From the Department of Women's and Children's Health
Karolinska Institutet, Stockholm, Sweden

Emotion recognition and expression in autism spectrum disorder: Significance, complexity, and effect of training

Steve Berggren

Karolinska Institutet

Emotion recognition and expression in autism spectrum disorder:

Significance, complexity, and effect of training

THESIS FOR DOCTORAL DEGREE (Ph.D.)

By

Steve Berggren

Principal Supervisor:
Professor Sven Bölte
Karolinska Institutet
Department of Women's and Children's Health
Neuropsychiatry Unit
Center of Neurodevelopmental Disorders (KIND)

Co-supervisor:
Ph.D Daniel Lundqvist
Karolinska Institutet
Department of Clinical Neuroscience
Neuro NatMeg

Associate Professor Andreas Olsson
Karolinska Institutet
Department of Clinical Neuroscience
Division of Psychology

Opponent:
Professor Sarah Parsons
University of Southampton
School of Education

Examination Board:
Professor Emeritus Per Gustafson
Linköpings Universitet,
Department for Clinical and Experimental Medicine
Child and Adolescent Psychiatry

Professor Emeritus Per Anders Rydelius
Karolinska Institutet
Department of Women's and Children's Health

Professor Emerita Ulla Ek
University of Stockholm
Department of Special Education

To Johanna, Pontus and Majken

ABSTRACT

The overall scientific aim of this thesis is to examine emotion recognition in children with Autism Spectrum Disorder (ASD), its specificity to ASD and connection to other cognitive functions, as well as to map the effects of previous and novel emotion recognition and emotion expression training programs in children with ASD across cultures. Emotion processing training in ASD is a potentially valuable tool to improve the lives and outcomes of children with ASD, but it has been lacking an adequate scientific preparation, content and motivational design, as well as high-end technical expertise.

In study I, we review the existing randomized controlled trials on emotion recognition training for children and adolescents with ASD, focusing external validity, a largely aspect in the area. External validity is significant to evaluate for several reasons. First, emotion recognition training approaches have been diverse, and ASD forms population a heterogeneous population. Second, children and adolescents with ASD often have difficulties with generalizing knowledge from the training context to new situations, and it is not clear how this is reflected in the results of the various emotion recognition training programs. Third, emotion recognition training is often performed using computerized programs in controlled settings, raising questions about the extent to which the effects translate to everyday situations. The systematic review demonstrated few indications to presume that current emotion training programs generalize outside of the training setting into everyday life social interactions. This review highlights the need to focus on external validity in future emotion recognition training studies, and to improve reporting of these aspects.

Study II examined basic facial affect recognition in well-matched samples of children with ASD, Attention-Deficit Hyperactivity Disorder (ADHD) and typical development using the computer-based FEFA-2 test. We examined accuracy and response times for general and specific facial affect recognition skills in whole face and eye-region stimuli. The ASD samples performed inferior to typical developing controls. There were no difference between the ADHD sample, on one hand, and the ASD and typical sample, on the other. In the clinical samples, particularly the ADHD sample, cognitive distractibility explained a substantial proportion of variance of basic facial affect recognition performance. This research largely confirms previous findings on emotion recognition in ASD, and aspects of specificity compared to ADHD, a neurodevelopmental condition overlapping with ASD. Importantly, the study shows that performance on emotion recognition tasks is not only

depending on pure emotion recognition capacities, but is also largely influenced by other cognitive functions.

Study III explored cultural differences in emotion recognition in children with ASD and typically developed children. Compared to many previous studies, differences in recognizing emotion expression was tested in three modalities of basic and complex emotion processing, namely in face, voice, and body language including gestures. These expressions were also examined in integrated form using complex social scenes. The study was conducted across three countries and cultural contexts: Israel, United Kingdom and, and Sweden. Children with ASD showed impairments in both basic and complex emotions on all three modalities and their integration in context compared to typically developing matched control children. Both children with ASD and typical development performed better on basic than complex emotions. Cross-cultural differences were limited to some face and body stimuli, indicating high cross cultural comparability of emotion recognition findings.

Study IV included a cross-cultural evaluation of the effects of the serious game "Emotiplay" in ASD on emotion recognition skills, and parent-reported autism symptomatology and adaptive skills in United Kingdom, Israel and Sweden. Emotion recognition tasks comprised face, voice, body, and integrative social scenes. Children used Emotiplay 8-12 weeks in a home setting. In the United Kingdom children were tested pre-post, while children in Israel and Sweden were randomized to training or a waiting-list control group. Results showed improvements in emotion recognition regarding body language and integrative tasks as well as adaptive socialization in the United Kingdom site. In Israel and Sweden, the active groups improved more than controls on all emotion recognition outcomes. There was also an effect on autism related symptoms in the sample from Israel.

Findings support the feasibility and usefulness of serious gaming to enhance emotion recognition and possibly reduce autism symptoms and socialization issues in autistic children. Emotiplay was found useful across three cultures. Still, future research and follow-up studies are needed to determine long-term effects and evaluate its impact on real life situations.

SCIENTIFIC PAPERS INCLUDED IN THE THESIS

I.   **Berggren, S**., Engström, A. C., & Bölte, S. (2016). Facial affect recognition in autism, ADHD and typical development. *Cognitive Neuropsychiatry,* 21(3), 213-227.

II. **Berggren, S**., Fletcher-Watson, S., Milenkovic, N., Marschik, P. B., Bölte, S., & Jonsson, U. (2017). Emotion recognition training in autism spectrum disorder: A systematic review of challenges related to generalizability. *Developmental Neurorehabilitation* [April 10, Epub ahead of print]

III. Fridenson-Hayo, S., **Berggren, S**., Lassalle, A., Tal, S., Pigat, D., Meir-Goren, N., ... & Golan, O. (2017). 'Emotiplay': a serious game for learning about emotions in children with autism: results of a cross-cultural evaluation. *European Child and Adolescent Psychiatry* [Mar 8, Epub ahead of print].

IV. Fridenson-Hayo, S., **Berggren, S**., Lassalle, A., Tal, S., Pigat, D., Bölte, S., ... & Golan, O. (2016). Basic and complex emotion recognition in children with autism: cross-cultural findings. *Molecular Autism,* 7(1), 52.

SCIENTIFIC PAPERS NOT INCLUDED IN THE THESIS

Bölte, S., Willfors, C., Berggren, S., Norberg, J., Poltrago, L., Mevel, K., ... & Toro, R. (2014). The roots of autism and ADHD twin study in Sweden (RATSS), 17(3), 164-176.

O'Reilly, H., Pigat, D., Fridenson, S., **Berggren, S**., Tal, S., Golan, O., ... & Lundqvist, D. (2016). The EU-emotion stimulus set: a validation study. *Behavior Research Methods,* 48(2), 567-576.

Zander, E., Willfors, C., **Berggren, S**., Choque-Olsson, N., Coco, C., Elmund, A., ... &Bölte, S. (2016). The objectivity of the Autism Diagnostic Observation Schedule (ADOS) in naturalistic clinical settings. *European Child and Adolescent Psychiatry,* 25(7), 769-780.

Bölte, S., Bartl-Pokorny, K. D., Jonsson, U., **Berggren, S**., Zhang, D., Kostrzewa, E., ... & Marschik P.B.. (2016). How can clinicians detect and treat autism early? Methodological trends of technology use in research. *Acta Paediatrica*, 105(2), 137-144.

Willfors, C., Carlsson, T., Anderlid, B. M., Nordgren, A., Kostrzewa, E., **Berggren, S**., ... & Bölte, S. (2017). Medical history of discordant twins and environmental etiologies of autism. *Translational Psychiatry*, 7(1), e1014.

Arora, M, Reichenberg, A, Willfors, C, Austin, C., Gennings, C, **Berggren, S**, Lichtenstein, P, Anckarsäter, H, Tammimies, K, and Bölte, S. Fetal and Postnatal Metal Dysregulation in Autism. In press.

Choque Olsson N, Flygare O, Coco C, Görling A, Råde A, Chen Q, Lindstedt, K, **Berggren S**, Serlachius E, Jonsson U, Tammimies K, Kjellin L, Bölte S, (2017), Social Skills Training for Children and Adolescents with Autism Spectrum Disorder: A Randomized Controlled Trial, *Journal of the American Academy of Child & Adolescent Psychiatry.* [May 17, Epub ahead of print].

LIST OF ABBREVIATIONS

ABAS-2	Adaptive Behavior Assessment System, Second Edition
ADHD	Attention Deficit/Hyperactivity Disorder
ADI-R	Autism Diagnostic Interview-Revised
ADOS-2	Autism Diagnostic Observation Schedule-Second Edition
AE	Autism-Europe
APA	American Psychiatric Association
ASD	Autism Spectrum Disorder
CAST	Childhood Autism Spectrum Test
CPT-II	Conners' Continuous Performance Test II
DSM	Diagnostic and statistical manual of mental disorders
DSM-IV-TR	Diagnostic and statistical manual of mental disorders-Fourth Edition-Text Revision
EE	Emotion expression
EEG	Electroencephalography
EP	Emotion processing
ER	Emotion recognition
FAR	Facial affect recognition
FEFA	Frankfurt Test and Training of Facial Affect Recognition
fMRI	Functional Magnetic Resonance Imaging
ICD-10	International Classification of Diseases-Tenth Edition
ICF/-CY	International Classification of Functioning, Disability and Health/-Version for Children and Youth
ID	Intellectual Disability
IQ	Intelligence Quotient
K-SADS-PL	Kiddie Schedule for Affective Disorders and Schizophrenia for School Aged Children - Present and Lifetime version
MeSH	Medical Subject Headings
MRI	Magnetic Resonance Imaging
NDD	Neurodevelopmental Disorders
PDD-NOS	Pervasive Developmental Disorder Not Otherwise Specified
RCT	Randomized Controlled Trial
SG	Serious Game

SBU	Swedish Council on Health Technology Assessment
SC	Social Cognition
SCID	Structured Clinical Interview for DSM-IV
SRS	Social Responsiveness Scale
TD	Typically developing
ToM	Theory of Mind
UK	United Kingdom
USA	United States of America
VABS-II	Vineland Adaptive Behavior Scale-Second Edition
WHO	World Health Organization
WISC-IV	Wechsler Intelligence Scale for Children-Fourth edition

CONTENTS

1 INTRODUCTION

1.1 Autism Spectrum Disorder

Neurodevelopmental disorders (NDD) is an umbrella term[1] for conditions arising from disruptions or extreme variations of the maturation, architecture, and functioning of the developing brain. NDD affect cognition and behavior, persistently reduce functional adaptive skills and quality of life, and are associated with increased mortality[2,3,4]. Autism spectrum disorder (ASD) is a diagnosis under the NDD umbrella. ASD has a phenotypically heterogeneous presentation, defined by impairments in social communication and interaction alongside repetitive, stereotypic activities and interests, as well sensory processing alterations[1] ASD was described in the 1940s by Leo Kanner[5] and Hans Asperger[6]. Leo Kanner specifically described ASD as an *"example of inborn autistic disturbances of affective contact''*, clearly stating that emotion processing challenges are part of ASD. The core description has remained quite stable over time, while views on its causes have been shifting. Before more recently, research has often been monodisciplinary, focusing on rather narrow aspects of genetics, environment, biological processes or behavioral outcomes. Research has also mostly investigated ASD categorically, rather than dimensionally. Today's evidence recognizes ASD to have multiple, complex and sometimes unique individual causes, including both genetic and environmental determinants.[7,8] In addition to clinical phenotypes, broader phenotypes of the disorder and traits of autism are presumed to exist, the latter not only being heritable, but also continuously distributed in the general population. Research indicates that dysregulation of epigenetic markers or mechanisms, such as DNA methylation, play an important role in the inception and lifelong modulation of neurodevelopmental processes in ASD.[9] The systemic and central nervous system pathophysiology in ASD is consistent with possible oxidative stress, neuro inflammation, and mitochondrial dysfunction that are likely to be caused by the environment.[10] Environmental factors that act via epigenetic mechanisms are potentially reversible. Discoveries from different disciplines have found disruptions of key biological pathways in NDD, such as catecholaminergic imbalances, glutamatergic synapse function, chromatin modelling, and ion channel pathways. Complex genetic fundamentals issues, along with bioenvironmental factors, act as assumed to act at etiological triggers.[24] Neurobiological and cognitive evidence indicate ASD is a condition of altered neuronal-cortical organization and connectivity, which causes deviant executive bottom-up/top-down functioning and social cognition.[25] This subsequently leads to the clinical phenotypes and functional impairments in a broad range of adaptive skills.[26][11,12,13] Recent studies have also revealed that the gut microbiota has wider effects on physiology and development than originally believed, including early-life

programming of brain circuits,[14] including those associated with ASD.[15] Key cognitive alterations converge around limited social cognition, executive function, and top-down information processing in ASD.

1.1.1   Prevalence and Comorbidity

Current international epidemiological research suggests that around 1 to 2 % of the general population is affected by ASD,[8,16,17,18] with females probably being less often affected than males (sex ratio 1:2-4). However, females might be underdiagnosed, as diagnostic criteria traditionally focus on the phenotype in boys. If girls are diagnosed with ASD, they are often more severely affected (including higher co-existence of mental retardation). Certainly, potential gender specificities are understudied, and unfortunately, research on ASD is still somewhat biased by male evidence. There has been a steady increase in prevalence of ASD in the last decades, but particularly last 10-15 years. The increase could be explained by changes in how ASD has been defined and interpreted, destigmatizing, improved support systems, and increased awareness[19,20]. Psychiatric and somatic comorbidity is common in ASD, with intellectual disabilities (ID), Attention Deficit Hyperactivity Disorder (ADHD), and epilepsy being amongst the most frequent co-existing complications[21, 22]. ASD is currently not curable, but malleable to a certain degree to prevent worse outcomes[23]

1.1.2   Functioning

ASD challenges the ability to meet age appropriate developmental demands, from everyday interaction with family members, peers, and teachers. These functional difficulties increase the risk of social exclusion.[27] Children with ASD experience rejection, bullying and isolation.[28] In the long run, these circumstances significantly reduce education and occupational attainment, intendent living,[29] social networks, intimate relationships and increase the likelihood of mental health problems, such as anxiety and depression. It is therefore of paramount importance to as early as possible attend to the social communication difficulties that individuals with ASD experience. Indeed, intervention studies of ASD have shown that the earlier support is provided, the better the reachable treatment outcome.[30] While the conceptualization of ASD is dominated by its definition in diagnostic manuals, such as the DSM-5, individual functioning can only be understood appropriately by assessing personal resources and context. For this purpose, the International Classification of Functioning, Disability and Health for adults, as well as its version for children and youth [ICF/ICF-CY] [31,32] has generated by the WHO.

1.1.3 Diagnostics

ASD is a clinical diagnosis based on history taking, behavior observation and informant reports. Nevertheless standardized instruments are increasingly used not only in research, but also practice, and often part of guidelines for assessment. DSM-5 explicitly recommends the usage of validated tools. Two of the most widely used scales are the Autism Diagnostic Observation Scale-2 (ADOS-2)[34], an observation instrument, combined with the Autism Diagnostic Interview – Revised (ADI-R)[35], an investigator-based -structured interview. Both instruments are well studied and have shown good psychometric properties[36] especially when applied complementary. The instruments combine caregivers' views on early development, symptoms of social reciprocity, communication, repetitive behaviors and interests, together with an observation of an individual's behavior in a naturalistic setting by an expert. Experimental evidence suggest, that diagnosing ASD might possible from age of 12 months,[37] but in most cases children are much later, and early detection screening tools for young have demonstrated limited specificity and sensitivity[38] for ASD.

1.1.4 Intervention

Current interventions for ASD are not targeting its potential causes, but focus on providing learning opportunities, train skills and to create friendly environments to facilitate social communication, reduce dysfunctional behaviors, and increase adaptive capacities to avoid negative consequences. Early intervention and early detection are favorable to improve long-term outcomes[40]. Interventions setting in ASD should be multiple and naturalistic and include preschool/schools, home, and workplace. Interventions should also include a multitude of significant individuals of the environment, such as parents, siblings, other relatives, spouses, and teachers. Treatment is not only provided to the individual with ASD, but, importantly includes psychoeducation and skilling-up of parents and other caregivers. [41]. Still, the evidence base for the majority of treatments in ASD is insufficient, with a lack of large randomized trials and long-term outcome assessments. In general, it is presumed that many individuals on the spectrum ASD will need or benefit from at least some form of lifelong support[42].

2 SOCIAL COGNITION

ASD is coined by an array of cognitive alterations, often summarized in terms of executive malfunction, weak central coherence and social cognition (SC). Executive malfunction comprises a set of affected cognitive control processes that are essential for self-regulation, goal directed behavior, and foresighted planning. Dysfunctions in executive functions have been regularly reported in ASD. In a recent review[81] by Craig and colleagues, children with ASD showed deficits in the areas of cognitive flexibility and planning and the study also provided further support for more deficits in cognitive flexibility in ASD than in ADHD. Executive challenges may cause substantial difficulties to cope with demands in school, work and social context for the individual with ASD[82,83]. The weak central coherence account of ASD tries to understand autism beyond executive and social challenges, by introducing the dimension of cognitive style. According to the model, today also labeled as attention to detail or local bias theory, individuals on the autism spectrum, by default, focus use a perceptive style the preferring detail over gestalt and context. [80].

SC is an umbrella term encompassing a multitude of social information processing components enabling to understand or reasoning about others and one's own feelings, thoughts, and intentions. SC is important for successful social reciprocity, social interaction, and acquisition of social skills[73] SC is crucial to understand how other people are trying to communicate in social interactions, to attend to socio-emotional cues, interpret them correctly and respond appropriately. Thus, SC skills plays a major role in everyday life and in psychosocial outcomes. The functional neuroanatomy of SC comprises the medial prefrontal cortex, superior temporal sulcus, temporo-parietal junction, temporal poles, amygdala, and insula. These areas might summarized to different networks: the amygdala network, the theory of mind (ToM)/mentalizing network, the mirror neuron network, and the empathy network[44]. SC is composed of several subcomponents, such as social perception, social orientation/attention, metalizing/theory of mind, cognitive and emotional empathy, and emotion recognition (ER) and emotion expression (EE) abilities.[43] Emotion and cognition are often blended in a social interaction[45,46]. SC includes both unaware and fast implicit, as well as aware and slow explicit aspects, with implicit SC processing being particularly challenging in ASD.

2.1 Social cognition in ASD

Theory of mind (ToM) is a term that describes the ability to conceive mental states (what other people know, want, feel, or believe). Baron-Cohen 1985 and colleagues tested the "mindblindness" theory of autism. They wanted to see if the children with autism lack ToM. Later research[75] supports such impairments and suggests that empathizing plays a major role when it comes to the ability to attribute mental states to oneself and others. In fMRI studies, altered activity has been noted in tempo parietal regions of children with ASD. In general, TD children perform better than children with ASD on ToM tests. However, research[76] also reports that individuals with high functioning ASD have compensatory strategies to solve problems requiring ToM ability. Recent studies[77] shows that as individuals with ASD become adults, they may no longer fail ToM tests and that supports Kuusikko and colleges[72] that found that, difficulties in interpretation of emotional expressions among children with ASD might decrease with age. Researchers tracked eye gaze and concluded that these adults did not show an anticipatory eye gaze based on false belief. It is possible that a fundamental dysfunction in understanding others mental states may result in difficulties for individuals with ASD in all related tasks, including inferring or recognizing what another is thinking from a facial expression. However, studies do find that individuals with ASD may pass mindreading tasks and that the difficulty may be related particularly to task complexity. Studies[78] on adult individuals with ASD indicate worse performance than TD individuals on emotion recognition in faces, body movements, as well as in a voice emotion-labeling task. It might be argued that this behavioural pattern across modalities suggests an emotion processing impairment. Such impairment may result in the atypical facial emotion recognition in ASD rather than another cognitive dysfunction. However, difficulties in social interaction and communication are defining features of ASD, and associated with ER challenges, although they are neither universal, nor specific to ASD. ER alternations have been demonstrated in William's syndrome[47], language disorder[48], schizophrenia[49], psychopathy[50], conduct disorder[51] and dysthymia.[52], why they may present a broader difficulty typical of many neurodevelopmental, psychiatric and genetic syndromes. [53]. Still, evidence for ER challenges is probably most robust for ASD. Early work by Hobson and colleagues[55,56] showed that reading emotions is one of the core deficits in ASD, along with problems matching body actions with facial expressions[57,58,60]. Studies examined difficulties in interpretation of ER in face, voice, and body language in ASD, and some found deficits, but the results were mixed[61,62,63] while other studies[64,65] found a range of cognitive problems that may moderate ER deficits in ASD. Other studies shows that individual ER problems are not

16

universal for ASD[54,66]. On the contrary, they show that 10 to 70% have difficulties in emotion labelling and it is still unclear if these difficulties are affecting the whole spectrum of affective states or just basic emotions[67], complex emotions[68], subtle emotions[69] or single emotions[70,71]. Nevertheless, Lozier and colleges showed in a meta-analysis[60] comprising 43 studies with a total of N = 1,545 participants (ASD = 791, controls = 754) that ASD overall is associated with ER and EE problems even after correction for IQ and age.

3 EMOTION RECOGNITION

1.1.1 Facial affect recognition

The recognition of facial expressions of emotion is an important part of social communication and interaction in humans, and allow insight to others internal processes. Facial affect recognition (FAR) is the ability to access the meaning of facial expression in terms of the emotional states in others. As the face is an essential source of information in social interactions, the ability to appropriately read and respond to the facial expression of others is essential for successful participation in everyday social life.[84] In the brain, FAR is connected to amygdala function and cortical areas, such as the fusiform face area[85]. A large number of neuroimaging studies have investigated the face processing and face recognition impairment in ASD and revealed an altered functioning of visual association cortices specialized for faces[96] Several reviews and meta-analyses of FAR in ASD were conducted in recent years[54,66] While the results generally support FAR problems in ASD, the evidence is not fully consistent. Early studies[85] suggested that general ER deficits had a central role to explain symptomatology in ASD. Other studies tried to scrutinize whether challenges were specific to certain emotions rather than universal (e.g., fear, anger, and disgust[86,87,88] general facial ER,[89] complex emotions,[90] and subtle emotions)[91] and the degree of ASD specificity[92,93] Overall behavioural research suggests some more specific ASD-related FAR impairments in the area of negative, subtle and complex emotions [94,95] FAR task performance might be influenced by many factors in ASD and elsewhere, for instance presentation duration of FAR stimuli, IQ and age. The limited available evidence shows that short duration of FAR stimulus presentation is correlated with worse performance, indicating a speed component in FAR processing in ASD.[97,98] Moreover, a recent meta-analysis[60] concluded that ASD is associated with FAR difficulties across multiple expressions, even after correcting for IQ and age, and both for accuracy and response times.[99]

3.1 Tone of voice recognition

Like FAR, recognizing voices and their affective content plays an important role in social communication, research is far more sparse that FAR in ASD. For instance, neural mechanisms of voice processing in ASD are largely unknown. The few available behavioral studies suggest impairments in detecting the affective content of voice r in ASD.[100] Additional investigation of emotion in voice recognition is desirable, and challenges in the area are clearly socially restricting[101] and associated with the core deficits of ASD.

3.2 Body language and gestures

An important channel for emotion expression is body language that includes gestures and postural changes. Early development studies show that young infants as young as 12 months preferably orient to human biological motion[109] while children with ASD show difficulties discriminating biological from non-biological motion.[110] At age four typically developing children can use body language for social communication purposes. Studies on body language in ASD are rare, but existing evidence suggest that children with ASD have difficulties recognizing bio motion indicative of affect.,[111] and interpreting body language.[112]

3.3 Multi modal emotion processing

Perhaps not surprisingly, in addition to unimodal emotion processing challenges, , there is evidence that individuals with ASD show difficulties integrating information across face, tone of voice and body language modalities.[102,113] Unfortunately, multimodal emotion processing in ASD has only studied weakly. It is known from anecdotal accounts, that individuals with ASD have problems inhibiting sensory and irrelevant surrounding information, which may cause an overload of information, and can fuel dysfunctional outcomes.. Many of the atypical perceptual experiences reported by people with ASD may stem from the inability to efficiently filter, process, and integrate information from different modalities when presented simultaneously.[103] Most studies that examined multimodal processing have focused on the integration of auditory and visual social stimuli linked to communication, such as speech and its corresponding lip movements.[104] The results of most of these studies indicate that the ability to integrate audiovisual social stimuli is impaired in individuals with ASD[105]. On the other hand, there is little research on the integration of information from facial expressions and body language. Multimodal integration emotion recognition studies have revealed that presenting emotional cues in different channels does not necessarily help, and may even hamper the ability of individuals with ASD to recognize emotions and mental states.[106] Previous studies of

multimodal emotion recognition in ASD have shown deficits in adults[107] and in children[108]. However, the stimuli presented in these studies included verbal content, in addition to the visual and auditory emotional cues, which might have biased findings, owing to language problems frequently observed in ASD.

3.4 Impact of emotion recognition deficits

3.4.1 Social and work

People on the autism spectrum ASD are disadvantaged when it comes to meeting the general demands of society. Consequently, many individuals with ASD have difficulty coping with reaching a minimum level of social integration that allows satisfactory quality of life.[113,114] Deficits with reading and expressing emotions in facial affect, tone of voice and body contribute to the risk of social exclusion, peer rejection, bullying and isolation.[115] In the long run, these negative social experiences may contribute to low occupational attainment, poor social relationships, and an increased risk of psychiatric disorders.[116, 118] Furthermore, studies that followed individuals with ASD demonstrate that a majority of young adults with ASD have difficulty establishing romantic relationships or meaningful relationships later in life.[117] Adults with ASD report a lower degree of self-determination, independence from family, and self-confidence to make their own decisions.[119] Often adults with ASD remain dependent on relatives for daily functioning in comparison

3.4.2 School and peers

Children spend a great deal of their day at school, but many school lack conclusive concepts for the inclusion of children with ASD. School concepts for successful inclusion should take into account the emotion processing challenges of ASD, as children with difficulty in emotional recognition have more difficulty interacting socially that increase the risk of isolation and feeling alone.[122] Children and adolescents with ASD who do not receive adequate intervention have a greater risk to develop secondary psychiatric conditions such as depression, obsessive compulsive disorder, anxiety and social phobia.[123,124] Existing school-based services for ASD are generally not evidence-based, and do not systematically target social skills, despite the fact that peer problems and peer rejection are high in ASD. Difficulties in emotion recognition and more generally social skills are important negative factors in a child´s development and ability to perform at school Strong social skills predict less internalizing and externalizing symptoms in classrooms,[127] whereas poor social skills increase the risk for anxiety and depression[128]. Various interventions have been proposed to promote prosocial behaviors in ASD to improve social inclusion, school refusal, school performance, and wellbeing. Among those, social skills training has attracted the most attention. Social skills trainings usually comprise a wide range of education methods such as social stories, video modeling, social problem solving, scripting procedures, and peer-mediated interventions.[129] However, the implementation of educational intervention tailored for people on the spectrum is still largely in its infancy. In a review of the literature, Parsons and colleagues[130] stress the continuous need for detailed manuals, long term studies, real life outcomes and innovative research strategies to establish pragmatic procedures and treatment that works for children on the spectrum at school.

3.4.3 Parents

Parenting a child with ASD has an huge impact on everyday life, including the potential for lower incomes, heightened stress, poorer health, unemployment, and divorce.[131,132] Parents are forced to spend large amounts of time seeking, applying for or coordinating support and attending meetings within the health care providers, schools and other community services. There are different calculations on economic costs for an individual with ASD, and this may be compounded with the existence of other mental health issues. The economic costs have been estimated to be 10-15 million Swedish Crowns over a lifetime for an individual with ASD[133]. Due to these high economic costs, ASD is public health issue that affects, not individuals their immediate families and environment, but the entire society and the planning of educational, health care other support systems.

3.5   Training emotion recognition

Increasing diagnoses rates of ASD requires greater resources by health care and other support providers. At present, many countries across Europe - and globally - lack an adequate policy response to the needs of this growing population of young people. Therefore, there is an urgent need to seek new and innovative methods for approaching children with ASD and for fostering their integration into society. A solution may be found in innovative information and communication technology (ICT), carrying the potential to provide state-of-the-art, economically sound and quality ensured support online. Computerized environment have been shown to be especially appealing to individuals with ASD, due to its predictable, controllable and structured nature[134], which comply with a systemizing mind-set that has been associated with ASD. Systemizing is the drive to analyze or build rule-based systems, allowing one to predict the behavior of the system and control it. In contrast to their socio-emotional difficulties, individuals with ASD have intact and sometimes superior systemizing skills[135]. The attraction to systems is apparent in circumscribed interests in ASD[136], such as mechanics, and computers. Such areas and activities are attractive to many people on the spectrum because they are systematic, and therefore predictable. These special interests could be harnessed when teaching children with ASD, in order to keep them intrinsically motivated[137]. Motivation is indeed a major challenge when teaching socio-emotional communication skills to children with ASD. Whereas the motivation for social communication and interaction increases for adolescents[138,139], implicit social motivation is usually lower in children with ASD[140,141] and their interest in such training needs to be initiated and retained externally[142]. As noted above, harnessing the child's circumscribed interests when teaching socio-emotional communication may assist in raising interest and motivation[143,144]. There is also a need to better understand how children with ASD decode emotional expressions in order to develop more effective intervention programs that capitalize on their skills and facilitate their abilities to interact with others. Different kinds of training programs and ICTs aiming to increase ER ability in individuals with ASD have been being developed at a rapid pace. Most programs are computer based and generally aimed at specific tasks (e.g., recognition of facial expressions from stills).

3.6 Emotion recognition training

There are currently different programs used in clinical and home settings to train emotion recognition, such as : Emotiplay[145] (training the recognition of emotions from facial expressions, vocal intonation, body language, and their integration), the Frankfurt Test and Training of Facial Affect Recognition (FEFA) (training of emotion recognition from photographs of facial expressions and strips of the eye region)[146], the Emotion Trainer (teaches emotion recognition from facial expressions)[147], Let's Face It! (teaches emotion and identity recognition from facial expressions),[149] and Mind Reading (an interactive guide to emotions that teaches recognition of emotions and mental states).[108]

3.6.1 Serious gaming

Most serious games (SG) are implemented in computerized environments. Owing to their mostly predictable and consistent nature, being free from immediate social demands and stressors, they are assumed to work well for individuals with ASD. SG are designed for learning skills that are difficult and do not make rewards easy for the users[150]. SG intent to be goal directed and rewarding at the same time, with a step-wise and tailored increase of difficulty level of [152,153]. SG allow the user to repeat the lesson over and over, and the user can work at their own pace and set the level of understanding.

3.6.2 Effects of training emotion recognition

A multitude of studies have attempted to determine the effects of emotion processing training, predominantly facial affect recognition.[154,155]. Fletcher-Watson and colleges evaluated the effects of 22 randomized controlled trials (RCTs) on emotion recognition and theory of mind programs in a meta-analyses[156]. Despite remaining questions of generalizability and long-term outcome, the preliminary results from the analyses confirm that individuals with ASD benefit from ER training.

3.6.3 Generalization and external validity

Aside from significant improvements on taught material, most studies did either not systematically test external validity or reported limited generalizability from the curriculum situations to new material and beyond. However, successful implementation and judicious use of the interventions require reliable judgments about generalizability across different populations, training programs, and settings. It is also of great importance to clarify to what extent the training effects are translated into social skills in real-life situations, which presumably is the ultimate objective for the person undertaking the training.

3.6.4 Technology advancements

The expanding awareness of ASD and a steady climb of diagnoses rates of ASD around the world calls for more sophisticated intervention tools. Innovative technology has been a fast growing area and includes interactive technology, games, and other personalized advanced material for individuals with ASD.[157] Different kinds of game-based learning platforms with a purpose to teach ER, social skills, therapeutic, educational tools and other important skills for solving everyday challenges are part of a rapidly growing field. Technology can provide cognitive and perceptual stimulation to prepare for interpersonal contact[158] and taking contact with peers starting in a socially safe environment. In effect they can generate a sense of self-efficacy thereby lifting self-esteem.[159] It is well known that individuals with ASD prefer technology as a way to communicate, or on their spare time[160] or as support in a school environment.[160] However there are also some challenges using technology, including demands on technical ability, conceptual and vocabulary knowledge, motor skills, as well as risks, such as the possibility of over-use, diversion from other activities, and exposure to unproductive or inappropriate contents.

4 AIMS AND RATIONALE

The overall scientific aims of this thesis are to (i) compare emotion in children with ASD to typically developed children, and those with a diagnosis of ADHD, (ii) to examine factors moderating ER test performance, (iii) to review the emotion recognition training literature regarding aspects of external validity, (iv) to evaluate the effects of ER and emotion expression training in ASD using a serious game, and to (v) examine the cross-cultural validity and applicability of the training and potential cross-cultural differences in ER. The study conducted to reach these aims are fill several research gaps. The review is the first of its kind, and the comparative ASD versus ADHD study is the first to take into account for effects of potentially confounding executive function effects. Training studies are the first to investigate the effects of a serious game on emotion processing in ASD and its broader effects on autistic traits and adaptive behaviors in multi-cultural setting and design.

4.1 Study I

The objective of the first study was to systematically review the existing RCTs on ER training for children and adolescents with ASD, with a specific focus on external validity. While internal validity traditionally has been prioritized in studies evaluating interventions, external validity has often been neglected. More particular, there are several compelling reasons to examine this aspect closely. First, the examined ASD samples and interventions techniques are heterogeneous. Second, children and adolescents with ASD often have difficulties with generalizing skills among different situations, and it is not clear how this is reflected in the results of ER training studies. Third, ER training is often performed using computerized programs in controlled settings, raising questions about the extent to which the effects are translated to everyday social skills.

4.2 Study II

The second study is a comparative study that examined facial affect recognition performance (accuracy and response times) for basic emotion in whole face and eye-region stimuli. This study was done by exploring the mediating effects of attentional functions and social communication problem severity in participants with ASD, ADHD, and TD. The main objectives were to determine the specificity of FAR challenges in ASD compared to ADHD for global and specific basic emotion detection, and to evaluate the influences other yet unstudied factors on FAR performance.

4.3 Study III

The scientific knowledge about cultural differences and similarities in ER is limited. The aim to this study was to compare different emotion modalities, both basic and complex emotions, in three countries: Sweden, the United Kingdom and Israel, in order to determine cultural similarities and differences of emotion recognition in children with ASD.

4.4 Study IV

This study tested the effects of Emotiplay, a serious game, on emotion recognition skills, autistic traits and adaptive behaviors children with ASD across three different countries: Sweden, Israel and UK. The study used a one-group pre-post design in the United Kingdom and randomized controlled design in Israel and Sweden.

5 DESIGN

5.1 ASC Inclusion project

All studies composing this thesis focus on emotion recognition and emotion expression in children with ASD. Two of the studies examine emotion processing performance and cultural differences using the newly developed serious game "Emotiplay". These studies III and IV were part of the ASC-Inclusion project (ASC-inclusion.eu).[162] A multi-disciplinary research team was assembled for this project and consisted of leading researchers in the field of ASD and ICT-based human machine interaction solutions. The researchers were from seven different universities around Europe: Autism Research Centre (ARC) at Cambridge University (UCAM), UK, Cambridge Computer Lab (UCAM-CL), UK, KIND at Karolinska Institutet (KI), Sweden, and Bar-Ilan University (BIU), Israel, , Technische Universität München (TUM), Germany, and the University of Genova (UNIGE), Italy. Other partners were the Gaming development company , Compedia (COMP), Israel, and the stakeholder interest organization Autism-Europe (AE). The main purpose to this project was to collaborate on building an internet-based interactive serious game platform for emotion recognition and expression training for children with ASD. The game should combine several state-of-the-art technologies in one comprehensive game environment. The resulting game, "Emotiplay", former named ASC-Inclusion" has not yet reached its full potential, as especially training modules for emotion expression in terms of gestures, facial, and vocal expressions are still being developed Nevertheless, the current game consists of a rich variation of emotion recognition training games, animations, video clips, and audio clips. Though designed to assist children with ASD, Emotiplay can also serve other groups with emotion processing challenges, such as children

with learning difficulties[163], ADHD[164] behavioral and conduct problems[165], or socio-emotional difficulties[166]. Twenty common emotions (i.e., kind, unfriendly, joking, hurt, jealous, interested, bored, worried, frustrated, ashamed, proud, surprised, excited, disappointed happy, sad, afraid, angry, disgusted, and sneaky) had been a priori and scientifically rigorously empirically derived as the most important emotions for social interaction in daily living as identified by ASD patients, parents, and experts.[167] These emotions served as the general educational content within the ASC-Inclusion platform.

5.1.1 Study I

A systematic review of RCTs on ER training for children and adolescents with ASD, focusing on the generalizability of behavioral outcome related to ER or social skills. Seven databases (i.e., Cochrane; Medline; Embase; Cinahl; Psychinfo; Social Services Abstract; ERIC) were searched up until November 2015 using Medical Subject Headings (MeSH) and relevant text word terms. Two independent researchers conducted the study selection and data extraction. A checklist[168] was used to identify information about determinants of external validity with respect to five overarching themes (i.e., interventions, treatment providers, populations, contexts, and outcomes).

5.1.2 Study II

This study compared accuracy and response times for general and specific FAR in whole face and eye-region stimuli using a quasi-experimental, ex-post facto, case-control design. The study tested if accuracy (no. of correct answers) and response time differed between groups (i.e., ASD, ADHD and TD). FAR was assessed in matched samples of children and adolescents with ASD, ADHD and TD. Severity and confounding effects were controlled by matching the groups in sex, age, and IQ. Basic FAR was tested using FEFA, attention was tested using the computerized Conners' Continuous Performance Test II Version (CP II), and social communication was measured using Social Responsiveness Scale (SRS). Two clinical psychologists assessed both TD children and the children with ASD and ADHD. The TD children were assessed within the school and the ASD and ADHD children were assessed in the clinic.

5.1.3 Study III

In this study, children with high-functioning ASD and TD children were compared on four different ER tasks. The samples were matched for age, sex, and IQ, and recruited from three different countries (i.e., Sweden, Israel and UK). The ER tasks examined recognition of basic and complex emotions. The tasks were voice recordings, videos of facial and bodily expressions, and multimodal EE and ER in context. The instruments used were FEFA for facial recognition and the Emotion recognition battery. The tasks were performed within the clinic and clinical psychologists assessed the children.

5.1.4 Study IV

The final study was a cross-cultural evaluation (in the UK, Israel and Sweden) of the serious game Emotiplay's, a system to train ER in children with ASD. The study examined the effect of Emotiplay on ER skills in children with ASD and normal range to low IQ. This was done in two different ways: 1) in the UK, participants were tested before and after using Emotiplay, and 2) in Sweden and Israel, participants were randomized to an active group using Emotiplay or to wait list control group. We measured ER tasks that included body, face, voice recognition and integrated skills before and after using Emotiplay. We also measured adaptive socialization using SRS were parents scored levels of autistic symptoms.

5.2 Measures

5.2.1 Emotion recognition

In study III and IV used different ways to measure ER, namely face, voice, body and uni and multi modal emotion recognition. To do so, an ER battery was created by the BIU team in Israel using ER video clips from voice and body from the EU Emotion stimuli[169] set and a set of ER face video clips from the training program Mindreading[108]. In addition, clips from socially and emotionally loaded scenes of television series representing ER integrated tasks. The ER task battery contained 18 emotions, six basic emotions, and 12 complex emotions. In studies II to IV, basic emotion recognition outcome was also assessed using the FEFA[146] test using eyes and face stimuli (total performance score and single basic emotion scores). The FEFA test uses the cross-cultural concept of seven fundamental affective states[174] to assess explicit FAR skills by verbal labelling of emotions (happy, sad, angry, surprised, disgusted, fearful, and neutral) expressed in the eye regions and in whole faces.

5.2.2 Other measures

The computerized Conners' Continuous Performance Test II Version 5 (CPT-II) [171] was used in study II to measure attention (impulsivity and distractibility). This test generates several indices, of which two were used in study II: omission of stimuli errors (indicating distractibility) and commission of stimuli errors (indicating impulsivity). The parent report form of Social Responsiveness Scale (SRS) [172] was used to assess the severity in social communication in the participants. SRS contains items in six different groups and intend to assess social communication, social motivation, social awareness, social cognition, and mannerisms

In study III and IV, the parent form of SRS were used to assess the severity of autism traits symptoms within the area of social communication. To evaluate social adaptive functioning, in study IV, the Vineland Adaptive Behavior Scales (VABS-II) [173] was used. The Socialization scale comprises three subscales: interpersonal relationships, play and leisure time, and coping skills. IQ was measured in partly different ways in study III and IV, in Israel and Sweden two subtests, representing verbal and performance IQ (vocabulary and block design) from the Wechsler Intelligence Scales for Children (WISC IV)[174], were used and in addition to child's age Wechsler Primary and Preschool Scale of Intelligence (WPPSI-3)[176] were used in Israel. In Britain, four subtests were taken from the locally standardized versions of the second edition of the Wechsler Abbreviated Scales of Intelligence (WASI-2)[177].

5.3   Participants

5.3.1   Study I

The original studies included in the systematic review covered children and adolescents up to 18 years of age with a confirmed diagnosis of ASD.

5.3.2   Study II

This study contained N=99 child and adolescent volunteers (50 females, 49 males) aged 8.6–15.9 years (M=11.6; SD=2.0). All participants were outpatients of the child and adolescent psychiatric or paediatric clinics of Södertälje municipality, Stockholm County, Sweden. The cohort included 35 children with ASD (n=27, Asperger syndrome; n=6, atypical autism/pervasive developmental disorder not otherwise specified; n=1, autism as primary diagnosis) 32 with a primary diagnosis of ADHD (n=21, Hyperkinetic Disorder; n=11, Other Hyperkinetic Disorder), and 32 TD children. The TD cohort was recruited from primary and secondary schools in the Södertälje and Nykvarn municipalities, Stockholm County, Sweden. The children were allocated using the primary clinical diagnosis, either to ADHD or ASD, in both groups there were individuals with comorbid neuropsychiatric diagnosis. The diagnoses were all consensus diagnoses, following the regional guidelines for assessment and treatment of ASD and ADHD outlined by the Child and Adolescent Psychiatry, Stockholm County Council (Barn och ungdomspsykiatri, Stockholms läns landsting, 2015) as assessed by experienced clinical personal. Participants were aged 8.6–15.9 years (M=11.6; SD=2.0) with an average IQ of 102.8 (SD=11.2, range=75–128), according to the WISC-IV.; Wechsler, 2003).

5.3.3   Study III

A total of 113 children, aged 5–9 years, were recruited in Sweden (n=37; 19 ASD & 18 TD), Israel (n=42; 20 ASD & 22 TD), and the UK (n=34; 16 ASD & 18 TD). ASD diagnosis was confirmed by a clinical diagnosis according to DSM-IV-TR or ICD-10 criteria and by meeting ASD cutoff using the ADOS-2. The parents of the children in the TD groups confirmed that the children had no psychiatric diagnosis, no family members diagnosed with ASD, and no special needs in school. No participant in the TD group scored above the cut off score of 15 on the parent-reported Childhood Autism Spectrum Test (CAST). The children were recruited in various ways: databases, local clinics for children with ASD, special education classes and kindergartens, internet forums, and support organizations for individuals with ASD.

5.3.4 Study IV

Phase 1: UK clinical trail

Fifteen children with ASD aged 6–9 were recruited from special education classes, kindergartens, databases (volunteers) and from organizations supporting children with ASD. Participants had a primary diagnosis ASD and had been diagnosed by a medical doctor or a clinical psychologist according to DSM-IV, DSM-5, or ICD-10 criteria. Diagnosis was corroborated by meeting ASD cutoff on ADOS-2, all children met the ADOS-2 cutoff for ASD. Participants were recruited from volunteer databases, special education classes and kindergartens, and support organizations for individuals with ASD.

Phase 2: Israel and Sweden's controlled trial

A total of 83 children, aged 5–9 years, were recruited in Sweden (n=40) and Israel (n=43). ASD diagnosis was confirmed by a clinical diagnosis according to DSM-IV-TR or ICD-10 criteria and by meeting ASD cutoff using the ADOS-2. The children were recruited in various ways: databases, local clinics for children with ASD, special education classes and kindergartens, internet forums, and support organizations for individuals with ASD.

5.4 Analyzes

5.4.1 Study I

First, a narrative synthesis of the extracted information about generalizability was conducted for each overarching theme. This synthesis included a general judgment about generalizability. Second, the standardized mean difference (Hedge's *g*) and 95% confidence interval were calculated for all measures of ER and social skills in all included studies. The mean and standard deviation for each group at post-treatment (and at follow-up when available) were used as a basis for these analyses. The extent to which improvements in ER were associated with improved social skills was examined for each study in order to evaluate how the ER training generalized to daily social skills. Interventions specifically targeting ER were held separate from interventions combining ER training and social skills training. This was done to enable a rough assessment of whether specific ER training led to improved social skills or if additional social skills training was required for this to happen. Review Manager (RevMan) Version 5.3.4 was used to facilitate the review process.

5.4.2 Study II

In this study, a hierarchical analysis approach was used. First, we computed MANCOVAs for FAR total scores (global FAR) and the single basic emotions (specific FAR). Diagnostic group was a (ASD, ADHD, TD) and presence of psychiatric comorbidity (with/without) were between groups factors, while attention (CPT-II, impulsivity and distractibility), and social communication problem severity (SRS) were covariates. Univariate ANCOVAs were used in those cases where the general linear models (GLMs) were significant, to identify the factors/covariates driving the models' significance. Tukey's test was used post-hoc to identify significant between group comparisons. To determine the strengths and direction of covariation effects and to explore associations between covariates and certain clinical measures of interest (e.g., ADOS), Pearson correlations, partialling out for IQ, were computed. An alpha level of 0.05 was adopted for all analyses.

5.4.3 Study III

MANCOVA with repeated measures was used, with accuracy proportion scores of the four tasks (face, voice, body, and integrative) as the dependent variables, complexity (basic, complex) as the within-subject factor, and group (ASD, TD) and country (Israel, UK, Sweden) as the between-group factors. Participants differed on age and verbal ability in Israel, UK, Sweden, so these two factors were entered as covariates. Pairwise comparisons with Bonferroni corrections were used for further analysis of the interaction effects.

5.4.4 Study IV

In the UK sample, paired-sample t tests were used to test the change from pre- to post-intervention on the measures used. In the combined Swedish and Israeli MANOVAs with repeated measures was computed with ER task scores (face, voice, body, and integrative), SRS-2, and VABS-2 as dependent variables. Time (pre/post-intervention) was within-subject factor, and group (intervention, control) and country (Israel, Sweden) were between-group factors.

5.5   Ethical considerations

Study I is a systematic review of previously published studies, and does not require ethical approval. All parts of the study II, III, and IV have been reviewed and approved by the regional ethical committee in Stockholm (dnr. 2014/773-32/4; 2010/2003-31/3). Studies III and IV were also approved by the responsible ethical boards in the UK and Israel. Parents' informed consent for the child's participation was requested in accord with national and international standards, including the option to withdraw from the project at any stage. Participants' information was kept confidential, locked in and separated from any of the testing materials. In order to protect the participants' privacy and anonymity, each participant was given a unique, computer-generated user code, and all collected data was associated with this code. Users' personal details, associated with the user code, were kept separately and were not disclosed to other project partners. Collected data was encrypted and saved on secured servers, unavailable to anyone outside the project team. Particular ethical issues were raised by the inclusion of study participants who are children, have special needs, and/or who are not able to give informed consent. In any project where the direct experimental participation of children is planned, it must be demonstrated that this is absolutely necessary for the research, and that adults could not have been recruited instead without seriously affecting the project objectives. A potential ethical question regarding the current project relates to the applicability of the computerized environment aimed to teach socio-emotional skills to individuals with ASD. If these individuals have social interaction difficulties in everyday life, why not teach them these skills in real social situations? Would the computerized environment serve as a suitable substitute to adequately represent real life social situations? Reasons are as follows: (a) individuals with ASD prefer structured, rule-based environments and struggle to learn from non-structured situations; (b) they need simplified versions of the socio-emotional world that can reduce sensory stimulation, support their featured-based learning style of socio-emotional cues, and introduce cues separately in each perceptual channel; (c) they prefer and enjoy the computerized environment, which could enhance their motivation to learn socio-emotional skills which they find difficult and may refrain from actively learning in everyday life. Another reason for the use of the computerized environment is its availability. Since professionals, such as clinicians and educators, skilled in socio-emotional skill training for individuals with ASD are not widely available throughout Europe, compared to the availability of computers and internet connections, the project allows access to these curricula for individuals who cannot necessarily access it off the computer, as well as those who are too anxious to approach services such as social skills groups. Finally, it is important to note that ASC-Inclusion does not present itself

as a substitute for clinical or educational support, but rather as a complementary service, supporting the acquisition of these important skills. In the past decade, the increasing acceptance of the unique style of individuals with ASD vs. attempts to "cure" or "change" it has resulted in a shift in the medical perspective from viewing ASD as a "disease" that needs to be "cured" or "eliminated" to an evolving perspective (led by many high-functioning individuals with ASD and their family members, and gaining popularity on the internet), to viewing ASD as a different lifestyle, with a different perspective on society and the main goals in life. Taking this perspective, one might ask if the project is attempting to "fix" or "normalize" children with ASD by teaching them the socio-emotional skills, rather than accepting them for who they are.

6 RESULTS

6.1 Study I

A total of 13 eligible RCTs were identified. The interventions were variable regarding treatment components and format, spanning from programs primarily focusing on ER training to comprehensive social skills intervention programs including ER training as one out of several components. Several aspects limited the generalizability of the available studies. The study participants included few females and individuals outside the typical IQ range. Information on comorbid psychiatric disorders was not reported and the studies were not conducted in regular clinical settings. Finally, long-term follow-up assessments and observations in real-life situations were largely lacking. There were few indications that the training effects of interventions primarily targeting ER generalized to daily social interactions. These results provide a preliminary signal that specific training and improvement of ER does not in itself appear to lead to better social skills, but that more comprehensive programs that combine this component with applied training in social skills are required.

6.2 Study II

Results showed that the ASD group did not perform as well as the TD group in accuracy for general and specific FAR for both types of stimuli. The largest differences between groups were in neutral and happy face identification. Post-hoc comparisons showed that the ASD group recognized happy faces (M=8.2, SD=1.4), happy eyes (M=5.5, SD=1.9), and neutral eyes (M=4.8, SD=1.6) less accurately than the TD group (happy faces: M=9.8, SD=1.3; happy eyes: M=7.1, SD=1.2; neutral eyes =6.0, SD=1.4) (p<.0001). In addition, the ASD group responded significantly slower to angry, disgusted, fearful, surprised, sad, and neutral faces (M=3.3–4.4, SD=1.3–1.5) than the TD group (M=2.4–3.3, SD=0.9–1.3). Global face and eye FAR accuracy was negatively correlated with attentional distractibility (r = −0.34 and −0.44, p < .04) in the ASD group. In ADHD, global face and eye FAR accuracy and global FAR eyes test response time were negatively correlated with attentional distractibility (r = −0.31 to −0.33, p < .05).

6.3 Study III

The MANCOVA revealed an overall main effect for group ($F[4,102]=14.70$, $p<.001$, $\eta 2=.37$) and complexity ($F[4,102]=10.49$, $p<.001$, $\eta 2 =.29$), but not for country ($F[8,204]=1.73$, n.s.). Both age ($F[4,102]=11.82$, $p<.001$, $\eta 2=.32$) and verbal ability ($F[4,102]=8.11$, $p<.001$, $\eta 2 =.24$) had significant overall effects as covariates. The three two-way interactions were not significant: group by country ($F[8,204]= 1.41$, n.s.), group by complexity ($F[4,102]=1.56$, n.s.), and country by complexity ($F[8,204]=1.90$, n.s.).

6.4 Study IV

The UK sample and site showed that eight weeks of SG significantly improved performance on the ER body language task (Pre: M = 14.33, S.E. = 1.34; Post: M = 18.73, S.E. = .61; p < .01) and the ER integrative task (Pre: M = 11.13, S.E. = 1.03; Post: M = 13.47, S.E. = .72; p < .05). A significant change was also observed on the parent-rated VABS-II, but not on the SRS-2. The Swedish and Israeli findings indicated a significant improvement on all ER tasks for the active group (Face: Mean difference = 2.17, S.E. = .56, p < .001; Voice: Mean difference = 2.19, S.E. = .59, p < .001; Body: Mean difference = 4.63, S.E. = .64, p < .001; Integrative: Mean difference = 1.83, S.E. = .56, p < .01), but not for the control group. The SRS-2 scores dropped significantly in the Israeli intervention group (Mean difference = 7.88, S.E. = 2.86, p < .01), but no significant change on the SRS-2 were found for the Swedish intervention group or for the control groups. No significant effects were observed on the VABS-2.

7 DISSCUSION

7.1 Study I

This study synthesized RCTs aiming to teach ER in ASD. There was a wide variety of interventions, spanning from comprehensive training programs down to very brief computerized training programs. The programs contained multiple components. The studies included were small to large efficacy studies and reported, in most cases, positive outcomes. Nevertheless, it is unclear what effects these interventions had in real life social interactions. The clear link between ER training and improved social skills in real life is unclear, as most studies did not report any improved social skills. Poor external validity is far from unique in ER training studies. For example, social skills group training for children with ASD suffers from similar shortcomings.[168] Improved social skills in real life should be the most essential as individuals with ASD often experience difficulty in generalizing across situations. There is a need for lager studies with a longer follow up time and with a focus on external validity before any firm conclusions can be drawn whether ER training can benefit individuals in real life. There will always be challenges when studying participants from child and adolescent mental health care given the large variety of clinical characteristics and developmental stages represented in this group. Handling uncertainty related to heterogeneity within child and adolescent mental health care is a major challenge, but intervention research should strive for external validity such as generalization to IRL situations.

7.1.1 Limitations

There are some limitations to consider. First, we only included RCTs. Other study designs, such as single subject design, could be valuable to get a broader insight to how participants could respond to a specific treatment. Second, we did not contact authors for missing information, all information was extracted from the articles, and we did not review literature outside the scientific journals. Third, this review focused on external validity and did not check for risk for bias.

7.2   Study II

This study examined global and specific FAR accuracy and response times in face and eye stimuli in ASD, ADHD, and TD. Our hypotheses were partly confirmed and showed that ASD compared to TD had alterations in accuracy and response time for different forms of FAR operationalization, mostly driven by happy and neutral FAR face stimuli. The factor group for face and eyes global FAR showed less variance than attentional distractibility and no particular basic emotion was singled out. A correlational analysis was done and showed that distractibility had a large impact on accuracy and response time in ADHD and ASD, but not TD. In summary, it seems like distractibility appears to an important covariate of FAR in ASD and ADHD. Findings confirm FAR alterations in ASD, but not ADHD, and endorse mediating effects of certain attention functions. FAR training seems clinically meaningful in ASD. Future studies should include control for visual attention, facial configuration skills, use naturalistic FAR material, and also investigate implicit FAR.

7.2.1   Limitations

Limitations of this study that it only operationalized explicit FAR and not implicit FAR, which has been reported in other studies as a core alteration in EP in ASD. Second, it did not use eye-tracking or configural face processing to control for visual attention, which might bias our results due to social motivation or/and face perception. Third, we used still pictures from the face and eye region using the FEFA and it is not sure that stills are valid compared to more naturalistic stimuli of social scenes. Fourth, the participants all had an average level of functioning and how these participants' results could be generalized to lower intellectually functioning individuals with ASD is unknown. Fifth, we did not compare groups ASD and ADHD with a "pure" diagnosis. Both groups had a certain degree of comorbidity. About 30% of the participants with a primary ASD diagnosis also fulfilled criteria for ADHD. Comorbidity is common in ASD and ADHD and our analyses did not yield any effect of the presence of comorbidity on the patterns of findings.

7.3   Study III

The purpose of this study was to examine if there were differences in the recognition of basic and complex emotions between children with ASD and TD children in three countries: Israel, UK, and Sweden. Children with ASD showed deficits in all modalities, facial expressions, body language, vocal expressions, and integrative scenarios. While ER impairments were found across all three countries, an important finding was that there were few cultural differences. We had hypothesized greater variability in complex emotions than in basic emotion between cultures, which was not confirmed. One possibility is that such differences occur with increased age when an individual has acquired more culture specific knowledge. There were some cultural differences in face and body language tasks. Swedish participants performed more poorly than TD controls on complex emotions, but not on basic emotions, whilst participants from UK and Israel showed facial ER deficits both for basic and complex emotions. One explanation for the differences could be that the body task stimuli was filmed in the UK with actors of varying ethnicities

.

7.3.1   Limitations

This study examined cultural differences in ER contains limitations that need to be addressed. First, only a few females took part in the study, so gender differences were not possible to explore. Second, there should be an extended examination including other non-western cultures (e.g., African or Eastern cultures). Third, a larger sample of TD individuals should tested in order to appropriately examine ER cultural differences in the general population. Fourth, there was a difference in methodology between the different countries due to distance and parental needs. In Israel and UK, the clinical teams traveled to children's homes, while children in Sweden came to the clinic. Even with a standardized testing environment (e.g., standardized protocol), this means results could differ due to the different location for assessments and should be done in the same way in future studies.

7.4   Study IV

This study used the serious game, Emotiplay, to teach multimodal ER processing. Multimodal ER is important in social communication. The ability to recognize facial expressions, tone of voice and body language, is a basis to understand social cues about the subjective and emotional states, as well as the intentions of others. Especially, multimodal channel training has been overlooked in most other ER, and this is to the author's best knowledge the first ER training programs for ASD in form of a serious game, that has been evaluated. It is also the first study to examine cultural factors. This study shows promising results for Emotiplay's efficacy, and its cross-cultural applicability

7.4.1   Limitations

There are some limitations that need to be addressed. First, this study is limited by using different protocols between sites. Sweden and Israel used an extended version of the SG while an alpha version was applied in UK. There were also different amounts of time given in the various cultures for the children to finish the SG. In Israel, the children were given additional time to finish the SG, while the time frame was restricted in Sweden and UK. In future studies, individual pace and SG use patterns should be examined. Second, two versions of the ER battery were used, which were positively correlated ($r = .56$–$.70$) in all ER tasks. This may limit the interpretation of the findings. The use of the same body language task pre- and post-intervention is a limitation related to the above noted limitation. Nevertheless, the intervention group improved significantly more than the control group on the body language tasks. We think that it is unlikely that the results come merely from repetition. Third, blinded teachers' reports were not included in this study. Future studies should include raters, blind to the study's aims and conditions. Fourth, generalization difficulties have been reported as a problem when training ER through computer-based interventions. In this study, parents were provided with guidelines and activities designed to enhance participants' generalization into everyday life. The parents' involvement effects were not examined within this study. It is important for future research to examine the gains of the parents' involvement. Fifth, the effects on a cross-cultural level could be assessed with enough scrutiny, because of cultural resemblances between the UK, Sweden and Israel. Other countries outside the western world should be included in future studies. Sixth, this study included a treatment-as-usual control group (TAU), future studies should include active control group to get a better understanding of Emotiplay's more specific effects.

8 CONCLUSIONS AND FUTURE DIRECTIONS

8.1 Conclusions

This thesis has explored different aspects of ER challenges in children with ASD. It contains a systematic review that sought to explore the external validity of the current evidence base on ER training programs. External validity is crucial for whether clinical services will implement ER programs and how the program will have an impact on the individual with ASD in daily living. External validity has been overlooked in ER training research so far. The RCTs that were looked at revealed that external validity was underreported here, that sample sizes were mostly small, and lacked long-term outcome. Thus, next generation ER training RCTs need to fulfill criteria for both internal and external validity, ensuring a relevant clinical representation with varying symptom severity, comorbidity, IQ, and sociodemographic characteristics (e.g., gender and age). Larger samples will also allow sub analyses in order to identify moderators and mediators of the effect. The latter can inform precision medicine in ASD, allowing individualized treatment decisions, resource saving, and avoidance of unnecessary action. On balance, even today there are already a multitude of computer-based programs available that have demonstrated some evidence for improving ER skills in ASD[156] and ER has shown to trigger neuroplasticity of the social brain[170].

8.2 Future directions

ER training programs, such as the serious game, Emotiplay, show that individuals with ASD can improve in recognizing emotions expressed in the face, voice and body, both basic and complex emotions. However, there ER program still have a huge potential for improvement in terms of generalizability and quality of scientific evaluation. Some areas for improvement are blinded assessments, more sensitive and broader functioning and quality of life outcome variables, and naturalistic ER material. As Fletcher-Watson and colleagues summarized in a recent systematic review, some means and strategies to achieve training evaluation validity: A development of sensitive and psychometrically sound measures of the quality of social interaction and its response to training is needed. This could be complemented with systematically replicated single-subject studies as an add on for how the interventions can be tailored and optimized for specific sub-groups, in addition to primary diagnosis only, as individuals with comorbid diagnoses might embody a unique phenotype.

9 ACKNOWLEDGMENTS

To start with I would like to thank all the people, children, researchers and parents that not will be mentioned in this thesis. You have all been a great inspiration for my work, both in the clinic and research.

I would like to thank my main supervisor professor **Sven Bölte**. Without him, I would have probably never been a PhD student. He has always patiently listened to my more or less intelligent questions and shared his scientific skills and provided support, encouragement, and motivation. It has also been a privilege to meet with Sven Böltes fantastic research network around the world.

My co-supervisor **Andreas Olsson** and **Daniel Lundqvist** for your great patience and for always being open for questions and support.

Ulf Jonsson for your great support, inspiration and a little bit of "happy puppy therapy"

Peter Marschik and Kristiina Tammimies for your support.

An important part of my PhD has been the ASC INCLUSION team. The team consists of **Simon Baron Cohen** (also my mentor), **Ofer Golan**, **Björn Schuller**, **Antonio Camurri**, **Peter Robinson**, **Daniel Lundqvist**, **Helen O'Reilly**, **Shimrit Fridenson-Hayo**, **Eric Marchi**, **Amandine La Salle**, **Noga Meir**, **Shai Newman and all other involved people.** The discussions and collaboration have been tremendous and crucial for reaching my goal to achieve a higher understanding about emotion recognition research. I would also like to thank the Swedish ASC INCLUSION team, **Sigrid Elfström**, **Nina Milenkovic**, **Anna Granlund** and **Anna Råde**, it had been very difficult to pull this trough without your help.

I will also take the opportunity to thank the administrative help from **Eva Nordin** and **Lisa Wilsson**
My colleagues at KIND, especially **Charlotte Willfors, Christina Coco, John Hasslinger and Anna Pilfalk,** all co-authors, and **Anna Borg**, **Tatja Hirvikoski and Anna Fridell** for inspiring discussions and making KIND a very special work place.

My beloved wife **Johanna** for being patient and supporting. Our children **Pontus and Majken** and the rest of my family, **Barbro**, **Lars**, **Niclas, David, Rebecca, Francelia, Alva, Wilmer** and all other friends and relatives supported and inspired me on my journey.

10 REFERENCES

1   American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub.

2   Hirvikoski, T., Mittendorfer-Rutz, E., Boman, M., Larsson, H., Lichtenstein, P., & Bölte, S. (2016). Premature mortality in autism spectrum disorder. *The British Journal of Psychiatry*, 208(3), 232-238.

3   Bölte, S., de Schipper, E., Holtmann, M., Karande, S., de Vries, P. J., Selb, M., & Tannock, R. (2014). Development of ICF Core Sets to standardize assessment of functioning and impairment in ADHD: the path ahead. *European child & adolescent psychiatry*, 23(12), 1139-1148.

4   Bölte, S., Schipper, E., Robison, J. E., Wong, V. C., Selb, M., Singhal, N., ... & Zwaigenbaum, L. (2014). Classification of functioning and impairment: the development of ICF core sets for autism spectrum disorder. *Autism Research*, 7(1), 167-172.

5   Kanner, L. (1943). Autistic disturbances of affectice contact. Nervous Child, 2, 217-250

6   Asperger, H. (1944). Die „Autistischen Psychopathen" im Kindesalter. *Archiv für Psychiatrie und Nervenkrankheiten*, 117, 76-136..

7   Hallmayer, J., Cleveland, S., Torres, A., Phillips, J., Cohen, B., Torigoe, T., ... & Lotspeich, L. (2011). Genetic heritability and shared environmental factors among twin pairs with autism. *Archives of general psychiatry*, 68(11), 1095-1102.

8   Sandin, S., Lichtenstein, P., Kuja-Halkola, R., Larsson, H., Hultman, C. M., & Reichenberg, A. (2014). The familial risk of autism. *Jama*, 311(17), 1770-1777.

9   Grafodatskaya, D., Chung, B., Szatmari, P., & Weksberg, R. (2010). Autism spectrum disorders and epigenetics. *Journal of the American Academy of Child & Adolescent Psychiatry*, 49(8), 794-809.

10 Mandy, W., & Lai, M. C. (2016). Annual Research Review: The role of the environment in the developmental psychopathology of autism spectrum condition. *Journal of Child Psychology and Psychiatry*, 57(3), 271-292.

11 Pinto, D., Delaby, E., Merico, D., Barbosa, M., Merikangas, A., Klei, L., ... & Vorstman, J. A. (2014). Convergence of genes and cellular pathways dysregulated in autism spectrum disorders. *The American Journal of Human Genetics*, 94(5), 677-694.

12 Cristino, A. S., Williams, S. M., Hawi, Z., An, J. Y., Bellgrove, M. A., Schwartz, C. E., ... & Claudianos, C. (2014). Neurodevelopmental and neuropsychiatric disorders represent an interconnected molecular system. *Molecular psychiatry*, 19(3), 294-301.

13   Geschwind, D. H., & Levitt, P. (2007). Autism spectrum disorders: developmental disconnection syndromes. *Current opinion in neurobiology*, 17(1), 103-111.

14   Cryan, J. F., & Dinan, T. G. (2012). Mind-altering microorganisms: the impact of the gut microbiota on brain and behaviour. *Nature reviews neuroscience*, 13(10), 701-712.

15   Campbell, D. B., Buie, T. M., Winter, H., Bauman, M., Sutcliffe, J. S., Perrin, J. M., & Levitt, P. (2009). Distinct genetic risk based on association of MET in families with co-occurring autism and gastrointestinal conditions. *Pediatrics*, 123(3), 1018-1024.

16   Baron-Cohen, S., Scott, F. J., Allison, C., Williams, J., Bolton, P., Matthews, F. E., & Brayne, C. (2009). Prevalence of autism-spectrum conditions: UK school-based population study. *The British Journal of Psychiatry*, 194(6), 500-509.

17   Idring, S., Rai, D., Dal, H., Dalman, C., Sturm, H., Zander, E., ... & Magnusson, C. (2012). Autism spectrum disorders in the Stockholm Youth Cohort: design, prevalence and validity. *PloS one*, 7(7), e41280.

18   Kim, Y. S., Leventhal, B. L., Koh, Y. J., Fombonne, E., Laska, E., Lim, E. C., ... & Song, D. H. (2011). Prevalence of autism spectrum disorders in a total population sample. *American Journal of Psychiatry*, 168(9), 904-912.

19   Elsabbagh, M., Divan, G., Koh, Y. J., Kim, Y. S., Kauchali, S., Marcín, C., ... & Yasamy, M. T. (2012). Global prevalence of autism and other pervasive developmental disorders. *Autism Research*, 5(3), 160-179.

20   Lai, M. C., Lombardo, M. V., & Baron-Cohen, S. (2013). Autism. *Lancet*, 383(9920), 896-910.

21   Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008). Psychiatric disorders in children with autism spectrum disorders: prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child & Adolescent Psychiatry*, 47(8), 921-929.

22   Fombonne E. (2009). Epidemiology of pervasive developmental disorders. *Pediatric Research*. Jun;65(6):591-8.

23   Bölte, S. (2014). Is autism curable? *Developmental Medicine & Child Neurology*, 56(10), 927-931.

24   De Rubeis, S., & Buxbaum, J. D. (2015). Genetics and genomics of autism spectrum disorder: embracing complexity. *Human molecular genetics*, ddv273.

25   Hill, E. L., & Frith, U. (2003). Understanding autism: insights from mind and brain. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 358(1430), 281-289..

26   de Schipper, E., Lundequist, A., Coghill, D., de Vries, P. J., Granlund, M., Holtmann, M., ... & Singhal, N. (2015). Ability and disability in autism spectrum disorder: A systematic literature review employing the international classification of functioning, disability and health-children and youth version. *Autism Research*, 8(6), 782-794.

27   van Heijst, B. F., & Geurts, H. M. (2015). Quality of life in autism across the lifespan: A meta-analysis. *Autism*, 19(2), 158-167.

28   Zablotsky, B., Bradshaw, C. P., Anderson, C. M., & Law, P. (2014). Risk factors for bullying among children with autism spectrum disorders. *Autism*, 18(4), 419-427.

29   McEvilly, M., Wicks, S., & Dalman, C. (2015). Sick Leave and Work Participation Among Parents of Children with Autism Spectrum Disorder in the Stockholm Youth Cohort: A Register Linkage Study in Stockholm, Sweden. *Journal of autism and developmental disorders*, 45(7), 2157-2167.

30   Reichow, B. (2012). Overview of meta-analyses on early intensive behavioral intervention for young children with autism spectrum disorders. *Journal of autism and developmental disorders*, 42(4), 512-520.

31   World Health Organization. (2001). *International Classification of Functioning, Disability and Health: ICF*. World Health Organization.

32   World Health Organization. (2007). *International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY*. World Health Organization.

33   Üstün, T. B., Chatterji, S., Kostanjsek, N., Rehm, J., Kennedy, C., Epping-Jordan, J., ... & Pull, C. (2010). Developing the World Health Organization disability assessment schedule 2.0.*Bulletin of the World Health Organization*, 88(11), 815-823.

34   Lord, C., Rutter, M., DiLavore, P., Risi, S., Gotham, K., & Bishop, S. (2012). Autism diagnostic observation schedule–2nd edition (ADOS-2). *Los Angeles, CA: Western Psychological Corporation*.

35   Lord, C., Rutter, M., & Couteur, A. (1994). Autism Diagnostic Interview-Revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of autism and developmental disorders*, 24(5), 659-685.

36   Zander, E., Willfors, C., Berggren, S., Choque-Olsson, N., Coco, C., Elmund, A., ... & Linder, J. (2016). The objectivity of the Autism Diagnostic Observation Schedule (ADOS) in naturalistic clinical settings. *European child & adolescent psychiatry*, 25(7), 769-780.

37   Volkmar, F., Chawarska, K., & Klin, A. (2005). Autism in infancy and early childhood. *Annu. Rev. Psychol.*, 56, 315-336.

38   Charman, T., & Gotham, K. (2013). Measurement issues: screening and diagnostic instruments for autism spectrum disorders–lessons from research and practice. *Child and adolescent mental health*, 18(1), 52-63.

39   Zwaigenbaum, L., Bauman, M. L., Stone, W. L., Yirmiya, N., Estes, A., Hansen, R. L., ... & Kasari, C. (2015). Early identification of autism spectrum disorder: recommendations for practice and research. *Pediatrics*, 136(Supplement 1), S10-S40.

40   Fein, D., Barton, M., Eigsti, I. M., Kelley, E., Naigles, L., Schultz, R. T., ... & Troyb, E. (2013). Optimal outcome in individuals with a history of autism. *Journal of child psychology and psychiatry*, 54(2), 195-205.

41   Hirvikoski, T., Jonsson, U., Halldner, L., Lundequist, A., de Schipper, E., Nordin, V., & Bölte, S. (2015). A Systematic Review of Social Communication and Interaction Interventions for Patients with Autism Spectrum Disorder. *Scandinavian Journal of Child and Adolescent Psychiatry and Psychology*, 3(3), 147-168.

42   Magiati, I., Tay, X. W., & Howlin, P. (2014). Cognitive, language, social and behavioural outcomes in adults with autism spectrum disorders: A systematic review of longitudinal follow-up studies in adulthood. *Clinical Psychology Review*, 34(1), 73-86.

43   Fiske Susan, T., & Taylor, S. E. (2008). Social Cognition: From Brains to Culture.

44   Kennedy, D. P., & Adolphs, R. (2012). The social brain in psychiatric and neurological disorders. *Trends in cognitive sciences*, 16(11), 559-572.

45   Harris, L. T., & Fiske, S. T. (2007). Social groups that elicit disgust are differentially processed in mPFC. *Social cognitive and affective neuroscience*, 2(1), 45-51.

46   Scherer, K. R., Schorr, A., & Johnstone, T. (Eds.). (2001). *Appraisal processes in emotion: Theory, methods, research*. Oxford University Press.

47   Lacroix, A., Guidetti, M., Rogé, B., & Reilly, J. (2009). Recognition of emotional and nonemotional facial expressions: A comparison between Williams's syndrome and autism. *Research in Developmental Disabilities*, 30(5), 976-985.

48   Gross, T. F. (2004). The perception of four basic emotions in human and nonhuman faces by children with autism and other developmental disabilities. *Journal of abnormal child psychology*, 32(5), 469-480.

49   Bölte, S., & Poustka, F. (2003). The recognition of facial affect in autistic and schizophrenic subjects and their first-degree relatives. *Psychological medicine*, 33(05), 907-915.

50   Jones, A. P., Happé, F. G., Gilbert, F., Burnett, S., & Viding, E. (2010). Feeling, caring, knowing: different types of empathy deficit in boys with psychopathic tendencies and autism spectrum disorder. *Journal of Child Psychology and Psychiatry*, 51(11), 1188-1197.

51   Buitelaar, J. K., Van der Wees, M., SWAAB–BARNEVELD, H. A. N. N. A., & Van der Gaag, R. J. (1999). Theory of mind and emotion-recognition functioning in autistic spectrum disorders and in psychiatric control and normal children. *Development and psychopathology*, 11(01), 39-58.

52   Berggren, S., Engström, A. C., & Bölte, S. (2016). Facial affect recognition in autism, ADHD and typical development. *Cognitive neuropsychiatry*, 21(3), 213-227.

53   Collin, L., Bindra, J., Raju, M., Gillberg, C., & Minnis, H. (2013). Facial emotion recognition in child psychiatry: a systematic review. *Research in developmental disabilities*, 34(5), 1505-1520.

54   Harms, M. B., Martin, A., & Wallace, G. L. (2010). Facial emotion recognition in autism spectrum disorders: a review of behavioral and neuroimaging studies. *Neuropsychology review*, *20*(3), 290-322.

55   Hobson, R. P. (1986). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry*, 27(3), 321-342

56   Hobson, R. P., Ouston, J., & Lee, A. (1988). Emotion recognition in autism: Coordinating faces and voices. *Psychological medicine*, 18(04), 911-923.

57   Weeks, S. J., & Hobson, R. P. (1987). The salience of facial expression for autistic children. *Journal of Child Psychology and Psychiatry*, 28(1), 137-152.

58   Braverman, M., Fein, D., Lucci, D., & Waterhouse, L. (1989). Affect comprehension in children with pervasive developmental disorders. *Journal of autism and developmental disorders*, 19(2), 301-316.

59   Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1990). Are there emotion perception deficits in young autistic children? *Journal of Child Psychology and Psychiatry*, 31(3), 343-361.

60   Lozier, L. M., Vanmeter, J. W., & Marsh, A. A. (2014). Impairments in facial affect recognition associated with autism spectrum disorders: a meta-analysis. *Development and psychopathology*, *26*(4pt1), 933-945.

61   McCann, J., & Peppé, S. (2003). Prosody in autism spectrum disorders: a critical review. *International Journal of Language & Communication Disorders*, 38(4), 325-350.

62   Paul, R., Augustyn, A., Klin, A., & Volkmar, F. R. (2005). Perception and production of prosody by speakers with autism spectrum disorders. *Journal of autism and developmental disorders,* 35(2), 205-220.

63   Attwood, T. (2003). Understanding and managing circumscribed interests. *Learning and behavior problems in Asperger syndrome*, 126-147.

64   Kirchner, J. C., Hatri, A., Heekeren, H. R., & Dziobek, I. (2011). Autistic symptomatology, face processing abilities, and eye fixation patterns. *Journal of autism and developmental disorders,* 41(2), 158-167.

65   Deruelle, C., Rondan, C., Gepner, B., & Tardif, C. (2004). Spatial frequency and face processing in children with autism and Asperger syndrome. *Journal of autism and developmental disorders,* 34(2), 199-210.

66   Uljarevic, M., & Hamilton, A. (2013). Recognition of emotions in autism: a formal meta-analysis. *Journal of autism and developmental disorders*, *43*(7), 1517-1526.

67   Rutherford, M. D., Troubridge, E. K., & Walsh, J. (2012). Visual afterimages of emotional faces in high functioning autism. *Journal of autism and developmental disorders*, *42*(2), 221-229.

68   Heerey, E. A., Keltner, D., & Capps, L. M. (2003). Making sense of self-conscious emotion: linking theory of mind and emotion in children with autism. *Emotion*, 3(4), 394.

69   Greimel, E., Schulte-Rüther, M., Kircher, T., Kamp-Becker, I., Remschmidt, H., Fink, G. R., ... & Konrad, K. (2010). Neural mechanisms of empathy in adolescents with autism spectrum disorder and their fathers. *Neuroimage*, 49(1), 1055-1065.

70   Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of autism and developmental disorders,* 32(4), 249-261.

71   Humphreys, K., Minshew, N., Leonard, G. L., & Behrmann, M. (2007). A fine-grained analysis of facial expression processing in high-functioning adults with autism. *Neuropsychologia,* 45(4), 685-695.

72   Kuusikko, S., Haapsamo, H., Jansson-Verkasalo, E., Hurtig, T., Mattila, M. L., Ebeling, H., ... & Moilanen, I. (2009). Emotion recognition in children and adolescents with autism spectrum disorders. *Journal of autism and developmental disorders,* 39(6), 938-945.

73   Volkmar, F. R., Paul, R., Klin, A., & Cohen, D. J. (Eds.). (2005). *Handbook of autism and pervasive developmental disorders, diagnosis, development, neurobiology, and behavior* (Vol. 1). John Wiley & Sons.

74   Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition*, *21*(1), 37-46.

75   Baron-Cohen, S., Ashwin, E., Ashwin, C., Tavassoli, T., & Chakrabarti, B. (2009). Talent in autism: hyper-systemizing, hyper-attention to detail and sensory hypersensitivity. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 364(1522), 1377-1383.

76   Happe, F. G. (1995). The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child development,* 66(3), 843-855.

77   Senju, A., Southgate, V., White, S., & Frith, U. (2009). Mindblind eyes: an absence of spontaneous theory of mind in Asperger syndrome. *Science*, 325(5942), 883-885.

78   Philip, R. C. M., Whalley, H. C., Stanfield, A. C., Sprengelmeyer, R., Santos, I. M., Young, A. W., ... & Hall, J. (2010). Deficits in facial, body movement and vocal emotional processing in autism spectrum disorders. *Psychological medicine,* 40(11), 1919-1929.

79   Frith, U., & Happé, F. (1994). Autism: beyond "theory of mind". *Cognition,* 50(1), 115-132.

80   Roth, I., Barson, C., Hoekstra, R., Pasco, G., & Whatson, T. (2010). *The autism spectrum in the 21st century: Exploring psychology, biology and practice*. Jessica Kingsley Publishers.

81   Craig, F., Margari, F., Legrottaglie, A. R., Palumbi, R., de Giambattista, C., & Margari, L. (2016). A review of executive function deficits in autism spectrum disorder and attention-deficit/hyperactivity disorder. *Neuropsychiatric disease and treatment*, *12*, 1191.

82   Happé, F., Booth, R., Charlton, R., & Hughes, C. (2006). Executive function deficits in autism spectrum disorders and attention-deficit/hyperactivity disorder: examining profiles across domains and ages. *Brain and cognition,* 61(1), 25-39.

83   Rosenthal, M., Wallace, G. L., Lawson, R., Wills, M. C., Dixon, E., Yerys, B. E., & Kenworthy, L. (2013). Impairments in real-world executive function increase from childhood to adolescence in autism spectrum disorders. *Neuropsychology,* 27(1), 13.

84   Morris, R. W., Weickert, C. S., & Loughland, C. M. (2009). Emotional face processing in schizophrenia. *Current opinion in psychiatry,* 22(2), 140-146.

85   Hobson, R. P., Ouston, J., & Lee, A. (1988). Emotion recognition in autism: Coordinating faces and voices. *Psychological medicine,* 18(04), 911-923.

86   Ashwin, C., Chapman, E., Colle, L., & Baron-Cohen, S. (2006). Impaired recognition of negative basic emotions in autism: A test of the amygdala theory. *Social neuroscience,* 1(3-4), 349-363.

87   Wallace, S., Coleman, M., & Bailey, A. (2008). An investigation of basic facial expression recognition in autism spectrum disorders. *Cognition and Emotion,* 22(7), 1353-1380.

88   Philip, R. C. M., Whalley, H. C., Stanfield, A. C., Sprengelmeyer, R., Santos, I. M., Young, A. W., ... & Hall, J. (2010). Deficits in facial, body movement and vocal emotional processing in autism spectrum disorders. *Psychological medicine,* 40(11), 1919-1929.

89   Corbett, B. A., Carmean, V., Ravizza, S., Wendelken, C., Henry, M. L., Carter, C., & Rivera, S. M. (2009). A functional and structural study of emotion and face processing in children with autism. *Psychiatry Research: Neuroimaging,* 173(3), 196-205.

90   Heerey, E. A., Keltner, D., & Capps, L. M. (2003). Making sense of self-conscious emotion: linking theory of mind and emotion in children with autism. *Emotion,* 3(4), 394.

91   Greimel, E., Schulte-Rüther, M., Kircher, T., Kamp-Becker, I., Remschmidt, H., Fink, G. R., ... & Konrad, K. (2010). Neural mechanisms of empathy in adolescents with autism spectrum disorder and their fathers. *Neuroimage,* 49(1), 1055-1065.

92   Castelli, F. (2005). Understanding emotions from standardized facial expressions in autism and normal development. *Autism,* 9(4), 428-449.

93   Rosset, D. B., Rondan, C., Da Fonseca, D., Santos, A., Assouline, B., & Deruelle, C. (2008). Typical emotion processing for cartoon but not for real faces in children with autistic spectrum disorders. *Journal of autism and developmental disorders,* 38(5), 919-925.

94   Behrmann, M., Avidan, G., Leonard, G. L., Kimchi, R., Luna, B., Humphreys, K., & Minshew, N. (2006). Configural processing in autism and its relationship to face processing. *Neuropsychologia,* 44(1), 110-129.

95   Smith, M. J. L., Montagne, B., Perrett, D. I., Gill, M., & Gallagher, L. (2010). Detecting subtle facial emotion recognition deficits in high-functioning autism using dynamic stimuli of varying intensities. *Neuropsychologia,* 48(9), 2777-2781.

96   Domes, G., Heinrichs, M., Kumbier, E., Grossmann, A., Hauenstein, K., & Herpertz, S. C. (2013). Effects of intranasal oxytocin on the neural basis of face processing in autism spectrum disorder. *Biological psychiatry,* 74(3), 164-171.

97   Kliemann, D., Dziobek, I., Hatri, A., Steimke, R., & Heekeren, H. R. (2010). Atypical reflexive gaze patterns on emotional faces in autism spectrum disorders. *Journal of Neuroscience,* 30(37), 12281-12287.

98   Rump, K. M., Giovannelli, J. L., Minshew, N. J., & Strauss, M. S. (2009). The development of emotion recognition in individuals with autism. *Child development,* 80(5), 1434-1447.

99   Kaland, N., Mortensen, E. L., & Smith, L. (2007). Dis embedding performance in children and adolescents with Asperger syndrome or high-functioning autism. *Autism,* 11(1), 81-92

100 Schelinski, S., Riedel, P., & von Kriegstein, K. (2014). Visual abilities are important for auditory-only speech recognition: Evidence from autism spectrum disorder. *Neuropsychologia,* 65, 1-11.

101 Yardley, L. (2008). Demonstrating validity in qualitative psychology. *Qualitative psychology: A practical guide to research methods,* 2, 235-251.

102 Marco, E. J., Hinkley, L. B., Hill, S. S., & Nagarajan, S. S. (2011). Sensory processing in autism: a review of neurophysiologic findings.

103   O'neill, M., & Jones, R. S. (1997). Sensory-perceptual abnormalities in autism: a case for more research? *Journal of autism and developmental disorders,* 27(3), 283-293.

104   Grossman, R. B., Steinhart, E., Mitchell, T., & McIlvane, W. (2015). "Look who's talking!" Gaze Patterns for Implicit and Explicit Audio-Visual Speech Synchrony Detection in Children With High-Functioning Autism. *Autism Research,* 8(3), 307-316.

105   Taylor, N., Isaac, C., & Milne, E. (2010). A comparison of the development of audiovisual integration in children with autism spectrum disorders and typically developing children. *Journal of autism and developmental disorders,* 40(11), 1403-1411.

106   Hall, G. B., Szechtman, H., & Nahmias, C. (2003). Enhanced salience and emotion recognition in autism: A PET study. *American Journal of Psychiatry,* 160(8), 1439-1441.

107   Golan., & Baron-Cohen, S. (2006). Systemizing empathy: Teaching adults with Asperger syndrome or high-functioning autism to recognize complex emotions using interactive multimedia. *Development and psychopathology*, 18(02), 591-617.

108   Golan, O., Baron-Cohen, S., & Golan, Y. (2008). The 'reading the mind in films' task [child version]: Complex emotion and mental state recognition in children with and without autism spectrum conditions. *Journal of autism and developmental disorders,* 38(8), 1534-1541.

109   Simion, F., Regolin, L., & Bulf, H. (2008). A predisposition for biological motion in the newborn baby. *Proceedings of the National Academy of Sciences,* 105(2), 809-813.

110   Falck-Ytter, T., Rehnberg, E., & Bölte, S. (2013). Lack of visual orienting to biological motion and audiovisual synchrony in 3-year-olds with autism. *PloS one,* 8(7), e68816

111   Murphy, P., Brady, N., Fitzgerald, M., & Troje, N. F. (2009). No evidence for impaired perception of biological motion in adults with autistic spectrum disorders. *Neuropsychologia,* 47(14), 3225-3235.

112   Atkinson, A. P. (2009). Impaired recognition of emotions from body movements is associated with elevated motion coherence thresholds in autism spectrum disorders. *Neuropsychologia,* 47(13), 3023-3029.

113   Bishop-Fitzpatrick, L., Mazefsky, C. A., Minshew, N. J., & Eack, S. M. (2015). The relationship between stress and social functioning in adults with autism spectrum disorder and without intellectual disability. *Autism Research,* 8(2), 164-173.

114   Ginsberg, Y., Beusterien, K. M., Amos, K., Jousselin, C., & Asherson, P. (2014). The unmet needs of all adults with ADHD are not the same: a focus on Europe. *Expert review of neurotherapeutics,* 14(7), 799-812.

115   Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 358(1431), 459-473.

116   Howlin, P., Goode, S., Hutton, J., & Rutter, M. (2004). Adult outcome for children with autism. *Journal of Child Psychology and Psychiatry,* 45(2), 212-229.

117   Bishop-Fitzpatrick, L., Mazefsky, C. A., Minshew, N. J., & Eack, S. M. (2015). The relationship between stress and social functioning in adults with autism spectrum disorder and without intellectual disability. *Autism Research,* 8(2), 164-173.

118   Taylor, J. L., & Seltzer, M. M. (2011). Employment and post-secondary educational activities for young adults with autism spectrum disorders during the transition to adulthood. *Journal of autism and developmental disorders,* 41(5), 566-574.

119   Wehman, P. H., Schall, C. M., McDonough, J., Kregel, J., Brooke, V., Molinelli, A., ... & Thiss, W. (2014). Competitive employment for youth with autism spectrum disorders: Early results from a randomized clinical trial. *Journal of autism and developmental disorders,* 44(3), 487-500.

120   Hume, K., Boyd, B. A., Hamm, J. V., & Kucharczyk, S. (2014). Supporting independence in adolescents on the autism spectrum. *Remedial and Special Education,* 35(2), 102-113.

121   Constantino, J. N., Davis, S. A., Todd, R. D., Schindler, M. K., Gross, M. M., Brophy, S. L., ... & Reich, W. (2003). Validation of a brief quantitative measure of autistic traits: comparison of the social responsiveness scale with the autism diagnostic interview-revised. *Journal of autism and developmental disorders,* 33(4), 427-433.

122   White, S. W., Keonig, K., & Scahill, L. (2007). Social skills development in children with autism spectrum disorders: A review of the intervention research. *Journal of autism and developmental disorders,* 37(10), 1858-1868.

123   Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008). Psychiatric disorders in children with autism spectrum disorders: prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child & Adolescent Psychiatry,* 47(8), 921-929.

124   White, S. W., Ollendick, T. H., & Bray, B. C. (2011). College students on the autism spectrum: Prevalence and associated problems. Autism, 15(6), 683-701.

125   Kasari, C., & Smith, T. (2013). Interventions in schools for children with autism spectrum disorder: Methods and recommendations. *Autism,* 17(3), 254-267.

126   Taylor-Greene, S., Brown, D., Nelson, L., Longton, J., Gassman, T., Cohen, J., ... & Hall, S. (1997). School-wide behavioral support: Starting the year off right. *Journal of Behavioral Education,* 7(1), 99-112.

127   Henricsson, L., & Rydell, A. M. (2006). Children with behaviour problems: The influence of social competence and social relations on problem stability, school achievement and peer acceptance across the first six years of school. *Infant and Child Development,* 15(4), 347-366.

128   Segrin, C., & Flora, J. (2000). Poor social skills are a vulnerability factor in the development of psychosocial problems. *Human Communication Research,* 26(3), 489-514.

129   Reichow, B., Steiner, A. M., & Volkmar, F. (2013). Cochrane review: social skills groups for people aged 6 to 21 with autism spectrum disorders (ASD). *Evidence-Based Child Health: A Cochrane Review Journal,* 8(2), 266-315.

130   Parsons, S., Guldberg, K., MacLeod, A., Jones, G., Prunty, A., & Balfe, T. (2011). International review of the evidence on best practice in educational provision for children on the autism spectrum. *European Journal of Special Needs Education,* 26(1), 47-63.

131   Hayes, S. A., & Watson, S. L. (2013). The impact of parenting stress: A meta-analysis of studies comparing the experience of parenting stress in parents of children with and without autism spectrum disorder. *Journal of autism and developmental disorders,* 43(3), 629-642.

132   Jacob, A., Scott, M., Falkmer, M., & Falkmer, T. (2015). The Costs and Benefits of Employing an Adult with Autism Spectrum Disorder: A Systematic Review. *PloS one,* 10(10), e0139896.

133   Buescher, A. V., Cidav, Z., Knapp, M., & Mandell, D. S. (2014). Costs of autism spectrum disorders in the United Kingdom and the United States. *JAMA pediatrics,* 168(8), 721-728.

134   Solomon, M., Goodlin-Jones, B. L., & Anders, T. F. (2004). A social adjustment enhancement intervention for high functioning autism, Asperger's syndrome, and pervasive developmental disorder NOS. *Journal of autism and developmental disorders*, *34*(6), 649-668.

135   Golan, O., LaCava, P. G., & Baron-Cohen, S. (2007). Assistive technology as an aid in reducing social impairments in autism. *Growing Up with Autism: Working with School-Age Children and Adolescents*, 124-142.

136   Moore, D., McGrath, P., & Thorpe, J. (2000). Computer-aided learning for people with autism–a framework for research and development. *Innovations in Education and Teaching International*, *37*(3), 218-228.

137   Baron-Cohen, S., Wheelwright, S., Lawson, J., Griffin, R., & Hill, J. (2002). The exact mind: empathising and systemising in autism spectrum conditions. *Handbook of cognitive development*, 491-508.

138   Baron-Cohen, S., & Wheelwright, S. (1999). 'Obsessions' in children with autism or Asperger syndrome. Content analysis in terms of core domains of cognition. *The British Journal of Psychiatry*, *175*(5), 484-490.

139   Attwood, T. (2003). Understanding and managing circumscribed interests. *Learning and behavior problems in Asperger syndrome*, 126-147.

140   Tantam, D. (2000). Psychological disorder in adolescents and adults with Asperger syndrome. *Autism*, *4*(1), 47-62.

141   Tantam, D. (2003). The challenge of adolescents and adults with Asperger syndrome. *Child and adolescent psychiatric clinics of North America*, *12*(1), 143-163.

142   Dawson, G. (2008). Early behavioral intervention, brain plasticity, and the prevention of autism spectrum disorder. *Development and psychopathology*, *20*(03), 775-803.

143   Zeeland, S. V., Ashley, A., Dapretto, M., Ghahremani, D. G., Poldrack, R. A., & Bookheimer, S. Y. (2010). Reward processing in autism. *Autism Research*, *3*(2), 53-67.

144   Koegel, R. L., Vernon, T. W., & Koegel, L. K. (2009). Improving social initiations in young children with autism using reinforcers with embedded social interactions. *Journal of autism and developmental disorders*, *39*(9), 1240-1251.

145   Fridenson-Hayo, S., Berggren, S., Lassalle, A., Tal, S., Pigat, D., Meir-Goren, N., ... & Golan, O. (2017). 'Emotiplay': a serious game for learning about emotions in children with autism: results of a cross-cultural evaluation. *European Child & Adolescent Psychiatry*, 1-14.

146   Bölte, S., Feineis-Matthews, S., Leber, S., Dierks, T., Hubl, D., & Poustka, F. (2002). The development and evaluation of a computer-based program to test and to teach the recognition of facial affect. *International Journal of Circumpolar Health,* 61(sup2), 61-68.

147   Silver, M., & Oakes, P. (2001). Evaluation of a new computer intervention to teach people with autism or Asperger syndrome to recognize and predict emotions in others. *Autism,* 5(3), 299-316

148   Golan, O., Ashwin, E., Granader, Y., McClintock, S., Day, K., Leggett, V., & Baron-Cohen, S. (2010). Enhancing emotion recognition in children with autism spectrum conditions: An intervention using animated vehicles with real emotional faces. *Journal of autism and developmental disorders*, *40*(3), 269-279.s

149   Tanaka, J. W., Wolf, J. M., Klaiman, C., Koenig, K., Cockburn, J., Herlihy, L., ... & Schultz, R. T. (2010). Using computerized games to teach face recognition skills to children with autism spectrum disorder: the Let's Face It! program. *Journal of Child Psychology and Psychiatry, 51*(8), 944-952.

150   Koegel, R. L., Vernon, T. W., & Koegel, L. K. (2009). Improving social initiations in young children with autism using reinforcers with embedded social interactions. *Journal of autism and developmental disorders*, *39*(9), 1240-1251.

151   Golan, O., Ashwin, E., Granader, Y., McClintock, S., Day, K., Leggett, V., & Baron-Cohen, S. (2010). Enhancing emotion recognition in children with autism spectrum conditions: An intervention using animated vehicles with real emotional faces. *Journal of autism and developmental disorders*, *40*(3), 269-279.s

152   Baron-Cohen, S. (2006). The hyper-systemizing, assortative mating theory of autism. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *30*(5), 865-872.

153   Baranowski, T., Buday, R., Thompson, D. I., & Baranowski, J. (2008). Playing for real: video games and stories for health-related behavior change. *American journal of preventive medicine*, *34*(1), 74-82.

154   Bölte, S., Hubl, D., Feineis-Matthews, S., Prvulovic, D., Dierks, T., & Poustka, F. (2006). Facial affect recognition training in autism: can we animate the fusiform gyrus? *Behavioral neuroscience*, *120*(1), 211.

155   Bölte S.,(2004). Computer-based intervention in autism spectrum disorders; in Ryaskin OT (ed) *Focus on autism research*. New York, Nova Science, 247–260

156   Fletcher-Watson, S., McConnell, F., Manola, E., & McConachie, H. (2014). Interventions based on the Theory of Mind cognitive model for autism spectrum disorder (ASD). *The Cochrane Library*.

157   Durkin, K., Whitehouse, A., Jaquet, E., Ziatas, K., & Walker, A. J. (2010). Cell phone use by adolescents with Asperger Syndrome. *Research in Autism Spectrum Disorders,* 4(2), 314-318.

158   Watabe, T., & Suzuki, K. (2015). Internet communication of outpatients with Asperger's disorder or schizophrenia in Japan. *Asia-Pacific Psychiatry,* 7(1), 27-35.

159   Durkin, K., Boyle, J., Hunter, S., & Conti-Ramsden, G. (2015). Video games for children and adolescents with special educational needs. *Zeitschrift für Psychologie*.

160   Orsmond, G. I., & Kuo, H. Y. (2011). The daily lives of adolescents with an autism spectrum disorder: discretionary time use and activity partners. *Autism,* 15(5), 579-599.

161   Williams, C., Wright, B., Callaghan, G., & Coughlan, B. (2002). Do children with autism learn to read more readily by computer assisted instruction or traditional book methods? A pilot study. *Autism,* 6(1), 71-91.

162   Schuller, B., Marchi, E., Baron-Cohen, S., O'Reilly, H., Robinson, P., Davies, I., ... & Meir, N. (2013). ASC-Inclusion: Interactive emotion games for social inclusion of children with Autism Spectrum Conditions. *Intelligent digital games for empowerment and inclusion*.

163   Bauminger, N., Schorr Edelsztein, H., & Morash, J. (2005). Social information processing and emotional understanding in children with LD. *Journal of learning disabilities,* 38(1), 45-61.

164   Da Fonseca, D., Seguier, V., Santos, A., Poinso, F., & Deruelle, C. (2009). Emotion understanding in children with ADHD. *Child Psychiatry & Human Development,* 40(1), 111-121.

165   Stevens, D., Charman, T., & Blair, R. J. R. (2001). Recognition of emotion in facial expressions and vocal tones in children with psychopathic tendencies. *The Journal of genetic psychology,* 162(2), 201-211.

166   Pollak, S. D., Cicchetti, D., Hornung, K., & Reed, A. (2000). Recognizing emotion in faces: Developmental effects of child abuse and neglect. *Developmental psychology,* 36(5), 679.

167   Berggren S., O'Reilly H., Tal, S., Fridenzon, S., Newman, S., Golan, O., Baron-Cohen., S. Bölte & The difficulty and importance of emotions in children with a diagnosed Autism spectrum condition according to parents and clinical experts, in preparation.

168   Jonsson, U., Choque Olsson, N., & Bölte, S. (2016). Can findings from randomized controlled trials of social skills training in autism spectrum disorder be generalized? The neglected dimension of external validity. *Autism*, 20(3), 295-305.

169   O'Reilly, H., Pigat, D., Fridenson, S., Berggren, S., Tal, S., Golan, O., ... & Lundqvist, D. (2016). The EU-emotion stimulus set: a validation study. *Behavior research methods,* 48(2), 567-576.

170   Bölte, S., Ciaramidaro, A., Schlitt, S., Hainz, D., Kliemann, D., Beyer, A., ... & Walter, H. (2015). Training-induced plasticity of the social brain in autism spectrum disorder. *The British Journal of Psychiatry*, *207*(2), 149-157.

171   Tye, C., Asherson, P., Ashwood, K. L., Azadi, B., Bolton, P., & McLoughlin, G. (2014). Attention and inhibition in children with ASD, ADHD and co-morbid ASD+ ADHD: an event-related potential study. *Psychological medicine*, *44*(5), 1101-1116.

172   Constantino, J. N., & Gruber, C. P. (2007). *Social responsiveness scale (SRS)*. Los Angeles, CA: Western Psychological Services.

173   Sparrow SS, Cicchetti DV, Balla DA (2005) *Vineland adaptive behavior scales*, 2nd edn. American Guidance Service, Circle Pines

174   Wechsler, D. (2003). *Wechsler intelligence scale for children-WISC-IV*. Psychological Corporation.

175   Ekman, P., Friesen, W. V., & Ellsworth, P. (1972). *Emotion in the Human Face: Guide-lines for Research and an Integration of Findings: Guidelines for Research and an Integration of Findings*. Pergamon.

176   Wechsler, D. (2002). The Wechsler primary and preschool scale of intelligence—.

177   Wechsler, D., & Hsiao-pin, C. (2011). *WASI-II: Wechsler abbreviated scale of intelligence*.
       Pearson.

11 APPENDIX