react to the call because he or she obviously couldn't hear the call due to background noise; or when the reaction was not visible, because the child wasn't visible in the video.

3 Results

3.1 Footage:

As mentioned above (see Methods) 1472 min of recorded footage was available for analysis across all participants. We observed 388 minutes of footage from children later diagnosed with ASD, 504 minutes of footage from children with TAB and 552 minutes from TD children. The total durations of footage for the specific age categories and diagnoses ranged from 107 to 265 minutes. Table 7 gives the duration of available footage within all groups separately for the three age categories.

Table 7: Duration of footage in minutes within the groups separately for the three age categories

	ASD	TAB	TD
9-12 months	155	181	265
13-18 months	130	150	107
19-24 months	133	173	180

3.2 Number of Cases

Figure 4 gives the number of cases/individuals analysed separately for each age category and group. It should be noted that in the ASD and TAB groups more data were available than for TD children.

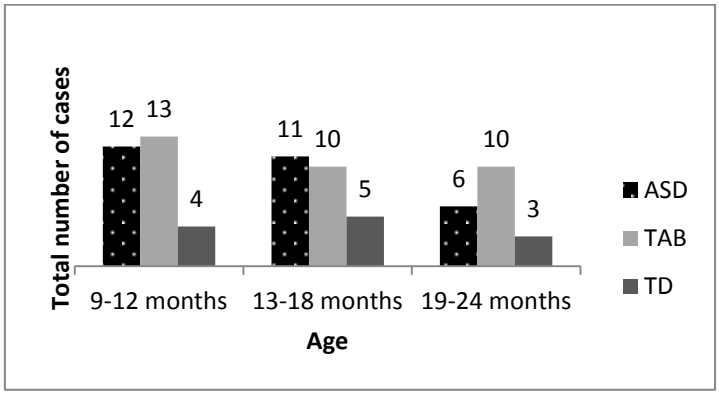

Figure 4: Number of cases observed in the age categories 9-12 months, 13-18 months and 19-24 months, for children with ASD, TAB and TD

Figure 5 illustrates the average duration of available footage per participant per age category. In two of the three age categories (i.e. 9-12 and 19-24 months) the duration was remarkably longer for TD children as compared to children with ASD and TAB.

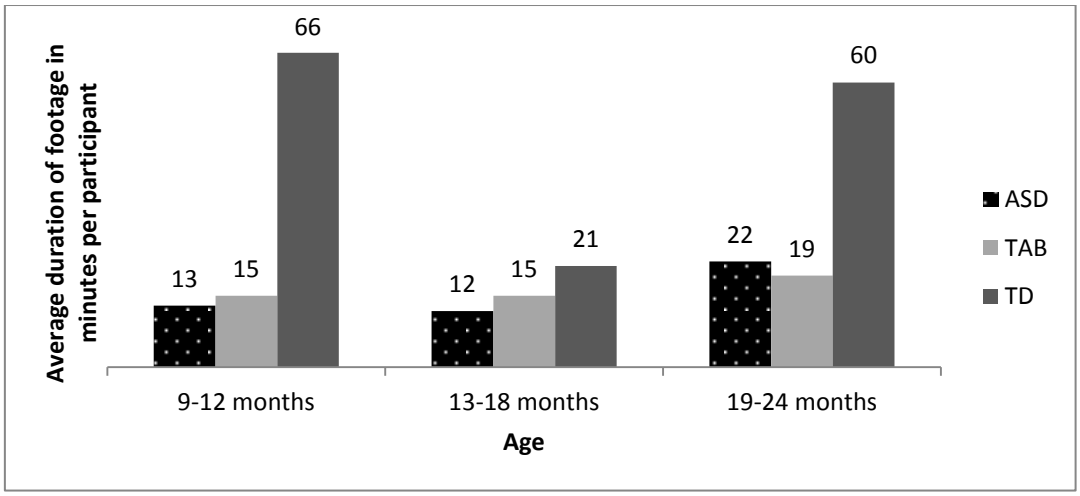

Figure 5: Average time of footage in minutes per participant at the age of 9-12 months, 13-18 months, and 19-24 months for children with ASD, TAB, and TD

3.3 Number of calls

Across all groups and age categories a total of 560 calls, to which a reaction was possible and observable, was scored. In the ASD group 270 calls occurred, 224 in the TAB group and 66 in the group of TD children. Figure 6 illustrates the number of calls for the three age categories.

Across all age categories the number of calls observed in TD children was considerably lower compared to children with ASD and TAB. However, as presented above the duration of the footage was comparable across the three groups. Hence, we don't consider the differences in calls to result from inequalities of available footage.

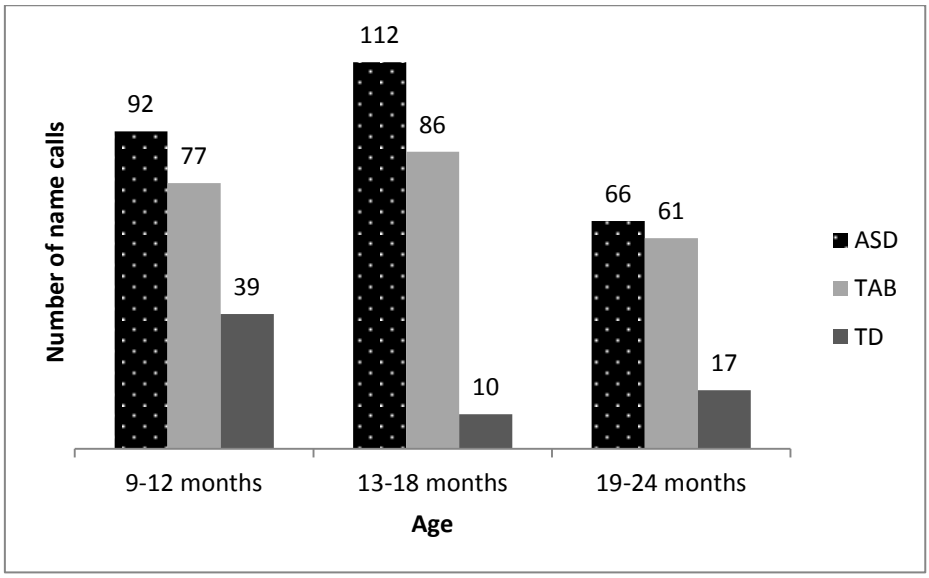

Figure 6: Number of name calls to which a reaction was possible and observable in the time of 9-12 months, 13-18 months, and 19-24 months for children with ASD, TAB, and TD

As a next step we analysed the average calling frequency per minute. Irrespectively of age, the highest calling frequency was observed for the ASD group. Children with TAB were called less often than children with ASD in all categories of age. Similar to the results for the total number of calls (see above Figure 6) TD children showed the lowest average calling frequency per minute across all age categories. Figure 7 illustrates the different calling frequencies of all groups separately for the three age categories.

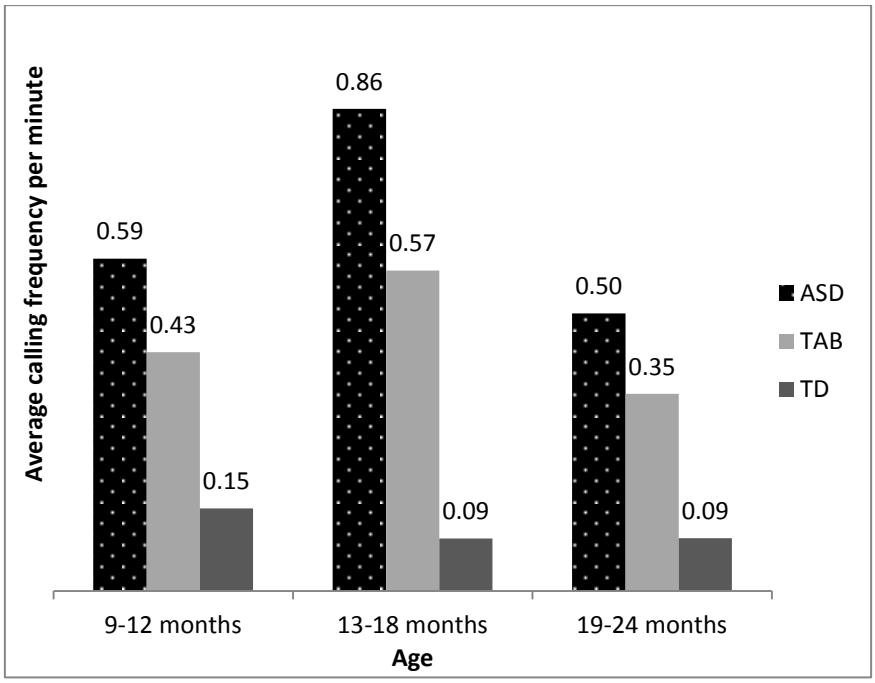

Figure 7: Average calling frequencies per minute in the age of 9-12 months, 13-18 months, and 19-24 months for children with ASD, TAB, and TD

3.4 Response Rate

The response rate was defined as follows: (Positive reactions to name calls) / (Number of name calls to which a reaction was possible and observable) x 100. The results indicate that the response rate was lower for children with ASD and TAB (see Figure 8).

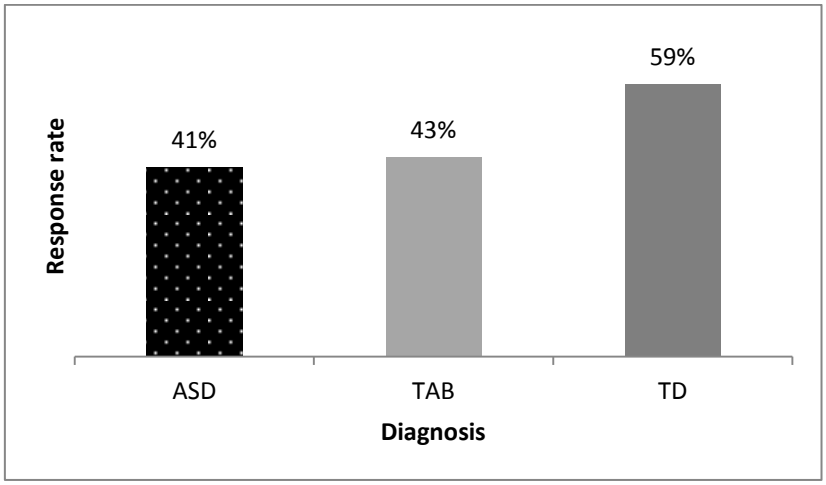

Figure 8: Response Rate of children with ASD, TAB, and TD in the age of 9-24 months.

In a next step we analysed responsive behaviour of children with ASD, TAB, and TD children with respect to age (i.e. 9 to 12 months, 13 to 18 months, and 19 to 24 months) (see Figure 9).

These findings indicate a difference in responsive behaviour between ASD, TAB and TD children. The response rate for children with ASD appears to decline from the age of 9 to 12 to 19 to 24 months, although at the age of 13 to 18 months the response rate seems to be better than in the other categories. But still the response rate is lower than the rate of responding found for TD developing children (65%) at the age of 9 to 12 to 19 to 24 months.

In contrast, response rates for children with TAB seem to be stable at around 40% across the three age categories.

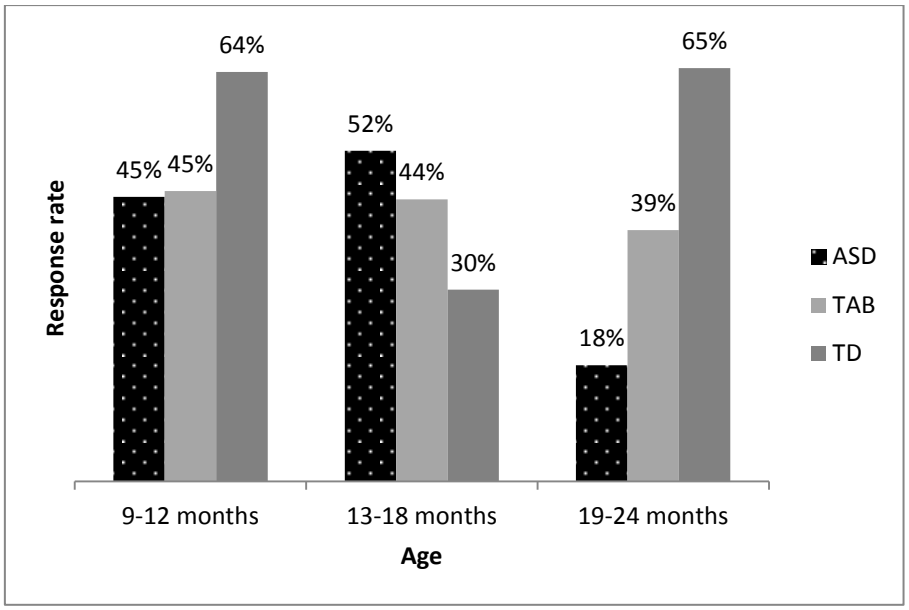

Figure 9: Response Rate of children with ASD, TAB, and TD in the age of 9-12 months, 13-18 months, and 19-24 months.

3.5 Modes of behavioural response

Figure 10 illustrates the distribution of modes of behavioural responses to a name call separately for children with ASD, TAB, and TD children. Across all groups, eye contact was the predominant mode of behavioural response, whereas other modes played a minor role. Nevertheless TD children used other modes than eye contact more often than children with ASD and TAB.

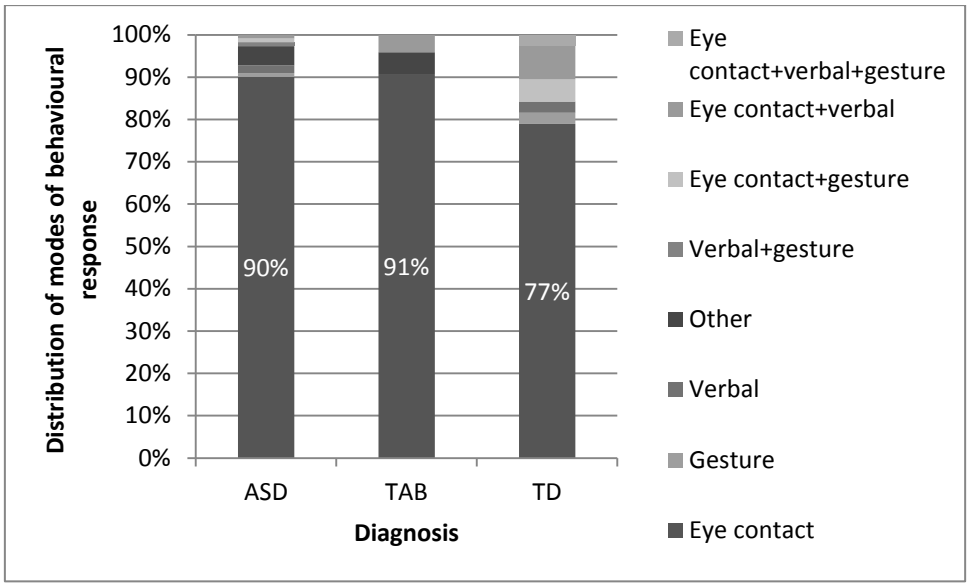

Figure 10: A comparison between the behavioural responses of children with ASD, TAB, and TD to their name being called, between the ages of 9 and 24 months. Key to the figure: Eye contact= eye contact with the caregiver who called the child by the name, including head movement (turning, looking up....) towards the caregiver. Verbal= the child was responding to the name by using vocalisations. Gesture= the child responses by using gestures like waving. Other= this category includes all other possible behaviours of the child which expresses a reaction towards its name being called.

4 Discussion

There have been numerous studies focusing on responsive behaviour of children with ASD; they focused on different aspects of early socio-communicative behaviour and revealed that response to name plays a key role in the behavioral spectrum of children with ASD (Werner et al., 2000; Baranek, 1999; Clifford & Dissanayake, 2008; Saint-Georges et al., 2010). Werner and colleagues (2000), for example, found that the specific behaviours of looking at the face of another person, showing, pointing, and failing to orient to name correctly classified 79% of the participants to ASD and TD, before one year of age.

To the best of our knowledge our approach was among the first to focus in detail on the ability to response to name, i.e. comparing three different groups over a broader age span, assessing the mode of response, and establishing clear cut definitions of name calls (for details please see Methods section). We were able to demonstrate that children with ASD and TAB reacted less often when called compared to TD children. Hence, the results of our study are in line with findings from previous studies (e.g.Werner et al., 2000; Baranek 1999, Clifford & Dissanayake, 2008; Saint-Georges et al., 2010).

Taking a closer look on the response rate, we saw that in the age categories of 9 to 12 and 19 to 24 months the results followed the line of prior findings and our expectations. An apparently stable response rate of 65% for TD children in the age of 9 to 12 and again in the age of 19 to 24 months was found in our study. However, in the age category of 13 to 20 months our findings did not match previous findings. During that age period TD children showed a very low response rate of only 30%. These findings must however be interpreted with caution. We believe that low response rate is related to the corpus restrictions for the control group in this age period. Werner et al. (2000) also reported a general response rate around 70% for TD children and 37% for children with ASD. Consequently, a sudden regression of responsive behaviour in TD children is unlikely and most probably related to a restricted corpus.

In addition, while the video recordings had comparable length, we registered a high discrepancy in the call frequency between the groups. We found that children with ASD were called more often by the parents (higher calling frequency) than children with TAB or TD children. This raises questions regarding the parents' role in early recognition of symptoms of ASD. Further research on this topic is warranted.

TD children were called less frequently than children with ASD in all groups and ages. A variation was especially seen at the age of 13 to 18 months. While only 10 calls were registered for TD children, 117 were noted for children with ASD (see Results). As calling frequency was very low and they did not react to some of the calls the response rate was very low in this age category (please see previous paragraph). Baranek (1999) also found that children with ASD needed more adult prompts in order to respond. One reason for this distinctive difference in the calling frequency of parents in our study could be the cultural background, since children with ASD and TAB were Italian whereas TD children were Austrian. Interestingly, this difference was also noticed between children with ASD and TAB, although both groups were exclusively Italian speaking participants. As a consequence the question remains: Why were children with ASD called more often than children with TAB and TD children?

One could speculate that parents of children with ASD subconsciously recognise impairments in social reciprocity (i.e. response to name) and therefore tend to call their children more often. In the study of Saint-Georges et al. (2011) they interpreted that the parents seemed to feel the lack of interactive initiative and responsiveness of their children with ASD. Parents tried intensively to motivate their children to socially interact. Thus they stressed that "credence should be given to parents intuition as they recognize, long before diagnosis, the pathological process through the interactive pattern with their child." (Saint-Georges et al., 2011, p. 11)

However, the questions arose why children with TAB were called less often than ASD, even though they fell into the autism spectrum and performed similarly in responding compared to children with ASD.

Another interesting aspect became apparent in our study. Eye contact was the preferred mode of response compared to verbal, gestural, or other responses. This held true for all 3 groups although TD children had more variable responses.

A personal note

On an anecdotal note, I would like to report about the differences in quality of eye contact which I noticed while analysing the videos. First of all, eye contact seemed to last shorter in children with ASD and TAB. Moreover, children with ASD and TAB appeared to react less natural. This means that TD children seemed to react immediately, easy and with confidence

certainly. Whereas, while observing children with ASD and TAB the observer often had time to 'hope' or 'wait' for reactions. Furthermore, it seemed that parents from children with ASD and TAB emphasised their calls with more pressure (see Saint-Georges et al., 2011 mentioned above). They were pushing or motivating their child for an answer, as they might have feared their child wouldn't answer. An attempt for explaining why TD children seem to response more natural could be the topic of distraction. While TD children often seem to already interact with their caregivers or friends when called by the name, it appeared that children with ASD or TAB needed to be forced out of their own world. Therefore, a problem in changing attention between different subjects might also be a field worth focusing on in future investigations. In our study we identified situations in which the child did not react, possibly because of distraction as 'no reaction'. It seemed as if children with ASD or TAB were distracted easier and therefore, answered less often when they were focusing on something else.

Other studies also suggest that children with ASD have problems in attention (Clifford & Dissanayake, 2008; Maestro et al., 2001).

4.1 Limitations

One of the limitations in our study is the uneven balance in participants (i.e. ASD, TAB) and controls (i.e. TD). In all age categories the numbers of individuals with ASD and TAB were at least twice as high as for TD children (even though the time of footage was comparable, for more see Methods 2.3.1Footage). Consequently, a comparison among these groups must be drawn with caution. Although, the material might be considered deficient, it needs to be mentioned that it is very difficult to gain data about the prodromal period of ASD. Furthermore, one is facing several limitations in working with home video material. Mentioned in many studies before also Zappella et al. (2015) stated that "Limitation for all studies based on home videos is, that they have different contents; they are discontinuous, and they mainly reflect pleasant situations that the parents would like to keep as pleasant memories. Nevertheless, some conspicuous behaviours or even signs – either unrecognised by parents, or which they believe to be harmless – do not escape the eye of the camera." (Zappella et al., 2015, p. 569-575) However, a definite statement through home videos can never be drawn. Findings from home videos can only reflect a small part of the whole picture. As Marschik and Einspieler said in their paper about video analysis "One of its most prominent insufficiencies is the absence of certain features in a given data set: if a particular

behavioural pattern like babbling is missing for instance, this does not necessarily mean that the pattern in question is missing in the socio- communicative repertoire of the participant" (Marschik & Einspieler, 2011, p. 355–357). Furthermore they stated that: "It requires a profound interdisciplinary approach across various methods of research – video analysis being one of them – in order to document the interrelation between a number of developmental domains and to piece together the jigsaw of neurodevelopmental disorders with a late (noticeable) clinical onset". (Marschik & Einspieler, 2011, p. 355-357) In addition they emphasised the importance of detailed coding protocols and qualified observers in order to obtain high inter-observer reliability.

4.2 Importance of response to name

Although ASD is not (yet) curable (Bölte, 2014) children with ASD and their families substantially benefit from an earlier detection (e.g. Koegel et al., 2014). Researchers and clinicians with a background in child and adolescent psychiatry, paediatricians, neuroscience or related disciplines are trying to find early markers for ASD. Even though, there is increasing awareness about ASD and more and more assessments (such as the ADOS-Toddler Module) are available, for younger children, there is still a large proportion detected far beyond toddlerhood (Shattuck et al., 2009). Support for children with ASD and their families should start as early as possible (e.g. Sven Bölte & Hallmayer, 2011; Koegel et al., 2014) most preferably in kindergarden age in order to foster early social and language learning (Knudsen, 2004).

On the way to detecting early markers for ASD "response to name" could play a part of a complex screening assessment that includes behaviour and biological biomarkers.

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