Assessment and modification of cognitive biases in children and young people with or without neurodevelopmental disorders

by

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Summary

When people experience a negative outcome as a result of another person's actions, their emotional and behavioural response may depend on the type of information they encode about the experience and the type of attributions they make to explain the event (Crick & Dodge, 1994). Interpersonal problems like aggression or social anxiety are more likely to occur when people selectively encode interpersonal information of negative valence or when people selectively attribute negative valence to interpersonal information (Dodge, 1993; Stuijfzand, Creswell, Field, Pearcey, & Dodd, 2018). The tendency to interpret another person's intent as hostile even when there is ambiguity about whether his or her actions were deliberate or coincidental, represents a hostile attribution bias that is positively associated with aggression (Verhoef, Alsem, Verhulp, & Orobio de Castro, 2019), especially with aggression that is reactive, namely a response to real or perceived threat (Card & Little, 2006; Dodge & Coie, 1987; Martinelli, Ackermann, Bernhard, Freitag, & Schwenck, 2018). Such valence-specific processing of interpersonal ambiguity also has the potential to explain externalising problems like reactive aggression and internalising problems like social anxiety in children and young people (CYP) with neurodevelopmental disorders.

Individuals with neurodevelopmental disorders, such as intellectual disabilities, autism spectrum disorder or attention deficit-hyperactivity disorder, have been grouped together in the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; American Psychiatric Association [APA], 2013). They frequently present with cognitive, social-cognitive or social-emotional deficits and special educational needs and are more likely than typically developing (TD) individuals to have externalising and internalising disorders (Craig et al., 2016; Emerson, 2003; England-Mason, 2020; Nadeau, Massé, Argumedes, & Verret, 2020; Simonoff et al., 2008; Taurines et al., 2010; van der Molen, van Luit, & Jongmans, 2007).

Given that the use of cognitive bias modification (CBM) to train people to process interpersonal ambiguity more positively can improve externalising and internalising symptoms (Cristea, Mogoașe, David, & Cuijpers, 2015; Grafton et al., 2017; MacLeod & Mathews, 2012), targeting this type of cognitive bias in CYP with neurodevelopmental disorders may also improve mental health outcomes in this group. However, despite evidence that externalising and internalising problems are more prevalent in CYP with neurodevelopmental disorders than in TD individuals, most cognitive bias research has focused on individuals of typical development. Therefore, the overall aim of the four papers included in this doctoral thesis was to shed light on the role of cognitive bias in CYP with neurodevelopmental disorders, specifically on the role

of valence-specific interpersonal ambiguity processing in this group, as well as to find inclusive ways to assess and modify this type of cognitive bias in order to benefit both CYP with and without neurodevelopmental disorders or special educational needs.

To provide an overview of the role of cognitive bias in atypically developing individuals, Paper 1 systematically reviewed evidence for valence-specific processing of interpersonal ambiguity in CYP with neurodevelopmental disorders, including its association with mental health. Sixteen studies assessing valence-specific interpretation of interpersonal ambiguity were identified, with hostile intent attributions being the type of bias that was most commonly researched in this group (n = 11). This cognitive bias was not consistently higher in CYP with neurodevelopmental disorders than in TD controls and was rarely assessed in terms of its link with mental health outcomes. While based on a small number of studies, increased cognitive bias in CYP with attention-deficit/hyperactivity disorder or autism spectrum disorder was found when assessing internality or globality of attributions, and social threat interpretation bias was linked to anxiety and successfully modified using CBM for interpretations (CBM-I) in CYP with mild intellectual disability. Since none of the eligible studies assessed valence-specific attention towards interpersonal ambiguity or memory for such stimuli, no conclusions could be drawn about attention bias or memory bias in neurodevelopmental disorders. Findings of Paper 1 demonstrated the scarcity of research examining biased interpersonal ambiguity processing in this group and highlighted the heterogeneity of cognitive bias definitions and assessments.

To investigate the inclusiveness of previous CBM studies toward atypically developing individuals, Paper 2 systematically reviewed evidence for the efficacy of CBM in CYP with neurodevelopmental disorders and the extent of this group's exclusion from CBM. Out of 30 eligible CBM studies, which all targeted either threat interpretation bias or hostile attributions, only three studies included CYP with neurodevelopmental disorders, while one third of studies explicitly excluded CYP with neurodevelopmental conditions, cognitive deficits or special educational needs. The two studies that included a quantified number of CYP with neurodevelopmental disorders provided tentative evidence for the feasibility of using CBM-I to reduce hostile interpretation of faces in CYP with autism spectrum disorder or attention deficit-hyperactivity disorder, and to reduce threat interpretations and social anxiety in CYP with mild intellectual disabilities. Despite such indications of its feasibility in CYP with neurodevelopmental disorders, CBM-I research was found to be characterised by a general lack of inclusiveness towards this group which is in conflict with their right and increased need to access psychological interventions.

In order to address this gap in the literature regarding cognitive bias assessment and modification that are inclusive towards CYP with or without neurodevelopmental disorders, a pilot randomised controlled trial, followed by qualitative interviews, was conducted in Paper 3 to examine the efficacy and acceptability of our newly developed accessible CBM-I called *Modifying Interpretations in Kids and Adoles*cents *(MIKA)* which targeted hostile attributions in an inclusive sample of 71 lower secondary school pupils (mean age = 12.2 years), one fourth of which presented with attention deficit-hyperactivity disorder, specific learning disorders or special educational needs relating to learning, social-emotional development or speech. Compared to an active control training, the CBM-I reduced hostile other-blaming attributions, assessed using two different sets of our novel cognitive bias measure *Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP)*, and also reduced reactive aggression which was assessed using the *Reactive-Proactive-Aggression-Questionnaire* (*RPQ*; Raine et al., 2006) that we translated into German. Qualitative group interviews conducted with 23 pupils at follow-up provided evidence for the acceptability of training content and delivery.

Paper 4 assessed the psychometric properties of the two VASAPP sets in 267 pupils from inclusive schools (mean age = 11.28 years). One sixth of pupils had special needs in cognition, learning, communication or emotional and social development. Pupils first completed one VASAPP set and the RPQ, followed by the other VASAPP set and the RPQ three months later. The two sets were found to be equivalent in their assessment of other-blame, which also showed good internal consistency, construct validity and convergent validity with aggression.

Overall, the four papers included in this thesis showed that valence-specific interpretation of interpersonal ambiguity represents a feasible and suitable treatment target in CYP with or without neurodevelopmental disorders. Tentative findings of anxiety-related interpretation bias and increased internal or global attributions in CYP with neurodevelopmental disorders need to be replicated. Given inconsistent findings relating to hostile intent attributions in this group, it may be important to examine the potential interplay of cognitive bias, victimisation and general and social cognition, to better explain aggression in CYP with neurodevelopmental disorders. Since cognitive bias research in this group is scarce, heterogeneous and insufficiently inclusive, there is need for accessible assessments like the VASAPP and interventions like the MIKA CBM-I, which successfully assessed and improved aggression-related attributions in inclusive school pupils. More frequent inclusion of both typically and atypically developing individuals in cognitive bias research is needed to make samples more representative of the general population, as well as to realise our commitment to inclusive research in an inclusive society.

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Introduction

Subtypes of aggression differ in terms of their function, mechanism and associated psychosocial maladjustment (Card & Little, 2006; Connor et al., 2019). Compared to proactive aggression, which refers to goal-directed acts like bullying, reactive aggression represents an angry response to real or perceived provocation or frustration and is more closely linked to victimisation, emotion dysregulation, depression and anxiety (Card & Little, 2006; Marsee, Weems, & Taylor, 2008).

Aggression is particularly prevalent in those with neurodevelopmental disorders (e.g. Dekker, Koot, van der Ende, & Verhulst, 2002; Fitzpatrick, Srivorakiat, Wink, Pedapati, & Erickson, 2016; King & Waschbusch, 2010), which have been grouped together in the DSM-5 (APA, 2013) because they frequently co-occur, have their onset in early childhood and show overlap in their genetics, neuropathology, symptoms, cognitive and social-cognitive deficits and comorbidity with other mental health problems and (Dewey, 2018; Gillberg, 2010; Hansen, Oerbeck, Skirbekk, Petrovski, & Kristensen, 2018).

The group of neurodevelopmental disorders consists of intellectual disabilities (ID), autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), specific learning disorder (SLD), communication disorders and motor disorders (APA, 2013). Due to frequent difficulties in cognitive, social and academic functioning, children and young people (CYP) with neurodevelopmental disorders often present with special educational needs in the school context (APA, 2013; Nadeau et al., 2020).

The inclusion of CYP with neurodevelopmental disorders into regular schools represents a standard of the UN Convention on the Rights of Persons with Disabilities that is legally binding for its over 180 member states that ratified the agreement, which include the EU, but not yet the United States (Kanter, 2019; United Nations General Assembly, 2006). While including CYP with neurodevelopmental disorders in inclusive schools has the potential to create equal opportunities for participation and development, their inclusion may be negatively impacted by this group's increased risk for aggression which exacerbates maladjustment and peer conflict.

Successful inclusion may be facilitated if we understand and target the cognitive and social-cognitive processes that contribute to aggression in both typically developing (TD) individuals and those with neurodevelopmental disorders. To achieve this, we need to find inclusive and accessible ways to assess and improve such processes in both groups.

Given that psychosocial maladjustment is more strongly linked to reactive aggression than to proactive aggression (Card & Little, 2006), this thesis is particularly interested in the role of reactive aggression in CYP with or without neurodevelopmental disorders. It explores the possibility that CYP with neurodevelopmental disorders are at a higher risk of showing reactive aggression because they are more likely to interpret other people's behaviours as hostile provocation when there is no clear indication of hostility. This would represent a cognitive bias in the processing of social information that is linked to reactive aggression (Martinelli et al., 2018).

Potential oversensitivity to provocation might be related to past experiences of real provocation, since CYP with neurodevelopmental disorders are frequently involved in bullying, both as victims and as perpetrators (Maïano, Aimé, Salvas, Morin, & Normand, 2016; Rose, Monda-Amaya, & Espelage, 2011; Schroeder, Cappadocia, Bebko, Pepler, & Weiss, 2014).

Regardless of whether someone's aggressive behaviour is the result of being victimised or represents the cause of being victimised, negatively biased processing of other people's behaviours, when there is no real provocation, can maintain a cycle of aggression (Dodge, 2006; Orobio de Castro & van Dijk, 2018). To break this cycle in both typically and atypically developing individuals, it may be important to assess and modify such biased information processing in inclusive settings, which the research of this thesis sets out to do.

To achieve this, we need information about whether cognitive bias differs between CYP with neurodevelopmental disorders and those of typical development and about whether cognitive bias and aggression are linked and can be modified in both groups.

Therefore, the thesis first carries out systematic reviews to provide an overview of the extent and modifiability of cognitive bias in neurodevelopmental disorders, followed by a pilot randomised controlled trial and qualitative interviews to assess the effectiveness and acceptability of a novel online training that targets cognitive bias in inclusive schools, measured via a newly developed accessible cognitive bias measure.

1. Background

This chapter introduces and clarifies the key concepts addressed in this thesis, including aggression, social information processing and cognitive bias. After outlining the different forms of aggression, their cognitive, social-cognitive and social-emotional correlates and their prevalence in neurodevelopmental disorders, an overview is provided of the link between biased or deficient social information processing and aggression in both TD CYP and those with neurodevelopmental disorders.

1.1 Aggression

Reactive and proactive aggression

Aggression during childhood and adolescence has a strong negative influence on an individual's psychosocial adjustment and can predict violence, criminality, unemployment, substance abuse and depression later in life (Card & Little, 2006; Fergusson & Horwood, 1998; Fite, Rubens, Preddy, Raine, & Pardini, 2014; Pulkkinen, 1996; Tsakanikos, Costello, Holt, Sturmey, & Bouras, 2007). Two subtypes of aggression are reactive aggression and proactive aggression. Angry or impulsive responses to real or perceived provocation or frustration characterise reactive aggression, in line with the frustration-aggression model (Berkowitz, 1993; Card & Little, 2006; Dodge & Coie, 1987), while premeditated and goal-directed acts like bullying and stealing represent proactive aggression. Reactive and proactive aggression are described as overt when behaviours involve physical or verbal aggression, like hitting or threatening to harm others. In contrast, reactive and proactive aggression are described as relational, when behaviours involve excluding others or gossiping about them, which damages their reputation, relationships and sense of inclusion (Crick & Grotpeter, 1995). Other studies have further distinguished between overt and covert aggression, where the latter refers to less confrontational acts of aggression like cheating, stealing or vandalism (Connor et al., 2019; Kupersmidt, Stelter, & Dodge, 2011).

Externalising and internalising disorders

Aggression is a behavioural symptom of oppositional defiant disorder, intermittent explosive disorder and conduct disorder, which are categorised in the DSM-5 as disruptive, impulse-control, and conduct disorders and commonly referred to as externalising disorders because they represent outward behaviour problems that have a direct negative impact on the external world (APA, 2013; Liu, 2004). People with oppositional defiant disorder are frequently angry

or annoyed, show vindictiveness or argumentative behaviours, like quarrelling with adults or blaming others for their own misbehaviours (APA, 2013). People with intermittent explosive disorder are also characterised by anger and additionally show impulsive acts of aggression towards others. Aggression in conduct disorder is more likely to be premeditated to achieve intimidation or personal gain, which may take the form of cruel behaviour towards people or animals, property destruction or theft, deceitfulness, or serious rule violations (APA, 2013). Arguably, conduct disorder therefore reflects more features of proactive aggression, while oppositional defiant disorder and intermittent explosive disorder reflect more features of reactive aggression, such as anger-based aggressive outbursts (Kempes, Matthys, Vries, & van Engeland, 2005).

Card and Little (2006) conducted a meta-analysis assessing the associations of reactive aggression and proactive aggression with different indices of psychosocial adjustment. They found that, independently of proactive aggression, reactive aggression was related to internalising problems like depression or anxiety which are called internalising disorders because they first and foremost affect the internal world of an individual (APA, 2013; Card & Little, 2006; Liu, 2004). In contrast, proactive aggression was not independently associated with internalising problems (Card & Little, 2006)). Other reviews have provided evidence for the link between reactive aggression and anxiety (Bubier & Drabick, 2009; Marsee et al., 2008). Experiences of being victimised, which were also related to reactive aggression independently of proactive aggression (Card & Little, 2006), may influence whether reactive aggression leads to internalising problems, as indicated by the finding that peer rejection moderated the relation between reactive aggression and later internalising symptoms (Fite et al., 2014).

Cognitive, social-cognitive and social-emotional correlates of aggression

Individuals with aggressive or antisocial behaviour problems frequently show impairments in executive functions, which include working memory, planning, inhibitory control and selective attention (Morgan & Lilienfeld, 2000). People high in reactive aggression may then be more likely to act impulsively in social interactions due to a lack of inhibition (Thomson & Centifanti, 2018). People with higher effortful control, namely with the ability to focus and shift their attention and inhibit their impulse (Rothbart & Bates, 1998), were less likely to show reactive aggression (Rathert, Fite, Gaertner, & Vitulano, 2011). Problems with effortful control may relate to symptoms of inattention, hyperactivity, impulsivity, frustration intolerance and anger susceptibility, which Card and Little (2006) defined as emotion dysregulation and ADHD

symptoms and which they found to be linked to reactive aggression, independently of proactive aggression.

Deficient response inhibition and planning ability were more strongly related to reactive aggression than to proactive aggression in Ellis, Weiss and Lochman (2009). Such deficits were also characteristic of children in the reactive group in Thomson and Centifanti (2018), when compared to a group of children with low aggression and a group high in both reactive and proactive aggression. Intact planning abilities in individuals high in proactive aggression may explain why this group is able to carry out goal-directed actions like manipulating others for personal gain (Thomson & Centifanti, 2018).

While it is still unclear whether aggression is linked to problems with affective empathy, namely the ability to feel other people's emotions. Evidence suggests, however, that the ability to take other people's perspective and understand their emotions, referred to as Theory of Mind (ToM) or cognitive empathy, is affected in aggression (Jolliffe & Farrington, 2004; Orobio de Castro & van Dijk, 2018). While ToM appears to be intact or even enhanced in proactively aggressive individuals, reactive aggression can be linked to lower levels of ToM (Renouf et al., 2010; Sutton, Smith, & Swettenham, 1999).

The fact that the relation between ToM and both subtypes of aggression was moderated by experiences of peer victimisation (Renouf et al., 2010) was interpreted by Austin, Bondü and Elsner (2017) as pointing to the possibility that negative experiences with peers make it more likely that proactively aggressive children use their ability to infer other people's thoughts to manipulate or deceive them. Reactive aggression, on the other hand, may be more likely to occur in people who have problems inferring other people's intent and who have been victimised in the past, because they may have problems adjusting their reactions to actual intentions of other people in new events and instead base their reactions on their past victimisation experiences, as suggested by Renouf et al. (2010).

In summary, deficits in executive functions, emotion regulation and ToM skills may represent a risk factor for reactive aggression. The fact that these cognitive, social-cognitive and social-emotional functions are particularly impaired in neurodevelopmental disorders, as outlined next, may place this group at a particular high risk for reactive aggression.

1.2 Aggression in neurodevelopmental disorders

Different neurodevelopmental disorders frequently co-occur and show overlap in their psychiatric comorbidities with both externalising and internalising problems and in their developmental deficits of varying severity relating to general and social cognition (e.g. Emerson, 2003; Hansen et al., 2018; Simonoff et al., 2008; Taurines et al., 2010). This section therefore focuses on aggression in the different types of neurodevelopmental disorders.

Attention-deficit/hyperactivity disorder (ADHD)

ADHD is characterised by persistent and impairing symptoms of inattention or hyperactivity-impulsivity that may occur in combination or in isolation and that present in multiple settings before the age of twelve years (APA, 2013). Inattentive symptoms include problems sustaining attention, concentrating, listening, organising and remembering things, while hyperactive-impulsive symptoms refer to difficulties sitting still or waiting one's turn and a tendency to talk excessively or act hastily (APA, 2013). ADHD has a negative impact on social and academic functioning and occurs in 5.29% of CYP worldwide, with prevalence rates ranging from 2.0 to 16.1 % in the US (Cleaton & Kirby, 2018; Polanczyk, Lima, Horta, Biederman, & Rohde, 2007). While ADHD is more common in boys than in girls during childhood, sex differences diminish later in adulthood and ADHD causes equal impairment in both sexes (E. B. Owens, Cardoos, & Hinshaw, 2015).

In terms of psychiatric comorbidity, between 45% and 84% of CYP with ADHD show comorbidity with oppositional defiant disorder, with or without conduct disorder, and up to 50% have major depressive disorder or anxiety (Pliszka, 2015). The review by Angold, Costello and Erklani (1999) reported that, compared to the general population, people with ADHD were ten times more likely to have oppositional defiant disorder or conduct disorder, over five times more likely to have depression and three times more likely to have anxiety. While boys with ADHD may be more likely than girls with ADHD to display externalising problems, there is evidence to suggest that girls with ADHD are more likely than their male counterparts to develop internalising problems later in life (Pliszka, 2015).

One potential explanation for the increased psychiatric comorbidity in ADHD is that emotion dysregulation, which has been linked to both externalising and internalising problems (Aldao, Gee, Los Reyes, & Seager, 2016), is particularly common in ADHD (Barkley, 2015; England-Mason, 2020; Graziano & Garcia, 2016). The fact that problems with emotion regulation have been closely linked to both ADHD and reactive aggression may also explain the close relation

of ADHD with reactive aggression (Bennett, Pitale, Vora, & Rheingold, 2004; Card & Little, 2006; Dodge, Lochman, Harnish, Bates, & Pettit, 1997; King & Waschbusch, 2010).

Moreover, the fact that reactive aggression has also been associated with deficits in executive functions (Rathert et al., 2011; Thomson & Centifanti, 2018), frequent impairments in attention, working memory, inhibition and planning in ADHD (Craig et al., 2016; Otterman et al., 2019; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) may place this group at an increased risk for reactive aggression, which in turn predicts psychosocial maladjustment (Saylor & Amann, 2016). While psychostimulant medications, commonly used to treat ADHD symptoms, improved overt and covert aggression in ADHD (Connor, Glatt, Lopez, Jackson, & Melloni, 2002), it is still unclear whether they can improve reactive aggression specifically and whether they can achieve long-term improvements (King & Waschbusch, 2010).

As outlined next, ASD represents another type of neurodevelopmental disorder that is frequently comorbid with ADHD and that shares deficits in emotion dysregulation and executive function with ADHD (England-Mason, 2020; Otterman et al., 2019), which may similarly place this group at an increased risk for reactive aggression.

Autism spectrum disorder (ASD)

Individuals with ASD are characterised by repetitive or stereotyped behaviours, restricted or fixated interests and inflexible routines, and have difficulties initiating or sustaining social interactions and relationships, and problems using verbal and nonverbal communication (APA, 2013). Individuals that would previously have been diagnosed with Asperger's disorder are now specified as having ASD without intellectual or language impairments in the DSM-5. Childhood prevalence estimates for ASD ranged from 0.6% to 3.5% in the UK and from 0.5% to 2.5% in the US (Cleaton & Kirby, 2018). The estimate of the male-to-female ratio of ASD in children was systematically calculated to be 3:1 (Loomes, Hull, & Mandy, 2017).

Around 28% of children with ASD were reported to have comorbid diagnoses of social anxiety, ADHD or oppositional defiant disorder. Individuals with ASD show a high prevalence of aggression (Kanne & Mazurek, 2011; Matson & Rivet, 2008), which may be higher in this group than in TD individuals (for a review, see Fitzpatrick et al., 2016). There is some evidence to suggest that aggression in ASD is more likely to be reactive than proactive (Bronsard, Botbol, & Tordjman, 2010; Farmer et al., 2015).

While individuals with ASD may share certain risk factors for reactive aggression with ADHD, namely problems with emotion regulation and executive functions (Craig et al., 2016; England-Mason, 2020), another possible risk factor for reactive aggression that is particularly pronounced in ASD relates to impairments in ToM (Mikami, Miller, & Lerner, 2019). Since ToM deficits have also been linked to social anxiety (Banerjee & Henderson, 2001; Colonnesi, Nikolić, Vente, & Bögels, 2017), comparatively more severe problems with ToM in ASD may similarly put this group at a particularly high risk of developing social anxiety, even relative to other types of neurodevelopmental disorders, like ADHD (Mikami et al., 2019; van Steensel, Bögels, & Bruin, 2013).

While evidence for deficits in affective empathy in ASD is less consistent (Chester & Langdon, 2016), both cognitive and affective empathy have been linked to conduct problems and reactive aggression in CYP with ASD (Carter Leno et al., 2021; Pouw, Rieffe, Oosterveld, Huskens, & Stockmann, 2013). A function linked to perspective-taking and empathy is the ability to recognise emotions, which is frequently impaired in individuals with ASD, with some indication that this deficit may be specific to negative emotions (Ashwin, Chapman, Colle, & Baron-Cohen, 2006; Shanok, Jones, & Lucas, 2019).

Intellectual disability (ID)

The DSM-5 diagnosis ID is applied when individuals show deficits in intellectual and adaptive functioning that started during the developmental period (APA, 2013). Intellectual functioning deficits include impaired problem-solving, reasoning, planning and learning, while adaptive functioning deficits refer to limitations in the ability to live independently, communicate and participate in social life (APA, 2013). The DSM-5 categorises the severity of ID as mild, moderate, severe or profound, based on the level of adaptive functioning deficit rather than based on IQ.

Prevalence of ID ranges from 1.14 to 3.6% (Cleaton & Kirby, 2018). Children with ID were more likely to be diagnosed with conduct disorder, anxiety disorder, ASD and ADHD than those without ID (Emerson, 2003). Externalising problems and aggression are more prevalent and more persistent in CYP with ID than in CYP of average intelligence (Dekker et al., 2002; Douma, Dekker, Ruiter, Tick, & Koot, 2007; Emerson, Einfeld, & Stancliffe, 2011), with a three to four times higher risk of behaviour problems in children with developmental delays relative to TD children (Baker, Blacher, Crnic, & Edelbrock, 2002). When ASD co-occurs in

ID, which is the case in 10-28% of CYP with ID (Cleaton & Kirby, 2018), this may increase the risk of aggression in ID (Totsika, Hastings, Emerson, Lancaster, & Berridge, 2011).

Impairments in executive functions and emotion regulation may also occur in CYP with ID (England-Mason, 2020; van der Molen et al., 2007) and have been associated with externalising problems in ID (Schuiringa, van Nieuwenhuijzen, Orobio de Castro, & Matthys, 2017; van Nieuwenhuijzen, Orobio de Castro, Wijnroks, Vermeer, & Matthys, 2009; Visser, Berger, van Schrojenstein Lantman-De Valk, Prins, & Teunisse, 2015). For instance, lower levels of working memory were found in children who had externalising behaviour problems and either mild ID, defined by these authors as having an IQ between 55 and 70, or borderline intelligence (IQ 71-85), compared to children with mild to borderline ID that had no externalising problems (Schuiringa, van Nieuwenhuijzen, Orobio de Castro, & Matthys, 2017). Authors pointed out that this difference emerged even after controlling for low IQ, which is a factor that likely puts individuals at risk for aggression (Huesmann, Eron, & Yarmel, 1987; Hyde, Shaw, & Moilanen, 2010), and interpreted this as suggesting that working memory may represent an independent risk factor for externalising problems (Schuiringa et al., 2017).

Specific learning disorder (SLD)

SLD refers to learning difficulties that are specific, namely that do not represent more general learning difficulties attributable to low intellectual functioning or to vision, hearing, motor or neurological disorders, but that are limited to one academic domain (APA, 2013). Accordingly, SLD either manifest as impairments in reading (i.e. dyslexia), in written expression, or in mathematics (i.e. dyscalculia), begin at school age and occur despite normal or above-average levels of intellectual functioning (APA, 2003).

Cleaton and Kirby (2018) estimated the childhood prevalence of dyslexia to range between 2% and 6% in the UK and between 8% and 12% in the USA. Prevalence rates of dyscalculia range from 3% to 6% (Castaldi, Piazza, & Iuculano, 2020). Dyslexia and dyscalculia co-occur in 28% to 64% of cases (Willcutt et al., 2010), are comorbid with ADHD in 31% to 45% of cases (DuPaul, Gormley, & Laracy, 2013) and have been linked to impairments in working memory (Peng & Fuchs, 2016).

Evidence for increased levels of aggression and externalising disorders in SLD has been inconsistent (Cornwall & Bawden, 1992). Dyslexia has frequently been linked to higher rates of conduct disorder, but this link might be explained by symptoms of inattention resulting from the high comorbidity of reading disabilities with ADHD (Carroll, Maughan, Goodman, &

Meltzer, 2005; McGee, Prior, Willams, Smart, & Sanson, 2002; Willcutt & Pennington, 2000). Levels of anxiety were reported to be higher in those with SLD than those without SLD (Nelson & Harwood, 2011; A. M. Wilson, Deri Armstrong, Furrie, & Walcot, 2009).

Motor disorders

One type of motor disorder is developmental coordination disorder, which involves deficits acquiring and executing coordinated motor skills that interfere with daily life and which was shown to occur in 1.8% of 7 year old children in the UK (APA, 2013; Lingam, Hunt, Golding, Jongmans, & Emond, 2009). Children at risk for developmental coordination disorder were more likely than TD children to show internalising and externalising problems, including aggression (Rodriguez et al., 2019), and children with developmental coordination disorder were more frequently observed to aggress against peers or be victimised by peers than TD children (Kennedy-Behr, Rodger, & Mickan, 2013). Developmental coordination disorder is frequently comorbid with ADHD, SLD or ASD (Dewey, 2018; Dewey, Kaplan, Crawford, & Wilson, 2002) and has been linked to executive function deficits (Biotteau, Albaret, & Chais, 2020; Leonard & Hill, 2015; P. H. Wilson et al., 2017).

Another type of motor disorder is stereotypic movement disorder, which is characterised by repetitive and seemingly random motor behaviours like head banging. Moreover, the motor disorder called tic disorder involves motor movements or vocalisations that are sudden and stereotyped, with a childhood prevalence estimate that was 6% in the UK and that ranged from 2.7% to 18.5% in the USA (APA, 2013; Cleaton & Kirby, 2018). A particular type of tic disorder, namely Tourette's disorder, is characterised by multiple persistent motor and vocal tics that may vary in severity over time (APA, 2013). About half of children with tic disorders have comorbid ADHD (Rothenberger, Roessner, Banaschewski, & Leckman, 2007) and individuals with tic disorders frequently display explosive rage attacks (Conte, Valente, Fioriello, & Cardona, 2020; Kumar, Trescher, & Byler, 2016).

Communication disorders

Communication disorders include language disorder, speech sound disorder and childhood-onset fluency disorder (i.e. stuttering), which involve difficulties acquiring language, problems producing speech sound and disturbed speech fluency and time patterning, respectively (APA, 2013). In addition, social (pragmatic) communication disorder refers to problems adjusting

verbal and nonverbal communication to social context and difficulties understanding nonliteral meaning of language such as metaphors or jokes (APA, 2013).

Stuttering has been associated with anxiety (Iverach et al., 2016; McAllister, Kelman, & Millard, 2015), which may partly be due to this group's frequent experience of being victimised (Blood & Blood, 2007). While stuttering CYP may also be vulnerable to behaviour problems (Briley, O'Brien, & Ellis, 2019), less is known about the subtypes of aggression in this group.

1.3 Neurodevelopmental disorders and special educational needs

Due to frequent difficulties in cognitive, social and academic functioning, CYP with neurodevelopmental disorders are at an increased risk of presenting with special educational needs in the school context (APA, 2013; Nadeau et al., 2020). The special educational needs and disability code of practice (Poulter & Timpson, 2015) used four special needs categories, namely 'cognition and learning', 'social, emotional, and mental health difficulties', 'communication and interaction', and 'sensory and/or physical needs'. While CYP with the neurodevelopmental disorder ID may present with Poulter and Timpson's (2015) special needs category 'cognition and learning', the German special needs system further distinguishes between the categories 'mental development' and 'learning' (Hollenbach-Biele & Klemm, 2020), with the former category more closely corresponding to moderate, severe or profound ID and the latter to mild ID. Since individuals with SLD do not show general impairments in learning (APA, 2013), this group does not match onto the German special needs category 'learning'. The neurodevelopmental disorders communication disorders and motor disorders respectively match onto the special needs categories 'communication' and 'interaction' (German special needs category: 'speech') and 'sensory and/or physical needs' (German category: 'physical or motor development'; Hollenbach-Biele & Klemm, 2020).

Neurodevelopmental disorders may present with needs across all special educational needs areas, although Poulter and Timpson (2015) only explicitly acknowledges this for individuals with ASD, who may, for instance, show special needs relating to 'communication and interaction' (German category: 'speech') and special needs relating to 'social, emotional, and mental health difficulties' (German category: 'emotional and social development').

The right to inclusive education

The UN Convention on the Rights of Persons with Disabilities, which was adopted in 2006 and ratified by almost 200 states, including the EU but not the USA, represents an international,

legally binding document that sets the standards for ensuring that people with disabilities can enjoy "all human rights and fundamental freedoms" without experiencing discrimination based on their disability (United Nations General Assembly, 2006). For instance, member states are required to ensure the right of people with disabilities to the highest standard of health (Article 25) and education (Article 24). As reiterated by Niendorf and Reitz (2020), Germany is one of the many countries that ratified the agreement and that therefore committed itself to ensuring its realisation.

In order for the educational system to be non-discriminatory and based on equal opportunity, it needs to be inclusive, as stated by the Convention (United Nations General Assembly, 2006). This implies that CYP with special needs have the right to be educated alongside their peers in regular schools, as highlighted in the Salamanca statement adopted during the World Conference on Special Needs Education (United Nations Educational, Scientific and Cultural Organization [UNESCO], 1994). Despite their right to equal and inclusive education, millions of people with disabilities still receive education of inferior quality and in isolation from their TD peers, as pointed out by the Committee that monitors the governments' implementation of the Convention (UN Committee on the Rights of Persons with Disabilities, 2016). The Committee also outlined different barriers within society that still hinder the implementation of inclusive education, which points to the need for societies and schools to make adjustments to accommodate the needs of people with disabilities (Niendorf & Reitz, 2020).

Aggression and victimisation in inclusive schools

The implementation of inclusion is further complicated by the scarcity of research relating to the effects of inclusion (UN Committee on the Rights of Persons with Disabilities, 2016). For instance, there is still uncertainty about how inclusion affects the social adjustment of pupils with or without neurodevelopmental disorders or special educational needs. It is unclear whether CYP with neurodevelopmental disorders show more or less aggression when they are educated in inclusive classrooms for pupils with or without special educational needs, compared to when they go to segregated special needs schools. Rose, Espelage and Monda-Amaya (2009) reported lower fighting perpetration and victimisation in pupils educated in inclusive school settings, compared to those in segregated school settings. In contrast, Reiter and Lapidot-Lefler (2007) found that harassment and victimisation occurred equally often in the two settings.

Being unsuccessfully integrated into mainstream classrooms could exacerbate victimisation and perpetuate aggression in children with neurodevelopmental disorders (Rose et al., 2011).

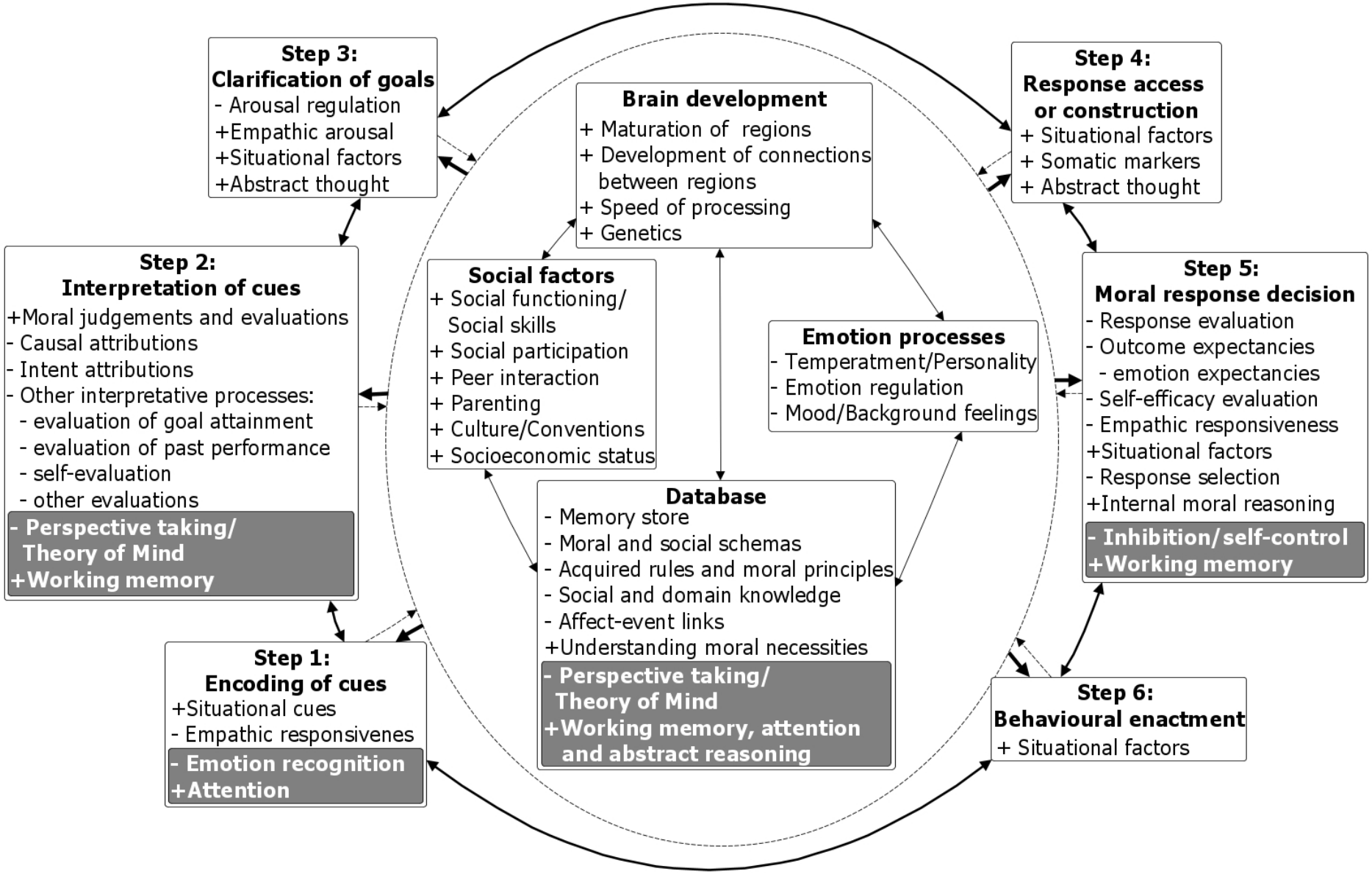
According to Martlew and Hodson (1991), children with special educational needs included in mainstream classroom were bullied more often than those without special needs. Certain characteristics of those with neurodevelopmental disorders, such as difficulties forming friendships and impairments in ToM in ASD, might make them more vulnerable to becoming targets of victimisation (Schroeder et al., 2014). As a reaction to experiences of victimisation, such individuals might themselves become perpetrators of aggression (Nabuzoka, 2003)

According to Article 31 of the UN Convention, member states are required to collect data that facilitate the formulation and implementation of the Convention's policies (United Nations General Assembly, 2006). This points to the necessity of conducting research that informs the realisation of the rights of people with disabilities, including their inclusion in society generally and in education specifically. The current thesis aims to do this by researching ways to understand and improve psychosocial adjustment in CYP with or without neurodevelopmental disorders or special educational needs.

1.4 Aggression and social information processing

Having introduced a number of risk factors for aggression that are particularly pronounced in individuals with neurodevelopmental disorders, such as deficits in cognitive, social-cognitive and social-emotional functions, as well as experiences of victimisation, this section presents a related factor that might help explain increased aggression in neurodevelopmental disorders, namely biases and deficits in the way people process social information. To that extent, this thesis will refer to the social information processing model (Crick & Dodge, 1994). This model proposes that a person's behavioural response to social situations depends on the type of information that is encoded by the person (step 1), how they interpret this information (step 2), which situational goal they select (step 3), the responses they construct (step 4), and how these responses are evaluated (step 5) and enacted upon (step 6, Crick & Dodge, 1994). As presented in Figure 1 (Garrigan, Adlam, & Langdon, 2018), the social information processing model can be integrated with theories about moral development in order to understand the different factors that influence decision-making. According to this integrated model, the six social information processing steps are influenced by the development of cognitive functions like working memory and social-cognitive functions like ToM, which I highlighted in white writing in Figure 1. By taking into account such developmental factors, this model may help us understand decision-making in individuals with developmental deficits, such as those with neurodevelopmental disorders (Chester & Langdon, 2016; Garrigan et al., 2018; Sadek, Daniel, & Langdon, 2021).

Figure 1. The Social Information Processing-Moral Decision-Making Framework (SIP-MDM), reprinted here with the original authors' permission



As illustrated by the factors presented at the centre of Figure 1, the different social information processing steps not only depend on biological factors, like brain maturation, but also on social factors, like parenting, on emotion processes, like arousal regulation, and on the so-called database that stores an individual's knowledge, memories and core beliefs (i.e. "schemas", Crick & Dodge, 1994).

Different types of assessment exist that can measure the different social information processing steps. For instance, vignette-based interviews like the Home Interview with Child (Conduct Problems Prevention Research Group, 1991) present people with vignettes and ask them questions relating to their hostile intent attribution and solution generation. To give another example of a measure, the web-based self-administered *Social Information Processing Application (SIP-AP)* by Kupersmidt, Stelter and Dodge (2011) presents video vignettes from a first-person perspective, followed by questions assessing how participants process vignettes.

The following scenario is an example of a hypothetical vignette used in the assessment of social information processing. It was developed by Dodge (1986), adapted for use in CYP with SLD by Tur-Kaspa and Bryan (1994) and by Bauminger, Edelsztein and Morash (2005):

> One free period Dan has nothing to do. He walks outside and sees two of his peers playing a game. Dan really wants to play with them. He walks up to them but they just keep on playing. (p. 48)

In this so-called 'peer entry' vignette, the event's outcome is undesirable for the protagonist, as he does not get to join his peers' game, but the other children's intentions are ambiguous as the available information does not make it clear whether they deliberately ignored him or merely did not notice him. Social information processing studies commonly ask participants to imagine that such a scenario happens to them, followed by open or forced-choice questions that assess the different processing steps, as outlined next.

Step 1: Encoding

One way to assess how people encode social information is to ask them to recall what they can remember about social scenarios like the peer-entry vignette above (Bauminger et al., 2005; Tur-Kaspa & Bryan, 1994). The type and amount of information that a person recalls may depend on their ability to focus attention on relevant social cues and to recognise emotions (Figure 1, Garrigan et al., 2018). For instance, when people with deficits in attention or emotion recognition process a non-hostile vignette, in which the protagonist's building blocks are

knocked over by another boy opening the door with a surprised facial expression (Leffert, Siperstein, & Widaman, 2010), they may encode the salient negative outcome cues relating to the knocked over building blocks, but fail to attend or identify more subtle social cues like the boy's surprised facial expression (Andrade et al., 2012).

This is important, as aggression has been associated with deficits in encoding. For instance, boys with oppositional defiant disorder or conduct disorder, with or without ADHD, recalled a smaller number of cues than TD boys (Matthys, Cuperus, & van Engeland, 1999). Findings also indicate that encoding deficits may be more characteristic of reactive aggression than of proactive aggression, as reactively aggressive children recalled fewer relevant social cues than TD children and compared to CYP high in proactive aggression (Dodge et al., 1997). While there is some indication that aggressive individuals may be more likely to recall hostile pieces of information than nonaggressive individuals (Dodge & Newman, 1981), preferential retrieval of negative information has been more commonly linked to depression (Marchetti et al., 2018), though less consistently in youth (Platt, Waters, Schulte-Koerne, Engelmann, & Salemink, 2017).

When people show deficits in the recall of relevant social cues, as described in relation to aggressive individuals above, this does not necessarily imply that they have failed to attend to them, as they may have attended to them but failed to adequately encode or remember them (Horsley, Orobio de Castro, & van der Schoot, 2010; Milich & Dodge, 1984). In contrast, a more direct way to measure attention to social information is to assess reaction times, such as by comparing how fast people react to hostile information, compared to non-hostile information (Gouze, 1987; Schippell, Vasey, Cravens-Brown, & Bretveld, 2003). For instance, Gouze (1987) reported that aggressive children were slower to shut off a light when simultaneously viewing an aggressive interaction than when they viewed a nonaggressive interaction.

However, such a finding of apparent difficulties directing attention away from threat in aggression (Gouze, 1987) was not confirmed by later studies. Using the so-called dot probe task, Schippell et al. (2003) found that reactively aggressive children, but not proactively aggressive children, took longer to press a button when a dot appeared at the location of the computer screen where a threat word had previously been presented, compared to when the dot replaced a neutral word. Since faster response times to dot-probes that replace threat-related cues indicate attention bias towards threat (MacLeod, Mathews, & Tata, 1986), such a finding of delayed response to threatening information in reactively aggressive children may be interpreted as a bias away from threat (Schippell et al., 2003). This is in contrast to findings of

studies on attention bias anxiety in both adults and CYP, which have provided evidence for associations between anxiety and increased attention to threatening stimuli (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Dudeney, Sharpe, & Hunt, 2015).

Evidence that aggression may not be characterised by hypervigilance towards hostile information, but instead by preferential attention to non-hostile information was provided by studies assessing attention via eye-tracking (Horsley et al., 2010; Troop-Gordon, Gordon, Vogel-Ciernia, Ewing Lee, & Visconti, 2018; Wilkowski, Robinson, Gordon, & Troop-Gordon, 2007). For instance, aggressive children in Horsley et al. (2010) spent more time looking at non-hostile cues than controls, as measured by tracking eye movements to social cues in ambiguous provocation situations. However, such increased attention to non-hostile cues did not enhance aggressive children's memory for such cues, as their subsequent recall of non-hostile cues was not higher, but in fact marginally lower than that of controls (Horsley et al., 2010). Authors theorised that aggressive children have a "hostile schema" which causes them to quickly interpret ambiguous provocations as hostile and then to selectively attend to non-hostile cues that do not match their hostile interpretation (Horsley et al., 2010). Such a proposal is in line with Schippell et al.'s finding (2003) that the attention bias away from threat in reactively aggressive children was associated with a tendency to interpret ambiguous situations as hostile. Therefore, as indicated by the cyclical nature of the social information processing model (see Figure 1), the different processing steps are linked and likely influence each other.

Step 2: Interpretation

The interpretation step involves making attributions about why a particular event occurred or why one's goals were achieved or not achieved, about whether other people acted with hostile or non-hostile intent and about how to evaluate the self and others, in light of previous experiences with such events or social partners (Crick & Dodge, 1994).

Hostile intent attributions

Intent attribution is frequently measured by asking participants to explain the event, to state whether the social interaction partners were "being mean" (i.e. hostile) or "not mean" (i.e. non-hostile; Leffert, Siperstein, & Millikan, 2000), to rate their agreement of possible interpretations, or to choose one of multiple interpretations. The tendency to interpret other people's behaviours as deliberate and hostile, rather than unintentional and non-hostile, is

referred to as hostile attribution of intent (HAI; Orobio de Castro, Veerman, Koops, Bosch, & Monshouwer, 2002).

Some social information processing studies have defined HAI as hostile attribution of intent to other people when their intent is ambiguous (Dodge, 1980, 2006), such as in the peer game example in which it is unclear whether the peers deliberately ignore the protagonist or are merely distracted by the game. When being asked "why the two peers keep on playing without inviting Dan to join them?" (Tur-Kaspa, 2004, p.11), people would show HAI if they explained the event by saying that the peers did not want to play with Dan or that they were being mean.

Other studies define and operationalise HAI not only as hostile intent attribution in ambiguous situations, but also as hostile intent attribution in clearly hostile or in clearly non-hostile situations (Orobio de Castro et al., 2002; Verhoef et al., 2019; Waldman, 1996). For instance, the peers' intent in the game vignette would have been clearly hostile if they had explicitly rejected Dan (e.g. "we don't want you here", Carothers & Taylor, 2004) and would have been clearly non-hostile if they had given a neutral reason for not letting Dan join in, such as that he needed to wait for them to "finish this round" (Orobio de Castro & van Dijk, 2018).

A recent meta-analysis of 111 studies, assessing the link between HAI and aggression, operationalised HAI as (i) the attribution of hostile intent to peers' behaviors in social situations where another person's intentions are ambiguous, or (ii) as the attribution of hostile intent in a mixture of situations, with some reflecting ambiguous intent and some reflecting hostile or benign intent (Verhoef et al., 2019). Authors demonstrated that the association between HAI and aggression was positive and modest (mean effect size d = 0.33) and stronger when participants were severely aggressive (Verhoef et al., 2019).

There is some evidence to suggest that HAI may be more characteristic of reactive aggression than of proactive aggression. Martinelli et al. (2018) identified twelve studies that assessed the relation of HAI with reactive aggression and with proactive aggression, including five studies that controlled for aggression subtype in their analyses, which indicated that HAI was more strongly related to reactive aggression. The fact that Verhoef et al.'s (2019) meta-analysis did not find a stronger association with reactive aggression in particular, might have been because the effect size relating to reactive aggression was not compared to that of proactive aggression, but to a general construct of aggression that may have included reactive participants (Verhoef et al., 2019).

Moreover, HAI in ambiguous scenarios was predicted by participants' expectation that other people will hurt them, humiliate them or take advantage of them, which represents a so-called cognitive 'schema' relating to mistrust and abuse (Calvete & Orue, 2010, 2012). Cognitive schemas are regarded as core beliefs or memory structures that are shaped by life experiences and that guide a person's perception of themselves and others (Crick & Dodge, 1994; John E. Lochman & Wells, 2002; Young, Klosko, & Weishaar, 2003). Hostile schemata like the mistrust schema may be the result of previous experiences of victimisation or abuse and may mean that people's processing of potentially non-hostile new situations will be consistent with their expectation that other people are generally hostile (Crick & Dodge, 1994). The mistrust schema predicted HAI in ambiguous scenarios six months later (Calvete & Orue, 2012) and was associated with reactive aggression, but not proactive aggression (Calvete & Orue, 2010).

While HAI has primarily been studied in the context of aggression, particularly reactive aggression (Martinelli et al., 2018), it has also been linked to internalising disorders (Quiggle, Garber, Panak, & Dodge, 1992; Reid, Salmon, & Lovibond, 2006; Schepman, Fombonne, Collishaw, & Taylor, 2014; Smith, Summers, Dillon, Macatee, & Cougle, 2016). For instance, Quiggle et al. (1992) reported that both the depressed group and the aggressive group were characterised by hostile intent attributions. It has been suggested that negative information processing biases like HAI are pervasive across aggression, depression and anxiety (Reid et al., 2006). As outlined next, externalising and internalising disorders may be better distinguished in terms of another form of interpretation bias, namely attribution of causality.

Attributions of causality

Individuals may differ in terms of their causal attributions for events, namely whether they perceive the so-called 'locus' of the event's cause to be internal (e.g. self-blame) or external (e.g. other-blame) and whether they perceive the cause to be enduring over time (i.e. stable), constant across situations (i.e. global) and "subject to volitional influence" (i.e. controllable; (Abramson, Seligman, & Teasdale, 1978; Anderson, Miller, Riger, Dill, & Sedikides, 1994). For instance, while children with depression resembled those with aggression in their attribution of hostile intent, only those with depression were characterised by a tendency to attribute negative outcomes to internal, stable, and global causes, rather than external, unstable, and specific causes (Alloy, Peterson, Abramson, & Seligman, 1984; Quiggle et al., 1992).

An example of an internal, stable and global cause is one's own character since it represents an internal rather than external feature and because it generally persists over time and across

situations (Abramson et al., 1978). The tendency to blame one's own character for events with undesirable outcomes or for victimisation (e.g. "If I were a cooler kid, I wouldn't get picked on"; Graham & Juvonen, 1998) represents an attribution bias called characterological self-blame (CSB; Janoff-Bulman, 1979), which has been distinguished from the more controllable form of internal attribution called behavioural self-blame (e.g. "I should have been more careful"; Graham & Juvonen, 1998).

In contrast, research on the role of causal attributions in aggression has been rare and inconclusive (Crick & Dodge, 1994), as studies assessing interpretation bias in aggression have focused on whether other people's behaviour in a specific situation is interpreted as mean, not whether they blame their own or other people's characters. While Graham and Juvonen (1998) focused on characterological and behavioural self-blame and reported associations between victimisation and CSB, loneliness, anxiety and low self-worth, authors additionally assessed "external" attributions like "these kinds of kids pick on everybody". Since this item appears to convey attribution of blame to characteristics about other people that generally persist across time and situations, a suitable label for such an external, stable and global attribution may have been characterological other-blame (COB). However, while a term exists to signify attributions of blame to one's own character, namely CSB, to the best of my knowledge no analogous term has been used to signify attributions of blame to another person's character. Therefore, the term COB will be used in this thesis to represent hostile attribution of character which is here defined as the tendency to attribute hostility not only to another person's intent, but to their personality. This thesis is interested in the role of COB in aggression.

Problems with the interpretation step are more likely when people have difficulties with ToM or working memory and if problems occurred during encoding (Crick & Dodge, 1994; Garrigan et al., 2018; Figure 1). In line with the combined cognitive bias hypothesis of psychopathology, encoding and interpretation biases influence each other and are more likely to increase the risk of externalising or internalising problems if they occur in combination than if they occur in isolation (Everaert, Koster, & Derakshan, 2012; Hirsch, Clark, & Mathews, 2006).

ToM and recognition or interpretation of facial expressions

If someone has only encoded salient negative outcome cues and not more subtle ambiguous or accidental intent cues during step 1 of social information processing, perhaps as the result of deficits in attention or emotion recognition, then the interpretation of a situation will be based on incomplete or primarily negative information, which may increase the risk of HAI (Andrade

et al., 2012; Choe, Lane, Grabell, & Olson, 2013). In line with this reasoning, Choe et al. (2013) found that good emotion understanding predicted lower HAI.

The interpretation of social interactions is not only influenced by deficits in the recognition of unambiguous facial expressions, but also by biases in the interpretation of ambiguous faces (Garrigan et al., 2018). Judging other people's ambiguous facial expressions to be hostile or angry is known as hostile interpretation of faces and has been linked to aggression, irritability and conduct problems (Mellentin, Dervisevic, Stenager, Pilegaard, & Kirk, 2015; Penton-Voak, Munafò, & Looi, 2017; Stoddard et al., 2016).

Executive functions

Even if people attend and recognise relevant social cues or show no biases in their interpretation of facial expressions, problems with working memory may cause problems integrating different social cues into one's overall interpretation of a situation. Hostile interpretations may be less likely to occur when someone has intact working memory. Working memory is needed to integrate social cues of differing valence which produce a high computational load, such as in situations with an undesirable outcome but accidental or ambiguous intent (Baddeley, 2000; Klingberg, 2010; van Rest et al., 2020).

Working memory is related to general intelligence which represents a risk factor for both HAI and aggression (Huesmann et al., 1987; Hyde et al., 2010). The fact that the effect sizes for the association between HAI and aggression were smaller when controlling for intelligence, indicates that low levels of intelligence may be an independent cause of HAI and aggression (Orobio de Castro et al., 2002).

The attribution of hostile intent in accidental or ambiguous scenarios is less likely when someone is able to take into account other people's perspective using ToM in order to envision, for instance, that the peers playing merely did not notice Dan. In line with this, Choe et al. (2013) showed that children aged 5 to 6 years old were less likely to show hostile interpretations of ambiguous social scenarios if they had demonstrated good ToM at the age of 3.5 years.

Moreover, Choe et al.'s (2013) finding that the relation between ToM and HAI was moderated by effortful control, which involves the ability to inhibit a dominant response, points to the potential influence of inhibition and self-regulation on HAI. According to Rosset (2008) and Orobio de Castro's developmental approach to aggression (2004), people may have an automatic impulse to interpret other people's actions as intentional and therefore need to

develop inhibitory control so that they can override this automatic attribution of intentionality when actual intent is accidental or ambiguous. Therefore, although not explicitly mentioned in Garrigan et al.'s model (2018) as a factor playing a role in the interpretation step of social information processing, problems with inhibition likely influence this processing step and may increase the risk of HAI.

Step 3. Goal clarification

The social information processing model proposes that during the third processing step, people clarify and select their goals or desired outcomes in a given situation (Crick & Dodge, 1994). When asked to imagine the example vignette in which Dan does not get asked by his peers to join in the game, a person's goal would be assessed by posing the following question: "If you were in the same situation as Dan, what would you like to have happen?" (Bauminger et al., 2005). In this situation, a negative or aggressive goal would be to get the ball for himself, while a positive goal would be to get invited to play. The likelihood of formulating a positive goal is higher if people assume that they just have to wait their turn in the game and if they can regulate their emotions, while the ability to think of new goals may require abstract thinking (Garrigan et al., 2018). In contrast, the risk of selecting the negative goal in Dan's example vignette would be higher if people make the hostile attribution that the peers deliberately exclude Dan, if they have problems regulating the feelings of anger that this interpretation may cause and if they lack empathy for how an aggressive response would affect others (Garrigan et al., 2018; Lemerise & Arsenio, 2000; Orobio de Castro & van Dijk, 2018).

Even though the role of goal clarification in aggression has received relatively little attention when compared to the other social information processing steps, there is some evidence to suggest that CYP high in proactive aggression are characterised by selecting instrumental goals, such as getting what they want (e.g. the ball), rather than selecting goals that enhance relationships (e.g. being liked, Crick & Dodge, 1996), which is in line with view of proactive aggression as instrumental (Dodge & Coie, 1987). While proactive aggression is linked to the motivation to achieve a self-serving goal, CYP high in reactive aggression are more likely to be motivated by their emotions of anger (Orobio de Castro, Verhulp, & Runions, 2012).

Step 4. Response generation

During step 4 of social information processing, a person generates a behavioural response to the situation, which may be accessed from memory or newly constructed using abstract thought

and is likely influenced by the person's interpretation, emotion and goal in a given situation (Crick & Dodge, 1994). Response generation may be measured by asking how one could respond to a situation, such as the one where Dan does not get asked to join in the game: "Tell me the different ways you can think of that Dan could deal with the situation" (Tur-Kaspa, 2004). An example of an aggressive response in this situation would be to grab the peers' ball, whereas waiting for one's turn to play or asking politely to join in would represent a competent or assertive response (Orobio de Castro & van Dijk, 2018). Alternatively, someone may respond by appealing to a third party or authority figure such as a teacher or parent, or by escaping the situation (Tur-Kaspa, 2004).

Compared to controls, boys with oppositional defiant or conduct disorder generated more aggressive responses and fewer assertive responses, and showed a smaller response repertoire (Matthys et al., 1999). While aggressive children were characterised by the generation of aggressive responses, depressed children were characterised by unassertive responses and anxious children by avoidant responses (Barrett, Rapee, Dadds, & Ryan, 1996; Crick & Dodge, 1994; Matthys et al., 1999; Schepman et al., 2014).

Step 5: Response decision

During the response decision step of the social information processing model, people evaluate the different behavioural responses to the situation in terms of whether they are good solutions, what kind of outcomes they would produce, whether they would feel confident enacting the response and whether they would select them (Crick & Dodge, 1994).

Response evaluation may be measured by presenting someone with different possible responses to social scenarios, such as the aggressive response to just grab the ball in the game example (Bauminger et al., 2005), and asking a person to rate how good they perceived the response to be or how good they would feel if they tried this response, ranging from very bad to very good (Dodge et al., 1997). Moreover, self-efficacy may be measured by asking a person how hard they would find it to carry out this response (Crick & Dodge, 1996), and response selection can be assessed by asking a person to choose one of the solutions that they themselves spontaneously generated in step 3 or that are presented to them (Tur-Kaspa, 2004).

Dodge et al. (1997) showed that children characterised by reactive aggression were significantly more likely than non-aggressive children to evaluate aggressive responses positively and as not hard to carry out. Moreover, when compared to those in the reactive aggression group, those in the proactive aggression group were more confident that an aggressive response would reduce

aversive treatment from others (Dodge et al., 1997). The finding that proactive aggression, not reactive aggression, is specifically characterised by the expectation that aggressive responses have positive outcomes, such as feeling good, was confirmed by Smithmeyer, Hubbard and Simons (2000) and by Arsenio, Adams and Gold (2009).

While aggression has been associated with an increased self-efficacy for aggressive responses and increased selection of aggressive responses (Matthys et al., 1999; Perry, Perry, & Rasmussen, 1986; Quiggle et al., 1992), depression may be linked to decreased self-efficacy for assertive responses and decreased expectation that assertive can have positive outcomes (Quiggle et al., 1992).

According to Garrigan et al.'s (2018) model, the response decision step is influenced by working memory and inhibition, since it requires a person to keep multiple responses in mind and to inhibit socially unacceptable responses (Klingberg, 2010; van Rest et al., 2019). Moreover, lower levels of ToM or empathic responsiveness may cause someone to have difficulties understanding how aggression might affect others, thus making it more likely that aggressive responses are evaluated positively (Chester & Langdon, 2016).

Step 6: Behavioural enactment

At the final step of social information processing (step 6), people carry out the behavioural response they have selected. While this step is rarely assessed in social information processing studies, a way to measure the competency of enacting responses is to ask a person to role-play a particular solution, such as asking a participant to act out how they would nicely ask their peers if they could join their game (Bauminger & Kimhi-Kind, 2008).

Social information processing training

As pointed out by Li, Fraser and Wilke (2013), the *Making Choices* program (Fraser, Nash, Galinsky, & Darwin, 2001) is a rare example of a school-based intervention that is clearly based on the social information processing model. It targets the different social information processing steps and, as indicated by five studies assessing its effectiveness, it successfully reduced pupils' aggression (for a review see Merrill, Smith, Cumming and Daunic (2017) or Leff, Waasdorf and Crick (2010). Moreover, Terzian, Li, Fraser, Day and Rose (2015) showed that the *Making Choices* program reduced hostile attributions and improved response decision in boys and girls, when compared to a control group, while training-related improvements of goal formulation and overt aggression were limited to boys. Another well-known program

based on the social information processing model is the *Fast track* training (Dodge & Godwin, 2013), which includes both child and parent training components. Dodge and Godwin (2013) reported that the effect of the training on antisocial behaviour of kindergarten children was mediated by the training's impact on hostile attribution, competent response generation and aggressive response evaluation.

1.5 Aggression and social information processing in neurodevelopmental disorders

Social information processing has also been assessed in CYP with neurodevelopmental disorders, namely in ADHD, ID, ASD and SLD, most frequently using interviews about vignettes that are either presented as text, pictures, or videos (Bauminger et al., 2005; van Nieuwenhuijzen, Vriens, Scheepmaker, Smit, & Porton, 2011; van Rest et al., 2014). Russo-Ponsaran et al. (2018) used a virtual environment to assess the different social information processing steps in CYP with ASD. An overview of differences in each processing step between TD CYP and those with neurodevelopmental disorders is provided next.

Encoding in neurodevelopmental disorders

In the context of social information processing and aggression, encoding processes of CYP with neurodevelopmental disorders has primarily been assessed in terms of memory recall. An overview of the evidence for differences between TD CYP and CYP with neurodevelopmental disorders in recall is presented below.

Given that attention, emotion recognition and empathic responding are linked to problems with the encoding step of processing (Figure 1, Garrigan et al., 2018), we might expect individuals with neurodevelopmental disorders to have problems with this step because these functions are frequently impaired in neurodevelopmental disorders. For instance, since a deficit in attention is a core feature of ADHD, a disorder characterised by attentional difficulties, hyperactivity and impulsivity, we may expect problems with encoding in CYP with ADHD. This prediction is also based on the finding that boys categorised as hyperactive and aggressive in a sample of boys with ADHD, conduct disorder or another psychiatric diagnosis, encoded less information about vignettes and recalled fewer neutral cues than TD boys (Milich & Dodge, 1984).

In line with the prediction of increased encoding difficulties in ADHD, the only two studies that have assessed encoding in ADHD, showed that those with ADHD showed a general deficit in encoding social cues, regardless of the valence of social cues (Table 1). Compared to TD controls, a smaller number of social cues were encoded by boys with ADHD, by boys that had

oppositional defiant disorder or conduct disorder and by boys that had both ADHD and oppositional defiant disorder or conduct disorder (Matthys et al., 1999).

Table 1. Encoding of neutral, positive or total cues in NDD, compared to TD controls

Encoding	No group difference	Lower in NDD
Neutral cues		- ADHD < TD (Andrade et al., 2012) - ID < TD (Leffert et al., 2000) - ASD < TD (Carothers & Taylor, 2004)
Positive cues		- ADHD < TD (Andrade et al., 2012)
Total cues	- ID = TD (Embregts & van Nieuwenhuijzen, 2009) - SLD = TD (Bauminger-Zviely et al., 2019**; Tur-Kaspa, 2004)	- ADHD < TD (Andrade et al., 2012; Matthys et al., 1999) - ADHD (with ODD/CD) < TD (Andrade et al., 2012; Matthys et al., 1999) - ASD < TD (Bauminger-Zviely et al., 2019; Mazza et al., 2017; Ziv, Hadad, Khateeb, & Terkel-Dawer, 2014) - ID < TD (van Rest et al., 2020) - SLD < TD (Bauminger et al., 2005; Bauminger & Kimhi-Kind, 2008; Bauminger-Zviely et al., 2019*; Tur-Kaspa & Bryan, 1994)

Note. NDD, neurodevelopmental disorders; ODD, oppositional defiant disorder; CD, conduct disorder

* for vignette depicting peer entry

**for vignette depicting peer provocation

Based on the few studies assessing encoding in ID, this group may have problems encoding relevant and factual information about vignettes, while findings relating to the encoding of neutral and negative cues, and of the total number of cues, were mixed (Tables 1-2). In a study that only consisted of participants who had mild ID or borderline intellectual functioning, in addition to severe behaviour problems, difficulties describing what happened in video vignettes were related to externalising behaviour (van Nieuwenhuijzen, Orobio de Castro, van Aken, & Matthys, 2009).

Given that emotion recognition likely increases problems with the encoding step of social information processing (Garrigan et al., 2018; Figure 1) and given that problems recognising visually or auditorily expressed emotions were linked to encoding of erroneous or irrelevant information in AS (Meyer, Mundy, van Hecke, & Durocher, 2006), we may expect this step to be particularly affected in CYP with ASD who frequently show emotion recognition problems

(Ashwin et al., 2006; Shanok et al., 2019). In line with this, the three studies comparing TD CYP and those with ASD in terms of the total number of cues encoded, found lower encoding scores in ASD (Table 1). Moreover, according to two studies, CYP with ASD encoded more negative and fewer neutral cues (Tables 1-2).

Three studies showed that CYP with SLD encoded fewer social cues in total than TD individuals, one study only reported this group difference for vignettes depicting peer entry, not peer provocation, and one study found kindergarten children with SLD not to differ from TD controls in terms of encoding (Table 1). Two studies reported that those with SLD were more likely than controls to encode irrelevant cues not mentioned in scenarios (Table 2).

Table 2. Encoding of negative or irrelevant cues in NDD, compared to TD controls

Encoding	No group difference	Higher in NDD	Lower in NDD
Negative cues	- ID = TD (Embregts & van Nieuwenhuijzen, 2009)	- ASD (with ID) > TD (Embregts & van Nieuwenhuijzen, 2009) - ID > TD (van Nieuwenhuijzen, Orobio de Castro, Wijnroks, Vermeer, & Matthys, 2004)	- ADHD < TD (Andrade et al., 2012)
Irrelevant cues		- AS > TD (Meyer et al., 2006) - ID (with or without behaviour problems) > TD (van Nieuwenhuijzen et al., 2011) - SLD > TD (Bauminger & Kimhi-Kind, 2008; Tur-Kaspa & Bryan, 1994)	

In summary, most evidence for difficulties in neurodevelopmental disorders with the encoding step of social information processing, when compared to TD individuals, was found for the total number of cues encoded, which was generally lower in ADHD, ASD, ID and SLD than in TD controls.

There was also some indication that CYP with ADHD, ASD or ID encode fewer neutral cues than controls. Since the encoding of a smaller number of relevant and neutral cues represents deficient encoding that has been associated with aggression (Crick & Dodge, 1994), such information processing problems in neurodevelopmental disorders may affect the next social information processing step and increase the risk of aggression in this group.

Interpretation in neurodevelopmental disorders

Hostile attribution of intent

Impairments in executive functions represents a risk factor for aggression and externalising disorders (Morgan & Lilienfeld, 2000), particularly reactive aggression (Ellis et al., 2009; Rathert et al., 2011; Thomson & Centifanti, 2018). Recently, van Rest et al. (2019) showed that the relation between working memory and aggression in CYP with mild ID or borderline intellectual functioning was mediated by hostile interpretations of a mixture of ambiguous and accidental scenarios. This points to the possibility that HAI can explain the link between executive function deficits and aggression in this group (van Rest et al., 2019).

Given that impaired working memory, inhibition and intellectual functioning have been linked to HAI (Meyer et al., 2006; van Nieuwenhuijzen & Vriens, 2012), it is possible that executive function deficits and low IQ increase the risk of HAI, which in turn predisposes individuals to aggression (Hyde et al., 2010). For instance, frequent working memory deficits in neurodevelopmental disorders (Craig et al., 2016; Otterman et al., 2019; Peng & Fuchs, 2016; van der Molen et al., 2007) may make it more likely that this group attributes hostile intent as it may impair their ability to integrate negative outcome cues and ambiguous intent cues (Klingberg, 2010; van Rest et al., 2019).

Moreover, given that lower levels of inhibition predicted higher HAI in ID and ASD (Meyer et al., 2006; van Nieuwenhuijzen & Vriens, 2012) and that inhibition is frequently impaired in neurodevelopmental disorders (Craig et al., 2016; Crisci, Caviola, Cardillo, & Mammarella, 2021), this group may have particular problems inhibiting hostile interpretations which may further increase this group's risk for making hostile intent attributions (Rosset, 2008; van Rest et al., 2019).

Another aspect that may predispose those with neurodevelopmental disorders to HAI is the fact that they frequently show problems with ToM (Mikami et al., 2019; Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998), which may be linked to HAI because it likely causes someone to have problems envisioning that another person's intent may be non-hostile when the outcome is negative (Chester & Langdon, 2016). Moreover, uncertainty about other people's thoughts or intentions as a result of ToM deficits may cause social events to generally appear ambiguous, even if they are clearly non-hostile (Sharma, Woolfson, & Hunter, 2014).

Since low levels of focused attention, working memory and inhibition are common in ID (van der Molen et al., 2007) and were associated with high levels of HAI in CYP with ID (van

Nieuwenhuijzen et al., 2011; van Rest et al., 2019), HAI may be expected to be higher in this group than in controls, especially given increased prevalence of aggression in ID (Dekker et al., 2002). In line with this reasoning, CYP with ID were more likely than controls to interpret neutral intent as hostile in the four studies that assessed HAI for accidental scenarios (Table 3).

Table 3. Hostile intent attributions in NDD, compared to TD controls

Attribution	No group difference	Higher in NDD	Lower in NDD
HAI, when intent = ambiguous	- ADHD = TD (Andrade et al., 2012; Mikami, Hinshaw, Lee, & Mullin, 2008; Sibley, Evans, & Serpell, 2010) - ADHD (medicated) = ADHD (placebo) = TD (King et al., 2009)* - AS = TD (Flood, Julian Hare, & Wallis, 2011) - SLD = TD (Bryan, Sullivan-Burstein, & Mathur, 1998)	- ID > TD (van Nieuwenhuijzen et al., 2011; van Rest et al., 2020) - ID (with behaviour problems) > TD (van Nieuwenhuijzen et al., 2011; van Rest et al., 2020) - SLD > TD (Weiss, 1984)	- ASD < TD (Carothers & Taylor, 2004) - ID < TD (Leffert et al., 2010)*
HAI, when intent = ambiguous or accidental (not reported separately)	- ADHD (with or without ODD/CD) = TD (Matthys et al., 1999) - ASD = TD (Meyer et al., 2006; Russo-Ponsaran et al., 2018) - ID = TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004) - SLD = TD(Bauminger et al., 2005; Bauminger & Kimhi-Kind, 2008; Tur-Kaspa, 2004)	- ASD > TD (Mazza et al., 2017; Ziv et al., 2014)	
HAI, when intent = accidental		- AS > TD (Carothers & Taylor, 2004)* - ID > TD (Gomez & Hazeldine, 1996; Leffert et al., 2000; Leffert et al., 2010; van Rest et al., 2020)	

* one ADHD group received methylphenidate (n=21) and one ADHD group (n=20) placebo

** for a vignette of another person displaying "insincere benign" intent (e.g. insincere apology)

Interpretation accuracy of children with ID was related to preferred social behaviour rated by teachers (Leffert et al., 2010). Such findings for increased HAI in ID and possible links between

HAI and aggression are also in line with findings by Larkin, Jahoda and MacMahon (2013) who reviewed evidence for increased social information processing biases and deficits in aggressive adults with ID. They reported that one study found increased HAI in the aggressive ID group when processing ambiguous vignettes (Pert, Jahoda, & Squire, 1999), while the other two studies found increased HAI in the aggressive ID group for accidental vignettes (Basquill, Nezu, Nezu, & Klein, 2004) or hostile vignettes (Jahoda, 2006).

As shown in Table 3, the two studies assessing HAI separately for ambiguous scenarios found increased HAI in CYP with ID. One study assessed "insincere benign" intent which they defined as hostile but which arguably is ambiguous (Leffert et al., 2010) and found those with ID to be less likely to interpret insincere benign intent as hostile. The two studies comparing TD CYP and those with ID in terms of their combined HAI score for ambiguous and unambiguous scenarios found no group differences.

In light of the close link of ADHD with reactive aggression (Card & Little, 2006) and this group's vulnerability for deficits in executive functions, including problems with working memory, inhibition and focused attention (Craig et al., 2016; Otterman et al., 2019; Willcutt et al., 2005), we may expect to find higher HAI in ADHD than in TD CYP. Moreover, the fact that boys scoring high on hyperactivity and aggression in a sample that consisted 35% of CYP with ADHD, were significantly more likely than TD boys to attribute hostile intent when processing a vignette depicting ambiguous provocation by a peer (Milich & Dodge, 1984), further points to possible increased risk for HAI in ADHD. However, as shown in Table 3, the five studies that have focused on ADHD specifically found no evidence for increased HAI in ADHD, when compared to TD controls.

Moreover, while deficits in executive functions in CYP with SLD (Peng & Fuchs, 2016) may be expected to increase the risk of HAI in this group, the five studies assessing this processing step in this group also did not find higher HAI in this group than in TD controls (Table 3).

Executive function deficits in CYP with ASD, which resemble those of CYP with ADHD (Craig et al., 2016; Otterman et al., 2019), may also predispose individuals with ASD to HAI, especially given links between inhibition and HAI in this group (Meyer et al., 2006). Another risk factor for HAI that occurs in different types of neurodevelopmental disorders but that is particularly pronounced in ASD relates to problems with ToM (Mikami et al., 2019). In contrast to these predictions, the four studies comparing TD CYP and those with ASD in terms of their HAI for a combination of ambiguous and unambiguous scenarios produced mixed results, with

half reporting higher HAI in ASD, and half reporting no group differences (Table 3). The one study that separately reported HAI for accidental and HAI for ambiguous scenarios in ASD found that CYP with Asperger syndrome attribute more hostile intent and to reject more neutral cues in accidental scenarios than TD controls, but that the ASD group attributed comparatively less hostile intent in ambiguous scenarios (Carothers & Taylor, 2004). One study focusing on ambiguous scenarios specifically, did not find higher HAI in Asperger syndrome than in controls (Flood et al., 2011).

In summary, out of the few studies that have so far assessed the interpretation step of social information processing in CYP with neurodevelopmental disorders (Table 3), most evidence for increased HAI was found for the processing of accidental scenarios in CYP with ID, when compared to TD controls.

Goal clarification in neurodevelopmental disorders

If goal clarification is indeed influenced by abstract thinking, emotion regulation and empathic arousal, as suggested by Garrigan and colleague's model (see Figure 1), then we may expect to find problems with this processing step in CYP with neurodevelopmental disorders who frequently have problems with these functions, most consistently with emotion regulation (England-Mason, 2020). However, few studies have assessed goal clarification in this group (Table 4).

For instance, even though emotion dysregulation may predispose CYP with ADHD to problems clarifying prosocial goals, social information processing studies on CYP with ADHD did not focus on this processing step. A study that asked boys with ADHD about their goals for a competitive game they were about to play found that boys with both ADHD and high levels of aggression were more likely to endorse goals related to trouble-making and fun at the cost of breaking rules or at the risk of teasing others (Melnick & Hinshaw, 1996). This study is however not included in Table 4 because it does not involve a social interaction with undesirable outcomes for the protagonist.

When asked about their desired outcome for vignettes conveying ambiguous, hostile or non-hostile interactions, children with ASD in Russo-Ponsaran et al. (2018) were less likely than controls to select prosocial goals (e.g. "work it out") and more likely to select avoidant goals (e.g. "wish it didn't happen") or no goals (Table 4). In the only other study assessing goal clarification in ASD, children with ASD were less likely than TD controls and children with SLD to clarify prosocial goals, but this difference only emerged for vignettes depicting

ambiguous peer provocation, not peer entry (Bauminger-Zviely et al., 2019). Evidence for differences in goal clarification in CYP with SLD, compared to controls, was mixed (Table 4).

Table 4. Goal clarification in NDD, compared to TD controls

Goal type	No group difference	Higher in NDD	Lower in NDD
Negative goals (e.g. retribution)	- ASD = TD (Russo-Ponsaran et al., 2018) - SLD = TD (Bauminger et al., 2005)	- ID (with or without behaviour problems) > TD (van Nieuwenhuijzen et al., 2011) - SLD > TD (Bauminger & Kimhi-Kind, 2008)	
Internal relief	- ID = TD (van Nieuwenhuijzen et al., 2011)	- ID (with behaviour problems) > TD (van Nieuwenhuijzen et al., 2011)	
Avoidant goals		- ASD > TD (Russo-Ponsaran et al., 2018)	
Submissive goals	- ID (with or without behaviour problems) = TD (van Nieuwenhuijzen et al., 2011)		
No goal	- SLD = TD (Tur-Kaspa, 2004)	- ASD > TD (Russo-Ponsaran et al., 2018)	
Total number of goals			- SLD < TD (Bauminger et al., 2005)
Positive/ prosocial goals	- ASD = TD (Bauminger-Zviely et al., 2019)** - SLD = TD (Bauminger et al., 2005; Bauminger-Zviely et al., 2019)		- ASD < TD (Bauminger-Zviely et al., 2019*; Russo-Ponsaran et al., 2018) - ID < TD (van Nieuwenhuijzen et al., 2011) - SLD < TD (Bauminger & Kimhi-Kind, 2008)

* for vignettes depicting peer provocation

** for vignettes depicting peer entry

With regards to the only study assessing this social information processing step in ID, van Nieuwenhuijzen et al. (2011) showed that external positive goals like wanting to make sure that peers "will be my friends again" were stated less often by CYP with mild ID or borderline intellectual functioning or by the clinical group that had mild to borderline ID and behaviour problems, compared to TD CYP.

Moreover, CYP in both ID groups were more likely than TD controls to seek revenge ("they deserve it") when vignettes were presented as videos or ambiguous. In addition, those with mild to borderline ID and behaviour problems were more likely to say that the goal of their behaviour would be for them to feel better (van Nieuwenhuijzen et al., 2011).

Response generation in neurodevelopmental disorders

A number of studies have investigated whether CYP with neurodevelopmental disorders differ from TD CYP in terms of the competence of the responses they spontaneously generate, such as whether their solutions are aggressive (Table 5), submissive or passive (Table 6) or competent (Table 7), and in terms of their response repertoire, namely how many responses they generated in total (Table 7).

As shown in table 5, one study found more aggressive responses in ADHD than in controls and one found this for medicated CYP with ADHD for peer provocation, not peer entry. Moreover, compared to girls without ADHD, girls with ADHD showed an increased tendency to suggest inept responses like aggression or withdrawal that would likely be ineffective in solving the problem or improving the relationship (Mikami et al., 2008).

Evidence for increased aggressive response generation in ID was mixed, with three studies finding those with ID to generate more aggressive responses than TD controls and three studies reporting no group difference (Table 5). The spontaneous generation of aggressive responses to hypothetical vignettes in children with mild ID or borderline intelligence was positively related to their externalising problems van Nieuwenhuijzen et al. (2009), was moderately correlated with their actual response to a staged conflict situation and strongly related to their aggressive behaviours observed by teachers in class (van Nieuwenhuijzen et al., 2005).

No evidence was found for increased aggressive responses in SLD, while only one of three studies found increased aggressive response in ASD (Table 5).

Table 5. Aggressive or incompetent response generation in NDD, compared to TD controls

Response	No group difference	Higher in NDD	Lower in NDD
Aggressive	- ADHD (medicated) = ADHD (placebo) = TD (King et al., 2009)** - ADHD girls = TD girls (Mikami et al., 2008) - ASD = TD (Embregts & van Nieuwenhuijzen, 2009; Meyer et al., 2006) - ID = TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004; van Rest et al., 2020) - SLD = TD (Bauminger & Kimhi-Kind, 2008; Tur-Kaspa, 2004)	- ADHD > TD (Andrade et al., 2012) - ADHD (medicated) > TD (King et al., 2009)* - ASD > TD (Ziv et al., 2014) - ID > TD (Gomez & Hazeldine, 1996; Leffert et al., 2000; van Nieuwenhuijzen et al., 2011) - ID (with behaviour problems) > TD (van Nieuwenhuijzen et al., 2011)	- SLD < TD (Bauminger et al., 2005)
Inept or ineffective	- SLD = TD (Tur-Kaspa, 2004)	- ADHD girls > TD girls (Mikami et al., 2008)	- SLD < TD (Bauminger et al., 2005; Bauminger & Kimhi-Kind, 2008)

*for vignette depicting peer provocation

**for vignette depicting peer entry

As shown in Table 6, CYP with ASD were characterised by passive-avoidant responses such as doing nothing or withdrawing from the situation. In contrast, those with SLD were not more avoidant than controls and not more likely to appeal to a third person. Moreover, there was some indication that those with ID are more likely than controls to appeal to authority or a third person and to generate submissive responses.

Most evidence for a deficit in generating competent responses in neurodevelopmental disorders was found in CYP with ASD or ID (table 7). Moreover, while van Nieuwenhuijzen et al. (2004) reported a greater response repertoire in ID compared to controls, and theorised that this might be due to a lack of inhibition, they later found the response repertoire in children with mild ID or borderline intellectual functioning to be smaller than or equal to that of TD controls (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2011). The two studies assessing total response repertoire in SLD, found it to be smaller in SLD than in TD controls.

Table 6. Passive, avoidant or submissive responses in NDD, compared to TD controls

No group difference	Higher in NDD	Lower in NDD
<u>Third-person:</u> - SLD = TD (van Nieuwenhuijzen et al., 2005) <u>Avoidant:</u> - SLD = TD (Bauminger & Kimhi-Kind, 2008)	<u>Appeal to authority:</u> - ID > TD (Gomez & Hazeldine, 1996; Leffert et al., 2000) <u>Submissive:</u> - ID (with behaviour problems) > TD (van Nieuwenhuijzen et al., 2011) - ID > TD (Embregts & van Nieuwenhuijzen, 2009) <u>Passive-avoidant:</u> - ASD > TD (Flood et al., 2011; Meyer et al., 2006; Ziv et al., 2014)	<u>Avoidant:</u> - ID < TD (Leffert et al., 2000) - SLD < TD (Bauminger et al., 2005) <u>Third-person:</u> - SLD < TD (Bauminger & Kimhi-Kind, 2008)

Table 7. Competent and total response generation in NDD, compared to TD controls

Response	No group difference	Higher in NDD	Lower in NDD
Competent	- ASD = TD (Bauminger-Zviely et al., 2019**; Embregts & van Nieuwenhuijzen, 2009) - ID = TD (Embregts & van Nieuwenhuijzen, 2009) - SLD = TD (Bauminger-Zviely et al., 2019**; Tur-Kaspa, 2004)		- ADHD < TD (Andrade et al., 2012) - ASD < TD (Bauminger-Zviely et al., 2019*; Mazza et al., 2017; Meyer et al., 2006; Ziv et al., 2014) - ID < TD (Leffert et al., 2000; van Nieuwenhuijzen et al., 2004; van Nieuwenhuijzen et al., 2011) - SLD < TD (Bauminger et al., 2005; Bauminger & Kimhi-Kind, 2008; Bauminger-Zviely et al., 2019*)
Total response	- ADHD = TD (Andrade et al., 2012) - ASD = TD (Embregts & van Nieuwenhuijzen, 2009) - ID = TD (Embregts & van Nieuwenhuijzen, 2009)	- ID > TD (van Nieuwenhuijzen et al., 2004)	- ADHD (with or without ODD/CD) < TD (Matthys et al., 1999) - ID < TD (van Nieuwenhuijzen et al., 2011) - SLD < TD (Bauminger et al., 2005; Bauminger & Kimhi-Kind, 2008)

* for vignettes depicting peer entry

** for vignettes depicting peer provocation

To summarise the results relating to the response generation step in CYP with neurodevelopmental disorders, findings overall indicated lower levels of competent responses in ASD and ID, higher levels of aggressive or inept responses in ADHD, increased passive-avoidant responses in ASD and a smaller response repertoire in SLD, when compared to TD controls (Tables 5-7).

Response decision in neurodevelopmental disorders

Given increased problems with working memory, inhibition or ToM in neurodevelopmental disorders (Craig et al., 2016; Mikami et al., 2019; Peng & Fuchs, 2016), response decision may be expected to be impaired in this group. However, no consistent evidence for differences between TD CYP and CYP with ASD or SLD was provided by the five studies assessing aggressive or incompetent response decision in these groups (Table 8).

The one study assessing response decision in ADHD reported that only children with ADHD who had comorbid oppositional defiant disorder or conduct disorder were more likely than TD controls to positively evaluate aggressive responses, to feel confident about enacting aggressive responses and to select aggressive responses (Matthys et al., 1999).

The fact that the ADHD group with comorbid oppositional defiant disorder or conduct disorder showed a similar aggressive response decision pattern than the group with only oppositional disorder or conduct disorder indicates that such a pattern may be more characteristic of disruptive, impulse-control, and conduct disorders rather than of ADHD (Matthys et al., 1999).

When compared to TD controls, children with ID generally evaluated aggressive responses more positively, while evidence for increased self-efficacy for aggressive responses and for increased selection of aggressive responses in ID was mixed (Table 8). Moreover, one study reported that CYP with mild ID (MID) and externalising problems and those with MID without externalising problems did not differ in terms of their aggressive response selection (van Nieuwenhuijzen et al., 2005).

Table 8. Aggressive or incompetent response decision in NDD, compared to TD controls

	No group difference	Higher in NDD	Lower in NDD
Positive evaluation	<u>Aggressive</u> - ADHD = TD (Matthys et al., 1999) - ID (with or without behaviour problems) = TD (van Nieuwenhuijzen et al., 2011)* - SLD = TD (Tur-Kaspa, 2004) <u>Inept</u> - ASD = TD (Ziv et al., 2014) <u>Incompetent</u> - SLD = TD (Bauminger et al., 2005; Bauminger & Kimhi-Kind, 2008; Tur-Kaspa, 2004)	<u>Aggressive</u> - ADHD (with ODD/CD) > TD (Matthys et al., 1999) - ASD > TD (Ziv et al., 2014) - ID > TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004; van Rest et al., 2020) - SLD > TD (Bauminger & Kimhi-Kind, 2008) <u>Incompetent</u> - SLD > TD (Bauminger & Kimhi-Kind, 2008)	<u>Aggressive</u> - ASD < TD (Embregts & van Nieuwenhuijzen, 2009)
Self-efficacy	<u>Aggressive</u> - ADHD = TD (Matthys et al., 1999) - ASD = TD (Embregts & van Nieuwenhuijzen, 2009) - ID = TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004)	<u>Aggressive</u> - ADHD (with ODD/CD) > TD (Matthys et al., 1999) - ID > TD (van Nieuwenhuijzen et al., 2011; van Rest et al., 2020) - ID (with behaviour problems) > TD (van Nieuwenhuijzen et al., 2011)	
Selection	<u>Aggressive</u> - ADHD = TD (Matthys et al., 1999) - ASD = TD (Embregts & van Nieuwenhuijzen, 2009; Russo-Ponsaran et al., 2018) - ID = TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004) - ID (with behaviour problems) = TD (van Nieuwenhuijzen et al., 2011) <u>Incompetent</u> - SLD = TD (Bauminger & Kimhi-Kind, 2008)	<u>Aggressive</u> - ADHD (with ODD/CD) > TD (Matthys et al., 1999) - ID > TD (van Nieuwenhuijzen et al., 2011; van Rest et al., 2020) <u>Incompetent</u> - SLD > TD (Bauminger et al., 2005; Tur-Kaspa, 2004)	

As shown below (Table 9), children with ID, with or without behaviour problems, evaluated submissive responses more positively than TD controls and generally felt more confident about enacting submissive responses, while research regarding submissive response selection in this group is lacking. Submissive response decision in ASD was only assessed by one study which found lower positive evaluation in ASD than in TD controls, but not difference in self-efficacy.

Table 9. Submissive response decision in NDD, compared to TD controls

	No group difference	Higher in NDD	Lower in NDD
Positive evaluation	Third-person - SLD = TD (Bauminger & Kimhi-Kind, 2008; Tur-Kaspa, 2004) Passive-avoidant - SLD = TD (Tur-Kaspa, 2004)	Submissive - ID > TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004) - ID (with behaviour problems) > TD (van Nieuwenhuijzen et al., 2011) Withdrawal - ASD > TD (Flood et al., 2011)* Passive-avoidant - SLD > TD (Bauminger & Kimhi-Kind, 2008)	Submissive - ASD < TD (Embregts & van Nieuwenhuijzen, 2009)
Self-efficacy	Submissive - ASD = TD (Embregts & van Nieuwenhuijzen, 2009) - ID = TD (van Nieuwenhuijzen et al., 2011)	Submissive - ID > TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004; van Nieuwenhuijzen et al., 2011) - ID (with behaviour problems) > TD (van Nieuwenhuijzen et al., 2011)	
Selection	Submissive - ID = TD (van Nieuwenhuijzen et al., 2011) - ID (with behaviour problems) = TD (van Nieuwenhuijzen et al., 2011) Third-person - ASD = TD (Russo-Ponsaran et al., 2018)	Withdrawal - ASD > TD (Russo-Ponsaran et al., 2018)	

* for vignette depicting peer entry

Three studies assessed how CYP with SLD evaluated passive solutions, such as resigning to watch the peers' game, or asking someone like a teacher for help, but did not consistently find this group to evaluate such solutions more positively than controls. The one study assessing evaluation of withdrawal response, found CYP with Asperger syndrome to evaluate such responses more positively than controls, when scenarios represented peer entry rather than peer provocation (Table 9).

As shown in Table 10 below, competent behavioural responses, such as politely asking peers if one could join their game (Bauminger et al., 2005), were evaluated less positively by children with ID or ASD who may also feel less confident than controls in carrying out competent responses (Table 10). Moreover, children with ID selected fewer competent responses than controls, while differences in the selection of competent responses in ASD was mixed.

Table 10. Competent response decision in NDD, compared to TD controls

	No group difference	Lower in neurodevelopmental disorders
Positive evaluation	- ADHD (with ODD/CD) = TD (Matthys et al., 1999) - SLD = TD (Bauminger & Kimhi-Kind, 2008; Bauminger et al., 2005; Tur-Kaspa, 2004)	- ADHD (with ODD/CD) < TD (Matthys et al., 1999) - ASD < TD (Embregts & van Nieuwenhuijzen, 2009; Flood et al., 2011; Ziv et al., 2014) - ID < TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004; van Nieuwenhuijzen et al., 2011) - ID (with behaviour problems) < TD (van Nieuwenhuijzen et al., 2011)
Self-efficacy	- ID (with or without behaviour problems) = TD (van Nieuwenhuijzen et al., 2011)	- ASD < TD (Embregts & van Nieuwenhuijzen, 2009) - ID < TD (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004)
Selection	- ADHD = TD (Matthys et al., 1999) - ASD = TD (Bauminger-Zviely et al., 2019**; Embregts & van Nieuwenhuijzen, 2009) - SLD = TD (Bauminger & Kimhi-Kind, 2008; Bauminger-Zviely et al., 2019**)	- ADHD (with ODD/CD) < TD (Matthys et al., 1999) - ASD < TD (Bauminger-Zviely et al., 2019*; Russo-Ponsaran et al., 2018) - ID < TD(Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004; van Nieuwenhuijzen et al., 2011) - SLD < TD (Bauminger et al., 2005; Bauminger & Kimhi-Kind, 2008; Bauminger-Zviely et al., 2019*; Tur-Kaspa, 2004)

* for vignette depicting peer entry

** for vignette depicting ambiguous provocation

Positive evaluations of assertive responses in CYP with mild ID or borderline intellectual functioning were as low as those in CYP with behaviour problems, with or without mild to borderline ID (van Nieuwenhuijzen et al., 2011), and were negatively associated with externalising behaviour problems in CYP with mild ID or borderline intelligence (van Nieuwenhuijzen et al., 2009). This indicates such response decision pattern may be characteristic of both ID and aggression.

To summarise, the results relating to the response decision step in neurodevelopmental disorders, when compared to TD controls, strongest evidence for problems with this step was found in CYP with ID, most consistently for competent responses, which individuals with ID were less likely to evaluate positively, less likely to feel confident about enacting and less likely to select than controls.

While findings also indicated that CYP with ID may be more likely than controls to evaluate aggressive responses and submissive responses positively, evidence for increased selection of aggressive responses has been mixed in ID.

CYP with ASD or SLD did not consistently differ from controls in terms of their selection of competent or incompetent responses. However, while those with SLD seem to adequately evaluate competent and incompetent responses, a few studies indicate that those with ASD may have a tendency to evaluate competent responses negatively and incompetent responses positively.

Research on the response decision step in ADHD is lacking, with the only identified study indicating that preference for incompetent over competent solutions is linked to the comorbidity of ADHD with oppositional defiant disorder or conduct disorder, rather than to ADHD specifically (Matthys et al., 1999).

Behavioural enactment in neurodevelopmental disorders

At the enactment step of the social information processing model, people carry out the behavioural response they have selected. While this step is rarely assessed in social information processing studies, a way to measure the competency of enacting responses is to ask a person to role-play a particular solution, such as asking a participant to act out how they would nicely ask their peers if they could join their game (Bauminger et al., 2008).

Bauminger et al. (2005) excluded this step because children with or without SLD provided "artificial" responses. While authors did not elaborate on this, it may be that researchers

generally do not assess or report this social information processing step because they do not regard it as a reliable measure of how a person would realistically act in a social situation.

One study that did assess and report this social information processing step in neurodevelopmental disorders was Tur-Kaspa (2004) who reported that girls with SLD were less competent at enacting a competent solution than girls without SLD.

Social information processing training in neurodevelopmental disorders

While most interventions targeting aggression in CYP, including those based on the social information processing model, have been conducted in TD individuals (Leff et al., 2010; Merrill et al., 2017), Jacobs and Nader-Grosbois (2020b) recently implemented an eight-session social information processing training in 15 children with mild to moderate ID in primary special needs schools in Belgium. Compared to the waitlist control group (n = 15), the training improved pupils' ability to judge the appropriateness of social behaviour, for instance by referring to social rules and social consciousness (Jacobs & Nader-Grosbois, 2020b).

Promising effects on behavioural problems have been reported in two German studies that implemented interventions based on the social information processing model in schools for pupils with special needs relating to social-emotional development or learning (Hagen, Vierbuchen, Hillenbrand, & Hennemann, 2016; Hövel, Hennemann, Casale, & Hillenbrand, 2015).

While the above interventions targeted different steps of the social information processing model, including response evaluation, the current thesis focuses on the encoding step and the interpretation step of processing, which represent the stages at which cognitive biases may occur, namely attention, memory or interpretation bias.

In order to understand a potential cognitive mechanism causing and maintaining externalising and internalising problems in CYP with neurodevelopmental disorders, this thesis is interested in the role of a particular type of cognitive bias in neurodevelopmental disorders, namely valence-specific processing of interpersonal ambiguity. The following section provides a definition of this type of bias and outlines the reasons for focusing on the processing of ambiguity and for concentrating on the encoding and interpretation stages specifically.

2. Valence-specific interpersonal ambiguity processing in neurodevelopmental disorders

2.1 Interpersonal ambiguity

This thesis focuses on the processing of information that is specifically interpersonal and ambiguous. Stimuli are here considered interpersonal when they relate to the behaviours or emotions of other people, such as their intent or facial expressions. The processing of interpersonal information is expected to be particularly relevant to understanding interpersonal problems like aggression, in CYP with or without neurodevelopmental disorders. Interpersonal information is here considered to be ambiguous when its overall meaning is unresolved, such as due to the absence of clear intent cues. This is exemplified by the following ambiguous scenario used in Hudley et al. (1993):

> Imagine that as you walk onto the playground one morning, you notice that your shoelace is untied. When you set your notebook down to tie your shoelace, an important homework paper that you worked on for a long time falls out. Just then, another kid you know walks by and steps on the paper, leaving a muddy footprint right across the middle. This other kid looks down at your homework paper and then up at you (p. 128).

The above scenario is ambiguous because it is unclear whether the other boy intended to cause damage. He might look down at the homework to see whether he managed to do the damage he intended or, alternatively, because he did not previously see the homework and only accidentally stepped on it. The unresolved nature of ambiguous information makes it unclear whether its overall valence is negative or neutral, which makes it open to being processed in a valence-specific (e.g. negative) manner.

We focus on ambiguity processing because the processing of ambiguous information, as opposed to unambiguous information, has been shown to distinguish participants with aggression and those without aggression (Dodge, 1980). Dodge and Godwin (2013) found that the impact of intervention targeting antisocial behaviour was mediated by its impact on hostile attributions, measured using ambiguous scenarios. Moreover, there is evidence to suggest that a specific focus on the processing of ambiguous interpersonal information, rather than unambiguous interpersonal information, may be important for understanding increased aggression in neurodevelopmental disorders. For instance, van Rest et al. (2020) found that participants with low IQ, corresponding to mild intellectual disability, were more likely than those with average IQ to feel angry, to evaluate aggressive responses positively and to select

aggressive responses, and that this difference only emerged when the situations were ambiguous, not when they were accidental or hostile.

2.2 Attention, memory and interpretation bias for interpersonal ambiguity

When considering interpersonal ambiguity processing, this thesis focuses on the first two social information processing steps, namely biases in encoding and interpretation. Even though encoding, interpretation and response decision are likely all influenced by the executive functions of working memory and inhibition and by the social-cognitive functions of ToM (Garrigan et al., 2018) and may therefore all be expected to be affected in individuals with neurodevelopmental disorders who frequently show problems with these functions of general and social cognition (Craig et al., 2016; Mikami et al., 2019; Peng & Fuchs, 2016; van der Molen et al., 2007), a focus on encoding and interpretation may be particularly important for understanding reactive aggression which has been linked to biases in these two early stages of social information processing, while proactive aggression has been linked to deficits in later information processing stages, such as response decision (Arsenio et al., 2009; Crick & Dodge, 1996; Dodge et al., 1997; Dodge & Coie, 1987; Smithmyer et al., 2000).

This thesis is particularly interested in reactive aggression because of its comparatively stronger links to psychosocial maladjustment (Card & Little, 2006). Moreover, by intervening early on in the processing cycle, we may not only reduce reactive aggression, but also make it less likely that proactive aggression and internalising problems emerge later in life, as outlined below.

Given the circularity of the social information processing model, targeting encoding and interpretation biases that cause or maintain reactive aggression may both reduce reactive aggression and prevent deficits in later social information processing stages, thus also decreasing the risk of proactive aggression (Bennett et al., 2004). This reasoning is supported by evidence that reactive aggression frequently precedes the emergence of proactive aggression, such as in children with ADHD who initially show reactive aggression but may start to show proactive aggression in adolescence (Bennett et al., 2004). This finding also points to the importance of intervening early in childhood to prevent the emergence of problems in adolescence (Bennett et al., 2004).

Moreover, the finding that reactive aggression in adolescence, not proactive aggression, predicted symptoms of depression and anxiety in late adolescence (Fite et al., 2014), further points to the need to target reactive aggression in order to reduce the risk of later maladjustment.

Since the relation between reactive aggression and internalising symptoms was moderated by peer rejection, victimisation experiences likely also play a role in the emergence of externalising and internalising problems (Fite et al., 2014). Findings which show that the relation between victimisation and aggression was partially mediated by hostile interpretations of interpersonal ambiguity (Dodge et al., 2003; Perren, Ettekal, & Ladd, 2013) and that the relation between victimisation and internalising problems was moderated by self-blame for ambiguous hypothetical interactions (Perren et al., 2013; Prinstein, Boergers, & Vernberg, 2001) point to the potential role of biased interpretation of ambiguity in explaining and influencing the emergence of emotional problems following victimisation. This has the practical implication that interventions targeting such interpretation biases have the potential to decrease the negative impact of victimisation and further justifies the focus of this thesis on early information processing biases relating to interpersonal ambiguity to understand and improve externalising and internalising problems.

Different types of biased interpersonal ambiguity processing are outlined next, including their role in neurodevelopmental disorders and the effects of their modification on mental health.

Memory bias

When processing ambiguous interpersonal situations like the homework vignette (Hudley & Graham, 1993), valence-specific processing may occur at the encoding stage when, for instance, social cues of negative valence (e.g. the dirty footprint) are preferentially recalled while ambiguous cues are neglected. Ambiguous cues are those cues that that could be interpreted as reflecting coincidental or accidental intent, like the fact that the other person looks down on the homework after, not before, stepping on it. As defined by this thesis, preferentially recalling negative over ambiguous or non-hostile cues when processing ambiguous social information would represent valence-specific memory bias for interpersonal ambiguity.

Although it is possible to study memory bias using ambiguous stimuli (e.g. Everaert & Koster, 2015; Hertel, Brozovich, Joormann, & Gotlib, 2008), valence-specific memory has so far primarily been measured using unambiguous stimuli, namely by showing participants negative, positive or neutral stimuli and assessing whether they are more likely to subsequently correctly recall or recognise stimuli of a particular valence, such as negative words or social cues (Bergman et al., 2020; Gaigg & Bowler, 2008; Platt et al., 2017).

In their review that assessed the potential role of cognitive bias in explaining comorbidity with depression in ASD, Bergman et al. (2020) did not find evidence for valence-specific memory

in children or adults with ASD, but pointed to the small number and low quality of studies. None of the studies included in their review assessed memory in the context of ambiguity processing.

As outlined in section 1.5 (Tables 1-2), studies using the social information processing model in CYP with neurodevelopmental disorders measured encoding in terms of how many social cues in total and how many social cues of a particular valence were recalled across all vignette types, irrespective of the scenarios' ambiguity. Studies generally indicated increased encoding of negative cues, as well as reduced encoding of neutral cues or, more commonly, of the total number of cues regardless of cue valence, in ID, ASD, ADHD or SLD (Tables 1-2).

The only study that separately assessed and reported participants' recall separately for ambiguous and unambiguous scenarios was van Rest et al. (2020). They showed that the low IQ group recalled fewer social cues than the average IQ group, regardless of whether the vignette was accidental, ambiguous or hostile (van Rest et al., 2020). Although their study represents a rare assessment of memory when processing interpersonal ambiguity, van Rest et al. (2020) did not assess whether cues of a particular valence (e.g. negative) were selectively recalled, and therefore did not assess valence-specific memory bias, as defined in this thesis.

As pointed out by Milich and Dodge (1984), recall does not directly measure attention, which is why it is unclear whether differences in the recall of certain types of information, such as in CYP with neurodevelopmental disorders, are due to differences in how information is remembered or due to differences in how information is attended. While the social information processing research field primarily measures encoding in terms of recall rather than attention, the wider cognitive bias research field more clearly distinguishes between memory bias and attention bias, as outlined next.

Attention bias

The few studies that have so far assessed attention bias in relation to ambiguous stimuli were conducted in TD individuals in the context of aggression. Using eye-tracking to assess attention bias towards hostile social cues in ambiguous provocation situations, studies did not find evidence for attention bias towards hostile cues or an attention away from non-hostile cues in aggressive CYP, but instead found this group to show increased attention to non-hostile cues (Horsley et al., 2010; Troop-Gordon et al., 2018; Wilkowski et al., 2007). Even though attention to non-hostile cues was enhanced in aggressive children, their subsequent recall of non-hostile

cues was marginally lower than that of controls (Horsley et al., 2010), which illustrates the importance of distinguishing between attention and memory.

Attention bias has primarily been explored in relation to anxiety and assessed in terms of selective attention to unambiguous stimuli such as clearly threatening or non-threatening faces or words, with evidence pointing to associations between increased attention to threatening stimuli and higher levels of anxiety in both adults and CYP (Dudeney, Sharpe, & Hunt, 2015, Bar-Haim et al., 2007).

While previous reviews on attention bias focused on TD individuals, two recent reviews assessed studies on attention bias in CYP and adults with ASD which, however, also only used unambiguous stimuli and which provided no evidence for increased cognitive bias in this group compared to TD controls or for links between attention bias and internalising problems in ASD (Bergman et al., 2020).

Attention bias modification

If evidence was found for the role of attention bias in explaining increased rates of externalising and internalising problems in neurodevelopmental disorders, then this would support the use of a treatment that targets attention bias, namely attention bias modification (ABM). ABM trains participants to direct their attention away from threatening stimuli and towards non-threatening stimuli, which has been shown to be effective at reducing anxiety, when compared to control (sham) training (Hakamata et al., 2010; Mogoaşe, David, & Koster, 2014).

So far, most ABM studies have used non-ambiguous stimuli in TD CYP, even though ABM can be conducted with non-ambiguous stimuli. For instance, AlMoghrabi, Huijding, Mayer and Franken (2019) showed that it is possible to use ABM to modify processing of interpersonal ambiguity. They presented participants with pictures of ambiguous social scenarios like the protagonist getting hit on the head by a basketball that was thrown by another player and then asked participants to look at "the part of the picture that best indicates whether the incident happened on purpose or by accident" (AlMoghrabi et al., 2019). If participants fixated on social cues that could be interpreted as conveying non-hostile intent like the ambiguously guilty face of the other basketball player, participants received positive feedback that their response was correct. This successfully increased participants' attention to non-hostile cues, compared to a condition which reinforced fixation on negative cues like the negative outcome portrayed by the ball hitting the protagonist's head (AlMoghrabi et al., 2019).

Interpretation bias

Valence-specific interpretation of interpersonal ambiguity may occur when a particular valence (e.g. negative) is selectively attributed to ambiguous information, such as when someone attributes hostile intent to the other boy in the ruined homework vignette (Hudley & Graham, 1993) by assuming that he deliberately stepped on the homework. Our use of the ambiguity criterion to define interpretation bias is in line with that of the wider cognitive bias field which has generally defined interpretation bias as valence-specific (e.g. negative or threatening) interpretation of ambiguity, especially in the context of anxiety (Schoth & Liossi, 2017; Stuijfzand et al., 2018). For instance, anxiety in CYP showed medium positive associations with negative interpretations of ambiguity (Stuijfzand et al., 2018). Moreover, anxious children's interpretations of ambiguity showed content-specificity, as indicated by findings that the specific aspect of their anxiety was reflected in the content of their bias (Mobach, Rinck, Becker, Hudson, & Klein, 2019). Accordingly, socially anxious individuals may not show a negative interpretation bias for physical threat-related information, like hearing the sound of an ambulance, but instead selectively process ambiguous social threat-related information, such as hearing people laugh when walking past them, which they tend to interpret as negative social evaluation (Houtkamp, van der Molen, Voogd, Salemink, & Klein, 2017; Mobach et al., 2019).

While the wider interpretation bias field has focused on the interpretation of ambiguity, primarily in relation to anxiety, the social information processing field have focused on externalising problems and HAI which they have frequently defined as hostile intent attribution both in ambiguous situations and in clearly non-hostile situations (Orobio de Castro et al., 2002; Verhoef et al., 2019; Waldman, 1996). However, this thesis argues that studies which operationalise HAI to also include processing of unambiguous information arguably fail to differentiate biased from inaccurate information processing.

Since there is no correct or incorrect way to interpret ambiguous stimuli, the negative interpretation of ambiguous stimuli is a matter of bias, not of accuracy. In contrast, the negative interpretation of unambiguously neutral (e.g. accidental) information is a matter of accuracy and therefore, as Dodge (2006) put it, represents "intention-cue detection inaccuracy". For example, inaccurate interpretation would occur if hostile intent was attributed to the boy in the building block vignette (section 1.4), whose accidental intent is conveyed by the causal line of events and the his surprised face (Dodge, 2006; Dodge, Murphy, & Buchsbaum, 1984; Leffert et al., 2010). Accordingly, evidence that CYP with ID were more likely than TD controls to interpret neutral intent in accidental scenarios as hostile (Gomez & Hazeldine, 1996; Leffert et

al., 2000; Leffert et al., 2010; van Rest et al., 2020) would point to a deficit in intent detection in this group (Crick & Dodge, 1994), not to a bias as it is defined here.

While inaccurate processing of unambiguous information is also likely relevant for understanding the cognitive processes associated with externalising problems, a focus on biased ambiguity processing facilitates the comparison and integration of findings from the wider cognitive bias field, which generally uses the ambiguity criterion to define interpretation bias, with the findings from the social information processing bias field which does not consistently use the ambiguity criterion to define HAI.

The few social information processing studies in CYP with neurodevelopmental disorders that have included ambiguous scenarios and separately reported results for ambiguity processing, have provided mixed evidence for group differences in biased intent processing (see Table 3), with some showing increased HAI for ambiguous scenarios in CYP with neurodevelopmental disorders compared to controls (van Nieuwenhuijzen et al., 2011; van Rest et al., 2020; Weiss, 1984), but others showing no group differences (Andrade et al., 2012; Bryan et al., 1998; Flood et al., 2011; Gomez & Hazeldine, 1996; King et al., 2009; Mikami et al., 2008; Sibley et al., 2010) or even lower HAI compared to controls, as was the case for children with Asperger syndrome in Carothers et al. (2004). However, these results are based on a small number of studies using heterogeneous methodology and therefore need to be viewed with caution.

A systematic review of studies that have used the ambiguity criterion to define cognitive bias, or at least separately reported ambiguity processing, might make interpretation bias results more comparable to those of the interpretation bias field which generally uses the ambiguity criterion. One aim of this thesis it to provide such a systematic overview.

Cognitive bias modification for interpretation (CBM-I)

Support for the focus of biased ambiguity processing in understanding and improving mental health outcomes is provided by findings that systematically training people to interpret ambiguous stimuli more positively via cognitive bias modification of interpretations (CBM-I; MacLeod & Mathews, 2012) can improve symptoms of anxiety, when compared to waitlist groups or sham training (Fodor et al., 2020; Krebs et al., 2018). While the evidence-base for the effectiveness of CBM-I for distinct clinical diagnoses of anxiety and depression is still insufficient (Fodor et al., 2020), evidence for its effectiveness in reducing aggression is promising (Hudley et al., 1998; Ren, Zhao, Yu, Zhang, & Li, 2021; Sukhodolsky, Golub, Stone,

& Orban, 2005; van Bockstaele, van der Molen, van Nieuwenhuijzen, & Salemink, 2020; Vassilopoulos, Brouzos, & Andreou, 2015).

While most CBM-I studies have been conducted in TD individuals, the CBM-I targeting HAI in highly aggressive adolescents by van Bockstaele et al. (2020), which reduced reactive aggression but not proactive aggression, was conducted in special schools for pupils with average IQ and learning difficulties or social-emotional problems. They used word fragment completion to resolve ambiguity in a neutral or positive direction. Neutral resolution involved imagining scenarios like getting hit hard against one's head by another tennis player's ball, followed by filling out the missing letter in the last word of the sentence ("The player is inexp-rienc-d"), which provides a neutral interpretation of the scenario. This is followed by a comprehension question ("Did the player accidentally hit the ball against your head?") and feedback that reinforces the neutral interpretation ("Yes, the player is inexperienced", van Bockstaele et al., 2020).

In contrast, resolving ambiguous scenarios in a positive way, such as by training people to interpret the sound of another person laughing at something they said as an indication that they are popular or funny, has been criticised for encouraging a positive bias that may be unrealistic or even maladaptive (Podina, Cosmoiu, Rusu, & Chivu, 2020).

Some CBM-I studies have used valence-selection instead of word completion to resolve ambiguity which asks participants to choose between a neutral or a negative interpretation of ambiguous scenarios and provides positive feedback when participants choose the neutral interpretation (Vassilopoulos et al., 2015). Such CBM-I has been found to reduce aggression in CYP, including in juvenile delinquents (Ren et al., 2021), but has mostly focused on TD individuals.

A pilot CBM-I reduced hostile interpretation of faces in adolescents with disruptive mood dysregulation disorder, a condition characterised by symptoms of persistent irritable mood and severe recurring temper outbursts (APA, 2013), by using a single session that asked participants to interpret ambiguous faces and that provided positive feedback designed to train participants to interpret these faces more positively than they did at baseline (Stoddard et al., 2016). While a large proportion of participants in this pilot study had comorbid ADHD, only TD individuals were recruited for the subsequent randomised controlled trial that provided evidence for the training's effectiveness in reducing hostile interpretation of faces when compared to a sham

training. This points to the need to include individuals with neurodevelopmental disorders in high quality research like randomised experiments evaluating CBM efficacy.

It is problematic that the diagnosis of a neurodevelopmental disorder frequently disqualifies participants from participating in high quality CBM research. For instance, participants with ASD were explicitly excluded from van Bockstaele et al.'s (2020) CBM-I for reactive aggression, even though authors recruited from special needs schools for pupils with learning difficulties and used audio-visual support to reduce cognitive demands.

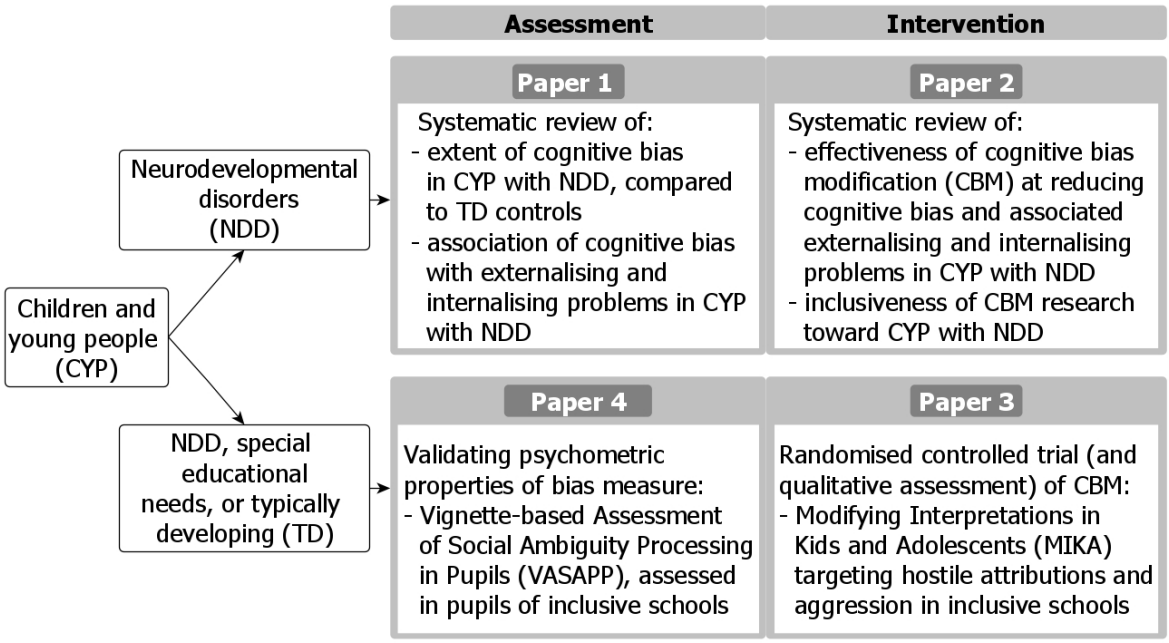
The findings outlined in this section have demonstrated the potential benefits of targeting the encoding or the interpretation stage of processing, specifically the encoding and interpretation of ambiguous interpersonal information. Moreover, they highlight the need to provide a systematic overview of the feasibility and effectiveness of CBM in CYP with neurodevelopmental disorders, which this thesis aims to provide.

3. Dissertation aims

Despite its potential importance in understanding and targeting the high prevalence of externalising and internalising problems in neurodevelopmental disorders, cognitive biases have rarely been assessed or modified in this group. To provide an overview of the role of a particular type of cognitive bias in neurodevelopmental disorders, namely valence-specific interpersonal ambiguity processing, this dissertation's first objective is to systematically review evidence for the extent of this bias in CYP with neurodevelopmental disorders, as well as its associations with mental health outcomes in this group (Figure 2). The second objective of the thesis is to systematically review evidence for the efficacy of CBM in CYP with neurodevelopmental disorders and the extent of this group's exclusion from CBM. The first two objectives are addressed by separate systematic reviews (Papers 1-2, Figure 2).

Moreover, in order to address this gap in the literature regarding cognitive bias assessment and modification that are inclusive toward CYP with or without neurodevelopmental disorders, the dissertation's next two objectives are to examine the efficacy and acceptability of a newly developed CBM-I targeting hostile attributions, assessed using a novel cognitive bias measure, in an inclusive sample of CYP with or without neurodevelopmental disorders, as well as to examine the psychometric properties of the new cognitive bias measure in a larger inclusive school sample. These two objectives are addressed by Papers 3 and 4, which represent primary studies conducted with pupils of inclusive lower secondary schools that include both TD CYP and those with neurodevelopmental disorders or special educational needs (Figure 2).

Figure 2. Thesis outline



Paper 1

While studies using the social information processing model have started to address the role of hostile intent attributions in explaining high rates of aggression in CYP with neurodevelopmental conditions like ID, ASD, ADHD and LD, the wider cognitive bias research field, which does not generally use the social information processing model and more frequently addresses internalising problems like anxiety, has focused on the role of cognitive bias in TD individuals. In order to address the gap in the literature regarding the role of cognitive bias in explaining the increased vulnerability for mental health problems in CYP with neurodevelopmental disorders, the first objective of this thesis, which is addressed in Paper 1, is to systematically review the extent of cognitive bias in CYP with neurodevelopmental disorders and the association of cognitive bias with externalising and internalising problems in this group.

As a novelty of this paper, this current review aims to integrate findings from the cognitive bias research field and the social information processing field that differ in how they assess and define cognitive bias. For instance, while the social information processing field frequently defines HAI as hostile interpretation of either ambiguous or unambiguous information, the cognitive bias field generally defines interpretation bias as selective (e.g. negative) interpretation of ambiguity. A consistent cognitive bias definition is needed to make findings from the two fields more comparable. Moreover, a specific focus on the processing of

ambiguous interpersonal information, rather than unambiguous interpersonal information, is expected to be important for understanding interpersonal problems like aggression and anxiety.

This paper therefore focuses on a specific type of cognitive bias referred to as valence-specific processing of interpersonal ambiguity and systematically reviews if cognitive biases relating to how interpersonal ambiguous information is attended, remembered or interpreted, have been identified in CYP with neurodevelopmental disorders and whether cognitive biases in this group are associated with mental health outcomes in this group.

Given the increased vulnerability for social-cognitive deficits and both externalising and internalising problems in neurodevelopmental disorders, cognitive biases are expected to be higher in this group than in TD individuals. Moreover, preliminary findings of increased aggression and cognitive bias in special needs schools that included pupils with neurodevelopmental disorders or special educational needs, compared to regular schools that only consisted of TD pupils (Kipp, 2018; Kunz, 2018; Schmidt & Vereenooghe, 2018), further indicate that cognitive bias may be higher in CYP with neurodevelopmental disorders than in TD controls.

If cognitive biases in CYP with neurodevelopmental disorders are indeed found to be higher than in TD CYP and to be linked to externalising and internalising problems, this might help explain the high psychiatric comorbidity in neurodevelopmental disorders. In terms of practical implications, such findings would highlight the importance of including this group in intervention studies like CBM that target cognitive bias and associated mental health problems.

To my knowledge, there are only two systematic reviews on cognitive bias in CYP with neurodevelopmental disorders and these only identified studies on attention and memory bias and only focused on ASD (Bergman et al., 2020; Fan, Duan, Yi, & He, 2020). In contrast to these previous reviews, the current review investigates cognitive bias across all types of neurodevelopmental disorders in order to take into account the frequent co-occurrence and shared vulnerabilities of the disorders in this group.

Paper 2

The possibility that cognitive bias might explain the increased risk for externalising and internalising problems in neurodevelopmental disorders and that interventions like cognitive bias modification (CBM) targeting cognitive bias could theoretically remediate such problems, warrants the inclusion of neurodevelopmental disorders in CBM research or, at the very least, warrants an adequate justification of their exclusion. Regardless of whether cognitive bias

differs between CYP with neurodevelopmental disorders and TD individuals, the inclusion of both groups in CBM is necessary to make samples more representative. Cognitive bias research has focused on TD individuals and, to our knowledge, no review has assessed the use of CBM in neurodevelopmental disorders. Therefore the second objective of this thesis, addressed in Paper 2, is to systematically review whether CBM studies targeting cognitive bias, namely valence-specific interpersonal ambiguity processing, have included CYP with neurodevelopmental disorders and how effective they have been at reducing cognitive bias and mental health problems in this group. Evidence in support of the feasibility and efficacy of using CBM to reduce cognitive bias and mental health problems in CYP with neurodevelopmental disorders would highlight the importance of including this group in CBM.

The review is further interested in whether and why people with neurodevelopmental disorders or special educational needs, which are frequently present in individuals with neurodevelopmental disorders, are excluded from CBM studies. Moreover, the suitability of CBM methodology for those with neurodevelopmental disorders or special educational needs is assessed. A potential practical implication of such methodological information, which has not been provided by previous reviews (e.g. Cristea et al., 2015), is that it allow us to evaluate the inclusiveness and representativeness of the CBM research field and find ways to make it more accessible and more representative of a population that includes both TD CYP and CYP with neurodevelopmental disorders or special needs. For instance, evidence for the exclusion of this group due to studies' cognitive demands would indicate that adaptations to CBM methodology might be needed so that participants with a range of cognitive abilities can participate.

Paper 3

Hostile attribution bias in CYP with neurodevelopmental disorders may represent a suitable and feasible target of CBM-I aiming to improve hostile attributions and aggression. However, such CBM-I research has not been inclusive towards CYP with neurodevelopmental disorders and therefore not representative of the general population or the inclusive school environment. Therefore, the third objective of this thesis, addressed in Paper 3, was to develop and implement an accessible and acceptable CBM-I targeting hostile attributions and aggression in inclusive secondary schools where pupils with neurodevelopmental disorders or special educational needs and those without such disorders or special need are educated together. A pilot randomised controlled trial was conducted to assess the hypothesis that this newly developed attribution training would lead to significantly greater reductions in hostile attributions

compared to a control training that did not target cognitive biases. The use of an active control group improves upon previous studies that found evidence for the efficacy of CBM-I targeting hostile attributions in improving aggression in CYP, relative to a test-retest control group (van Bockstaele et al., 2020; Vassilopoulos et al., 2015).

In order to further improve upon the methodology of these previous studies and to optimise training's accessibility and acceptability, the current study made a number of adjustments. Firstly, no participants were excluded based on neurodevelopmental conditions, disabilities or special needs. Secondly, training was conducted online on any device with internet access to allow flexibility regarding the time and location of training location. Thirdly, while van Bockstaele et al. (2020) used audiovisual support, the current CBM-I additionally used an animated avatar to narrate the training and interact with participants. Moreover, follow-up qualitative group interviews, which are only rarely found in CBM-I literature (Lisk, Pile, Haller, Kumari, & Lau, 2018) were conducted at follow-up to collect feedback about training acceptability, the results of which will have practical implications for how to make CBM more acceptable and accessible.

Overall, Paper 3 thereby aimed to address the scarcity of research on methodologically strong evaluations of CBM-I targeting hostile attributions, on adaptations of CBM-I for individuals with potential cognitive difficulties, and on the qualitative assessment of CBM acceptability. If this brief CBM-I is shown to be feasible, effective and acceptable in this inclusive sample, it may represent a particularly suitable intervention that can be implemented flexibly in different settings to target hostile attributions and aggression in individuals with a range of cognitive abilities.

Paper 4

Inclusive and representative cognitive bias research requires accessible measures that can be completed by participants regardless of possible cognitive deficits. Firstly, such measures would signify an appropriate response to an educational context that is becoming increasingly inclusive towards pupils with neurodevelopmental disorders, disabilities or special needs. Secondly, inclusive assessment of cognitive biases such as hostile attributions, would facilitate meta-analytic comparisons of different cognitive bias studies, whose assessment methods have so far been heterogeneous and, arguably, insufficiently accessible for pupils with neurodevelopmental conditions or special educational needs. In order to meet the requirements for inclusive cognitive bias research, I developed an accessible self-report attribution

questionnaire called *Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP)* that adjusted for potential cognitive or verbal difficulties by using simplified language, short sentences and pictorial representations of the Likert-scale and by including scenarios that were visualised by colourful cartoons.

Research on aggression-related attribution bias has so far focused on HAI, namely whether others' behaviour is interpreted as hostile in a specific situation (e.g. "they were trying to be mean", e.g. van Dijk, Thomaes, Poorthuis, & Orobio de Castro., 2019). In contrast, previous literature has not sufficiently explored the potential role of hostile attribution of character (e.g. "these kinds of kids pick on everybody", Graham & Juvonen, 1998), which arguably represents an external form of attribution that is stable and global, rather than unstable and specific. Attributions that are internal, stable and global have primarily been assessed in the context of depression, while their role in aggression is still unclear (Crick & Dodge, 1994).

In order to address the gap in the literature regarding the assessment of both other-blaming and self-blaming attributions, the VASAPP assesses attribution of blame to other people's characters, here called COB, or one's own character, called CSB, as well as a neutral form of attribution involving no blame (NB), based on pupils' interpretations of ambiguous social vignettes. Two sets of the VASAPP were created so that they may be used in the future at different assessment points to evaluate the efficacy of interventions targeting attributions.

The aim of this paper, which represents the fourth objective of this thesis, was to validate the two VASAPP sets in inclusive secondary school pupils with or without neurodevelopmental disorders or special educational needs who completed the two sets at different time points. The reliability of the questionnaire was assessed by examining the two sets' equivalence, as well as by assessing the internal consistency and alternate-form reliability of their attribution items.

Examining the questionnaire's validity involved an assessment of its content validity and construct validity, in addition to its convergent validity with aggression, as measured by the Reactive-Proactive Aggression Questionnaire (RPQ, Raine et al., 2006) which is also assessed in terms of internal consistency and test-retest reliability.

Given closer links between hostile attributions and reactive aggression, relative to proactive aggression (Martinelli et al., 2018; van Bockstaele et al., 2020) and between self-blame and depression, relative to aggression (Quiggle et al., 1992), other-blaming attributions, not self-blaming attributions, were expected to be positively related to aggression, namely specifically reactive aggression.

4. Paper 1: Interpersonal cognitive biases in children and young people with neurodevelopmental disorders: a systematic review (Schmidt & Vereenooghe; submitted)

4.1 Theoretical background and hypotheses

Cognitive biases are associated with internalising and externalising problems and by deficits in general or social cognition. Since neurodevelopmental disorders are characterised by increased rates of both mental health problems and cognitive and social-cognitive deficits, cognitive bias might be particularly high in CYP with neurodevelopmental disorders and might therefore represent an important intervention target in this group. However, the role of biased information processing in neurodevelopmental disorders has so far primarily been assessed by a small number of studies that used the social information processing model and that differed from the wider cognitive bias field in how they defined and assessed cognitive bias.

In order to clarify the role of cognitive bias in CYP with neurodevelopmental disorders, it is therefore important to integrate findings from the social information processing field and the cognitive bias field, which this review set out to do. This required taking into account that social information processing studies assessing biased information processing in neurodevelopmental disorders may not explicitly refer to 'cognitive bias' but instead use terms like 'attribution of intent'.

Moreover, an integration of the two fields' findings required the use of a consistent cognitive bias definition. In accordance with most interpretation bias research and in line with findings of specific links between interpersonal problems and biased processing of interpersonal information that is ambiguous, as opposed to unambiguous (Dodge, 1980), this review defined interpersonal cognitive bias as valence-specific processing of interpersonal ambiguity.

The aim of this paper was to systematically review if studies have identified cognitive biases relating to how interpersonal ambiguous information is attended, remembered or interpreted in CYP with neurodevelopmental disorders (objective 1) and whether cognitive biases in this group are linked to externalising and internalising problems (objective 2).

Given the higher prevalence of mental health problems in neurodevelopmental disorders, it was expected that cognitive biases in CYP with neurodevelopmental disorders would be higher than in TD CYP and would be linked to externalising problems like aggression and internalising problems like anxiety.

4.2 Methods

We conducted a systematic database search in five databases using terms synonymous to "children and young people", "neurodevelopmental disorder", "cognitive bias" and "modification" (see the first appendix of Paper 1 and Prospero for the registered protocol: CRD42017058346). Only peer-reviewed articles published in English, Dutch, French and German from 1980 onward were included. Participants of eligible studies were required to be under the age of 18 and to have any of the types of neurodevelopmental disorders that are listed in the neurodevelopmental disorders chapter of the DSM-5 or that were diagnosed or identified according to earlier versions of this diagnostic manual.

With regards to eligibility criteria for cognitive bias, studies had to assess and separately report valence-specific attention, memory or interpretation in relation to ambiguous interpersonal stimuli. Following both authors' screening of titles and abstracts of all articles, Kappa was calculated and disagreements resolved through discussion. The same procedures applied to reviewing the selected full-length articles, with reasons for excluding articles being recorded by each reviewer.

In order to address the review's primary objective regarding the extent of biased processing of interpersonal ambiguous stimuli in CYP with neurodevelopmental disorders, the first author extracted data relating to the cognitive bias types, their assessment method and their outcome data.

The review's second objective was addressed by extracting data relating to the link between cognitive bias and mental health outcomes in neurodevelopmental disorders.

Quality assessment involved evaluating individual studies' methodological quality and risk of bias, as well as the potential publication and reporting biases across studies.

4.3 Results and Discussion

Out of 6589 identified records identified from five databases, 122 full-text articles were assessed for eligibility. After reviewing the first 20 articles, disagreements were resolved by clarifying eligibility criteria relating to the definition and reporting of cognitive bias, which resulted in high inter-rater agreement for the remaining 102 studies. Sixteen studies met inclusion criteria. The most common reason for exclusion of full-text articles was that studies only used unambiguous stimuli or did not separately report results for ambiguous stimuli.

The 16 eligible studies all addressed interpretation bias in CYP with neurodevelopmental disorders, most commonly in ID (n=6) and ASD (n=6), followed by ASD (n= 3) and SLD (n=1). Interpretation bias most frequently related to HAI (n=11), but also to threat interpretation bias and causal attributions, and was measured using social information processing interviews or forced-choice questions about ambiguous social vignettes.

Table 11 presents findings of studies' cognitive bias comparisons between TD CYP and CYP with neurodevelopmental disorders, as well as results of associations between cognitive bias and mental health outcomes. A detailed presentation of the selection process and of the characteristics and outcomes of included studies can be found in the complete manuscript (Appendix A).

Findings relating to the extent of cognitive bias in neurodevelopmental disorders (objective 1) were inconclusive. Studies did not consistently find higher HAI in children with ID, ASD, ADHD or SLD compared to TD controls (Table 11). While such findings are unexpected, given previous reports of increased externalising problems in neurodevelopmental disorders (Dekker et al., 2002; Fitzpatrick et al., 2016; Kanne & Mazurek, 2011; King & Waschbusch, 2010; Pliszka, 2015), they should be viewed with caution considering the scarcity and heterogeneity of identified studies.

If future studies do not provide more consistent evidence for increased HAI in neurodevelopmental disorders, then it should be systematically examined whether other cognitive or social-cognitive processes, such as executive impairments, might better explain aggression in neurodevelopmental disorders or whether such processes interact with cognitive bias in causing and maintaining aggression in this group (for a more detailed discussion of this, see section 8).

The four studies that compared TD individuals and those with neurodevelopmental disorders in terms of cognitive biases other than HAI found evidence for comparatively higher social threat interpretation bias in boys with ASD comorbid with anxiety (Hollocks, Pickles, Howlin, & Simonoff, 2016), global attributions in AS (Flood et al., 2011) and internal attributions in CYP who had ADHD (Colalillo, Williamson, & Johnston, 2014) or ADHD with conduct problems and callous-unemotional traits (Haas, Waschbusch, King, & Walsh, 2015).

Table 11. Cognitive bias results in CYP with neurodevelopmental disorders

NDD	HAI	Causal attributions	Social threat interpretations
ADHD	- ADHD = TD (Andrade et al., 2012; King et al., 2009; Mikami et al., 2008; Sibley et al., 2010) - ADHD girls: Higher bias not associated with aggression (Mikami et al., 2008)	<u>Internal</u> Child responsibility: - Boys with ADHD > TD boys (Colalillo et al., 2014) Behaviour problems: - ADHD (with CP and CU) > TD or ADHD (with CP) (Haas et al., 2015) <u>External</u> Parent's effort/ability: - Boys with ADHD = TD (Colalillo et al., 2014) Other child's character, mood: - ADHD (with CP and CU) = ADHD (with CP) = TD (Haas et al., 2015)	
ASD	- ASD < TD (Carothers & Taylor, 2004) - ASD = TD (Flood et al., 2011)	<u>Internal</u> - AS = TD (Flood et al., 2011) <u>Global</u> - AS > TD (Flood et al., 2011) <u>Stable</u> - AS = TD (Flood et al., 2011)	- ASD boys with anxiety > controls (Hollocks et al., 2016) - ASD boys with anxiety = ASD boys without anxiety (Hollocks et al., 2016)
ID	- ID > TD (van Nieuwenhuijzen et al., 2011) - ID < TD (Leffert et al., 2010) - ID = TD (Gomez & Hazeldine, 1996)		- MID: Higher bias associated with social anxiety (Houtkamp et al., 2017) - MID: +ve CBM (vs. neutral CBM) → lower bias & social anxiety (Klein et al., 2018)
SLD	- SLD = TD (Bryan et al., 1998) - SLD: happy music → lower bias (Bryan et al., 1998)		

Note. CP, conduct problems; CU, callous-unemotional traits

With regards to this paper's second objective to examine associations between cognitive bias and mental health outcomes, the only study assessing relations between HAI and aggression

failed to find evidence for an association between HAI in girls with ADHD and their aggression scores, measured as a general construct without differentiating between reactive and proactive aggression (Mikami et al., 2008). In contrast, evidence for specific associations between social anxiety and negative interpretations of scenarios reflecting ambiguous social threat, as opposed to physical threat, was found in a sample of CYP with mild ID (Houtkamp et al., 2017), a subset of which received CBM-I that was successful at reducing both interpretation bias and social anxiety, compared to a text-reading control group (Klein et al., 2018). Such evidence for associations between cognitive bias and mental health in neurodevelopmental disorders and for the feasibility of CBM-I in CYP with neurodevelopmental disorders point to the importance of including this group in cognitive bias research, but need to be replicated.

4.4 Strengths and Limitations

All of the attention or memory bias studies identified in the review process used unambiguous stimuli and therefore had to be excluded. This was despite terms relating to attention bias and memory bias being included in the systematic search and it being possible for both types of bias to be measured using ambiguous stimuli (Troop-Gordon et al., 2018; Wilkowski et al., 2007). Hence, although it was theoretically possible to identify eligible attention bias and memory studies that meet the paper's ambiguity criterion for defining cognitive bias, only interpretation bias studies met all the reviews' eligibility criteria. The ambiguity criterion might therefore be regarded as a limitation of this paper because, without it, the review could have provided information about the role of attention bias and memory bias in explaining increased externalising and internalising problems in neurodevelopmental disorders. In contrast, only attention bias and memory bias studies were identified by a recent paper that systematically reviewed evidence for cognitive bias in CYP and adults with ASD, but that did not use the ambiguity criterion and did not find support for increased cognitive bias in this population (Bergman et al., 2020).

Unlike the rare examples of previous reviews on cognitive bias in neurodevelopmental disorders (e.g. Bergman et al., 2020; Fan et al., 2020), this review identified interpretation bias studies that were likely only picked up by search terms that did not explicitly refer to 'interpretation bias' but used related terms like 'hostile attribution of intent'. The inclusiveness of this review towards studies conducted in the interpretation bias context and also towards studies conducted in the social information processing context may be regarded as a strength as it allowed the current review to integrate findings of related research fields.

While many social information processing studies measured interpretation bias using ambiguous stimuli and therefore met this review's ambiguity criterion for defining cognitive bias, some had to be excluded because they extended their definition of HAI to include hostile intent attribution in unambiguously accidental vignettes and did not separately report results relating to ambiguous vignettes (e.g. Ziv et al., 2014). This paper might therefore be criticised for not reviewing findings relating to the selective interpretation of unambiguous information. Additional findings of reduced accuracy at interpreting neutral intent in ID and AS (Carothers & Taylor, 2004; Leffert et al., 2010) indicate that such intent detection deficits might play a role in neurodevelopmental disorders. However, our definition of cognitive bias was in line with most interpretation bias research (Schoth & Liossi, 2017; Stuijfzand et al., 2018), was expected to be important for understanding psychiatric comorbidity and was designed to improve the comparability of studies.

In contrast to Bergman et al. (2020), who only focused on ASD, the current review's selection strategy was inclusive towards all kinds of neurodevelopmental disorders. However, since only studies with at least one group entirely composed of CYP with neurodevelopmental disorders were included, this review was not inclusive towards cognitive bias studies with mixed samples that included both TD participants and participants with neurodevelopmental disorders (e.g. Milich & Dodge, 1984; Stoddard et al., 2016). Even though this selection strategy might be criticised for making findings less representative of the general population, it was chosen in order for findings to be generalisable towards neurodevelopmental disorders specifically. This had the potential to increase our understanding of whether cognitive biases, which have already been shown to be linked to mental health outcomes in TD individuals, also represent suitable treatment targets in CYP with neurodevelopmental disorders.

Evidence for the relevance of cognitive bias in this group would support the use CBM in inclusive settings that include both individuals of typical and atypical development. However, in light of this review's inconsistent findings and the small number and heterogeneity of identified studies, future research needs to use standardised assessments to further clarify the role of cognitive bias in CYP with neurodevelopmental disorders.

5. Paper 2: Inclusiveness of cognitive bias modification research toward children and young people with neurodevelopmental disorders: A systematic review (Schmidt & Vereenooghe; International Journal of Developmental Disabilities, 2020)

5.1 Theoretical background and objectives

Since cognitive bias represents a mechanism that causes and maintains internalising and externalising problems in both children and adults, its successful modification via cognitive bias modification for interpretations (CBM-I) or attention bias modification (ABM) can lead to improvements in symptoms like anxiety or aggression (Cristea et al., 2015; Grafton et al., 2017). Neurodevelopmental disorders represent a group of disorders with an increased risk for such mental health problems and thus potentially with an increased need for psychological interventions like CBM that target processes associated with such problems. While CBM studies evaluated by previous reviews have focused on TD individuals, the current systematic review is interested in whether CBM has been effective in reducing cognitive bias, specifically regarding ambiguous interpersonal information, and internalising or externalising problems in CYP with neurodevelopmental disorders (objective 1).

In addition to examining the efficacy of CBM for CYP with neurodevelopmental disorders, this review aimed to explore whether CBM studies for CYP have included any participants with neurodevelopmental disorders or special educational needs, whether they have explicitly excluded this group, and whether their CBM methodologies have generally been inclusive in terms of their cognitive and reading demands (objective 2). Moreover, assessing the reasons that CBM studies might state for excluding those with neurodevelopmental disorders or special educational needs provides information about the factors that might prevent their inclusion and that may be adjusted in future research to facilitate their inclusion.

5.2 Methods

We conducted a systematic database search in five databases using terms synonymous to “neurodevelopmental disorders”, “mental health problems”, “cognitive bias”, “modification” and “review” (for the full search string and more details, see the registered protocol CRD42017058346 on Prospero, or see the DOI link to the published paper in Appendix B).

The search aimed to identify studies picked up by previous reviews, as well as potential new studies. Only peer-reviewed articles published in English, Dutch, French and German from 1980 onward were included. Studies had to involve participants under the age of 18 and have

randomised controlled trial study designs that compared the effect of an active CBM training to a control condition, of which it was not expected to lead to changes in cognitive bias outcomes. Hence, studies in which the control condition aimed to induce a positive interpretation bias were excluded.

With regards to eligibility criteria for the cognitive bias, studies had to assess and separately report valence-specific attention, memory or interpretation in relation to ambiguous interpersonal stimuli. Following the first author's screening of all identified records' title abstracts, and the second author's screening of 35% of records, all full-length articles extracted from the identified reviews and found through the ancestry approach were reviewed by both authors. Kappa coefficients of agreements were calculated at each step.

In order to address the review's first objective regarding the efficacy of CBM for CYP with neurodevelopmental disorders, data relating to study sample characteristics, study design, cognitive bias assessment and differential effectiveness of CBM in reducing cognitive bias and mental health outcome was extracted from those studies that (a) identified the number of CYP with a type of neurodevelopmental disorder, and (b) for which the neurodevelopmental disorders was listed in the DSM-5 (APA, 2013) or matched the diagnostic criteria of earlier diagnostic manuals.

The review's second objective regarding the general inclusiveness of CBM toward CYP with neurodevelopmental disorders was addressed by examining all identified CBM studies in terms of (a) their inclusion of CYP with neurodevelopmental disorders, (b) their use of explicit exclusion criteria referring to neurodevelopmental disorders or special educational needs, and (c) their rationales for excluding this group. Further data extracted from these studies related to the number of training sessions and trials per session, training and study duration, the use of computerised training delivery and audio-visual support, the extent of attrition at post-assessment and the differential effectiveness of CBM in reducing cognitive bias and mental health outcomes, relative to the control group.

5.3 Results and Discussion

The search of five databases identified 2270 records. Seventy-eight full-text articles were extracted from 42 reviews or found through the ancestry approach, out of which 28 published papers met inclusion criteria, without disagreements between the two reviewers. The most common reason for excluding full-text articles was their use of unambiguous stimuli or negative CBM control groups. All included studies examined CBM-I, either in community samples

(n=12), in CYP selected for high internalising or externalising problems (n=13) or in clinically anxious or depressed CYP (n=5). Assessed and targeted interpretation bias related to negative interpretations of ambiguous scenarios (n=19) or word-image pairs (n=2), or to hostile interpretations of ambiguous scenarios (n=6) or faces (n=3). CBM-I studies targeted interpretation bias by resolving ambiguity in a non-threatening manner, either using word fragment completion (n=13), valence selection (n=10), persuasion (n=5) or imagery (n=2).

This review only identified two CBM-I studies that included a quantified number of CYP with neurodevelopmental disorders and that were thus eligible for this review's evaluation of CBM efficacy in neurodevelopmental disorders (objective 1). One of these studies targeted social threat interpretation bias in a sample that consisted exclusively of CYP with mild ID selected for social anxiety, using CBM-I that was computerised, audio-supported, simplified in language and delivered in a one-to-one school setting (Klein et al., 2018). This CBM-I applied WFC as the ambiguity resolution method which involved asking participants to complete word fragments that positively resolved ambiguous social scenarios, followed by positive feedback for correctly answering comprehension questions that reinforced the scenarios' positive interpretation. Compared to a control training that involved the completion of non-emotional unambiguous scenarios, Klein et al.'s (2018) CBM-I reduced interpretation bias on two different bias measures and improved self-reported social anxiety improvements at follow-up ten weeks later.

The only other eligible study that was identified as including a specified proportion of CYP with neurodevelopmental disorders was a CBM intervention targeting hostile interpretation of faces in a sample selected for externalising problems, 75.6% of which had either ASD, ADHD or both (Hiemstra, Orobio de Castro, & Thomaes, 2019). Using valence selection to resolve ambiguity, participants rated photographs of ambiguously morphed faces as angry or happy using an iPad™ at school and received positive feedback when angry ratings were lower than at baseline. Compared to a control group that provided no feedback for ratings, this CBM-I reduced the proportion of angry ratings, but did not produce differential effects on anger, HAI or aggression. While training effects in Hiemstra et al. (2019) therefore did not generalise to related cognitive biases or mental health outcomes, findings may also not apply to neurodevelopmental disorders in general because one quarter of participants did not have neurodevelopmental disorders, all participants were male and, as in Klein et al. (2018), no structured diagnostic interviews were used to confirm diagnoses.

While Klein et al. (2018) and Hiemstra et al. (2019) overall provided tentative evidence for the feasibility of using CBM-I to reduce cognitive bias in CYP with mild ID, ASD or ADHD, an examination of all 29 CBM studies in terms of their general inclusiveness toward CYP with neurodevelopmental disorders (objective 2, Table 12) showed that only three studies included any CYP with neurodevelopmental disorders and that one third of studies even explicitly excluded those with a diagnosis of neurodevelopmental disorders or those with difficulties often present in people with neurodevelopmental disorders, such as cognitive deficits and special educational needs. These exclusion criteria related to neurodevelopmental disorders most frequently referred to intellectual impairment, ASD or problems with reading or learning, and most commonly occurred in CBM-I using word fragment completion as their ambiguity resolution method. A rationale for such exclusion was provided only by a single study, namely by Micco et al. (2014) who used word fragment completion and explained the exclusion in terms of their study's reading demands.

Table 12. Summary of characteristics and outcomes of included studies (n=30)

Type of CBM method used in studies	n/total NDD inclusion	n/total NDD-related exclusion criteria	n/total compu-terised	n/total audio or visual support	n/total improved bias (improved mental health)	Mean number of sessions (trials per session)	Mean number of days of training (of study)	Mean % drop-out at post-test
Word fragment completion	1/13	6/13	13/13	2/13	10/13 (3/13)	6.5 (52.7)	18.3 (120.2)	7.7
Valence selection	1/10	2/10	5/10	4/10	9/10 (4/10)	2.9 (29.4)	5.7 (13.2)	7.6
Persuasion based	1/5	2/5	0/5	4/5	5/5 (2/5)	8.8 (4)	19.2 (145.6)	16.3
Imagery biased	0/2	1/2	2/2	2/2	1/2 (1/2)	5 (69.5)	20.4 (143.4)	

The fact that studies using valence selection to resolve ambiguity were less likely to use explicit neurodevelopmental disorders-related exclusion criteria and more likely to have short training durations and to use audio-visual support, when compared to studies using word fragment completion (Table 12), indicates that the use of valence selection to resolve ambiguity may be

comparatively less demanding than the use of word fragment completion and more inclusive toward those with neurodevelopmental disorders or special educational needs. Imagery-based methods that positively resolve ambiguous pictures using captions might also be suitable for neurodevelopmental disorders but were only assessed in two identified studies, neither of which included neurodevelopmental disorders and one of which excluded those receiving special education.

Resolving ambiguity by persuading participants of non-threatening interpretations has the advantage of being comparatively more interactive, but involves explicit rather than implicit attribution training and may thus require cognitively demanding self-reflection. Persuasion-based methods were used by almost all of the identified CBM studies targeting hostile attribution of intent, one of which included an unquantified proportion of participants with ADHD but excluded those with ASD (Sukhodolsky et al., 2005).

The low representation of CYP with neurodevelopmental disorders in CBM-I research and their frequent and unjustified categorical exclusion shows that the increased risk of mental health problems in this group has not been adequately addressed and that CBM-I samples have not been sufficiently representative of the general population which includes both TD CYP and CYP with neurodevelopmental disorders or special educational needs.

Given evidence for the feasibility of CBM-I in mild ID, ASD and ADHD identified in this review, CBM research should include participants with neurodevelopmental disorders or otherwise provide sufficient rationales for excluding this group that is in great need of psychological interventions, that may benefit from this type of intervention and that may only require minor methodological adaptations like audio-visual support in order to participate. If authors assume that CBM demands disqualify those with neurodevelopmental disorders from participating, they should either test this assumption by assessing task comprehension and reading ability as a criterion for participation, or otherwise reduce their studies' cognitive and reading demands in order to enable this group's participation.

5.4 Strengths and Limitations

We cannot draw conclusions about the inclusiveness of attention bias modification (ABM) toward neurodevelopmental disorders because all of the identified ABM studies used unambiguous stimuli and therefore had to be excluded due to our ambiguity criterion for defining bias. While the ambiguity criterion might therefore be regarded as a limitation, it did not per see exclude ABM studies, since it is possible to conduct CBM using ambiguous stimuli

(AlMoghrabi et al., 2019). Unlike a previous review on CBM in TD CYP (Cristea et al., 2015), this review excluded studies using negative CBM as their control condition, which may be regarded as a strength because it allowed comparing the efficacy of CBM only to control conditions that were not expected to affect cognitive bias.

Moreover, unlike previous CBM reviews, this review focused on methodological aspects of CBM like training demands, adaptations and exclusion criteria, which provides information about the lack of inclusiveness and representativeness of the CBM field, with practical implications for how future CBM research should take into account the needs of people with neurodevelopmental disorders or special educational needs.

6. Paper 3: Targeting hostile attributions in inclusive schools through online cognitive bias modification: a randomised experiment (Schmidt & Vereenooghe, submitted)

6.1 Theoretical background and objectives

The tendency to interpret other people's ambiguous actions as hostile has been linked to aggression in TD CYP (Orobio de Castro et al., 2002; Verhoef et al., 2019). In contrast, research on the role of such hostile attribution bias in CYP with neurodevelopmental disorders is still scarce and inconclusive, even though this group are at an increased risk of showing aggression (Dekker et al., 2002; Fitzpatrick et al., 2016; King & Waschbusch, 2010). While cognitive bias modification for interpretations (CBM-I) targeting hostile attributions can improve aggression (Hudley et al., 1998; Sukhodolsky et al., 2005; van Bockstaele et al., 2020; Vassilopoulos et al., 2015), CYP with neurodevelopmental disorders or special educational needs have rarely been included in such intervention studies and have frequently been explicitly excluded without an explanation. Even van Bockstaele et al. (2020), who successfully reduced reactive aggression in CYP via CBM-I targeting HAI and who used audio-visual contents to make their training accessible to a sample consisting of pupils with average IQ, learning difficulties or social-emotional problems, excluded participants with ASD without providing an explanation.

CBM-I was previously shown to be feasible in mild ID, ASD and ADHD in studies making minor adaptions to regular CBM by using audio-visual support, simplified language, frequent breaks or rewards (Hiemstra et al., 2019; Klein et al., 2018). Therefore it is possible to remove barriers like cognitive demands that may otherwise hinder the inclusion of those with neurodevelopmental disorders or special educational needs. While the educational context is becoming increasingly more inclusive towards pupils with neurodevelopmental disorders or

special educational needs, CBM-I studies in CYP, which are frequently conducted at school (Cristea et al., 2015), have so far not been sufficiently representative of the inclusive school environment.

This study adopted inclusive inclusion criteria and study methods in order to deliver feasible, effective and acceptable CBM-I targeting hostile attributions, with the aim of also reducing reactive aggression, in pupils of inclusive secondary schools that include CYP with or without neurodevelopmental disorders or special educational needs. To maximise training's accessibility, acceptability and user engagement and to improve upon previous studies that have targeted HAI and aggression in CYP, training was conducted online and an animated avatar was used for training narration and interactive exercises.

While previous CBM-I studies targeting hostile intent attributions in CYP used a test-retest control group (e.g. Van Bockstaele et al., 2020; Vassilopoulos et al., 2015), we used an active control group. In Study 1, we evaluated the efficacy of our new online CBM-I at reducing hostile attributions and reactive aggression. It was hypothesised that the CBM-I would lead to significantly greater reductions in hostile attributions compared to the control training. In line with findings of HAI being more closely linked to reactive aggression than to proactive aggression (Martinelli et al., 2018), and in line with van Bockstaele et al. (2020), who found specific effects of their CBM-I on reactive aggression, not proactive aggression, we expected our CBM-I to significantly reduce self-reported reactive aggression, not proactive aggression.

In order to gather information about how acceptable the intervention is for pupils and about how to improve training content and delivery and overcome barriers to participation, follow-up focus groups were conducted. Given the use of audio-visual support, animated videos and sessions that were short and delivered online, training acceptability was expected to be high.

6.2 Methods

Participants were 71 lower secondary school pupils from two inclusive secondary schools in the Northwest of Germany (Mean age = 12.2, SD = 1.5, % female = 49.3, 25.4%). 25.4% of the sample presented with ADHD, SLD or special educational needs relating to learning, social-emotional development or speech, while teachers reported no neurodevelopmental disorders or special needs for the remaining participants. Pupils generated an anonymous participant code and completed four different pre-training measures, namely the Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP, see supplemental material 1 of Paper 4 in Appendix D), the Reactive-Proactive Aggression Questionnaire (RPQ, Raine et al., 2006), the

Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) and the Revised Peer Experiences Questionnaire (R-PEQ; De Los Reyes, Andres de & Prinstein, 2004). These measures assessed hostile attributions, aggression, emotional and behavioural problems and victimisation experiences, respectively. I newly developed the VASAPP on the basis of previous attribution measures (for an assessment of its psychometric properties, see section 7 and Paper 4 in Appendix D), while we translated the R-PEQ and the RPQ (RPQ-Deutsch, see the appendix of Paper 3 in Appendix C) into German.

The VASAPP consists of six ambiguous social vignettes, involving a protagonist who experiences undesirable social outcomes that could be interpreted either as being deliberately caused by other people with hostile intent or as being accidentally or coincidentally caused by other people with neutral intent. Participants were asked to imagine being the scenario's protagonist and to rate how much they agreed with three different explanations (neutral, hostile or internal) for why the outcome happened. The neutral explanation conveyed the non-hostile interpretation that the event was the result of a coincidence or accident, thus reflecting no blame (NB). The hostile explanation was designed to reflect characterological other-blame (COB), namely attribution of blame to another person's character (e.g. "That mean guy treats other people's stuff badly"), while the internal explanation involved blaming one's own character (e.g. "I deserve that this happens"), designed to reflect characterological self-blame (CSB).

Agreement was rated on a 5-point Likert scale (1=*no, definitely not*; 5=*yes, definitely*), visualised using glasses containing varying quantities of water (see section 7.2). The order of the answer options (i.e. COB, CSB, NB) was counterbalanced across scenarios. Interpretation bias was calculated by subtracting the 'no blame' score from the 'blame' score. For instance, a participant who gave a rating of 5 for COB and a rating of 1 for NB, would have a hostile attribution bias score of 4.

Two sets of the VASAPP (A and B) containing different vignettes were created so that they could be used at pre-training and post-training assessment respectively and therefore be used to evaluate the generalisation of the CBM-I's effects to new vignettes, as well as to reduce the risk of practice effects (Costa et al., 2012). Piloting these two sets in a student sample (n = 185) showed the sets to be equivalent in their assessment of other-blaming (i.e. COB) and self-blaming (i.e. CSB) attributions (see section 7.2 for an outline of VASAPP items and sets).

At pre-training assessment, participants were randomly allocated to complete three online sessions of either CBM-I (n = 37) or active control training (n = 34) self-administered at school

once a week, lasting up to 15 minutes each. Each class was assigned two unique URL links: one for CBM-I and one for the control training, delivered using the e-learning software iSpring Suite (iSpring Solutions, Version 9.7.6.18006). While we did not record participant-level completion data of training, we recorded the number of times the URL links to the respective training sessions were opened in a given class, which gave us an estimate of how many participants in a class had started a particular session.

CBM-I involved interpreting ambiguous scenarios or faces in a non-hostile manner. Each CBM-I session comprised six trials: four containing ambiguous scenarios and two containing ambiguous faces. Figure 3 shows examples of the first session's ambiguous scenarios, presented as videos or cartoons showing how other people could be interpreted as behaving hostile or mean towards the protagonist Mika in the red shirt. Participants were asked to imagine being in Mika's ambiguous situations and, as illustrated in Figure 3, three different CBM-I methodologies were used to resolve scenarios: (a) forced choice between hostile and neutral interpretations with feedback reinforcing the latter, (b) neutral resolution through persuasion, and (c) positive resolution through imagery-based methods.

The two trials with ambiguous faces involved the presentation of a photo of an adolescent with an ambiguous facial expression or bodily posture next to one where the adolescent looked hostile (Figure 4). Participants in the CBM-I group received positive feedback for identifying the ambiguous face as the non-hostile one. The control training was identical in procedure and delivery, but involved attention and memory exercises, such as factual questions (Figure 5). In order to reduce cognitive and reading demands, we enabled participants to simultaneously read and hear all written or verbal elements of the trainings, which I audio-recorded in the trainings' development phase and presented auditorily as the voiceover for the avatar 'Mika'. This avatar thus narrated all sessions of both trainings, in addition to performing short animated dances after each trial to enhance motivation and concentration.

Post-training assessment was completed one week after the final (i.e. third) training session and comprised the second set of the VASAPP, the RPQ and the R-PEQ. All classes that had participated in the pilot randomised controlled trial in one of the two schools were then invited to take part in qualitative interviews aimed at assessing training acceptability. After giving informed consent for this follow-up study, 29.9% of those who had previously participated in the trial took part in these interviews, which were conducted in two groups one month after training. Interviews involved both closed and open questions regarding training likeability, adherence, user experience, delivery, content, expectations, and barriers to participation.

Figure 3. CBM-I trial examples targeting hostile interpretation of ambiguous scenarios

CBM-I method	1. Ambiguous vignette	2. Ambiguity resolution
Valence selection (participant selects an explanation and feedback reinforces non-hostile option/corrects hostile option)		Stell dir vor, die Situation passiert dir. Warum passiert dir das? Der andere Schüler wollte mich mit seinem Getränk überschütten. Der andere Schüler ist ausgerutscht und hat deshalb versehentlich sein Getränk verschüttet. Nein Es kann doch sein, dass er nur sein Getränk verschüttet, weil er ausrutscht.
Persuasion (participant is provided with arguments for why ambiguous situation may be non-hostile)		 Es sieht doch so aus, als ob der andere Schüler seinen Pinsel im Wasserglas waschen will. Dafür streckt er seinen Arm aus und kommt deshalb versehentlich gegen meine Hand, so dass ich mich vermale.
Positive caption positively resolves ambiguous image		 Freunde

Figure 4. CBM-I trial example targeting hostile interpretation of ambiguous faces

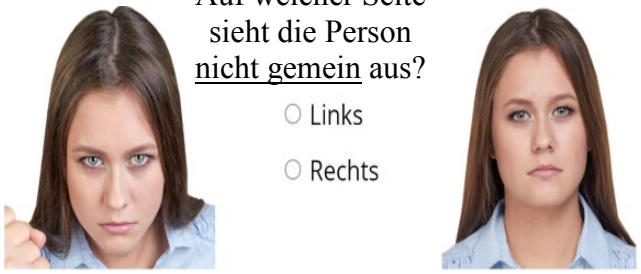
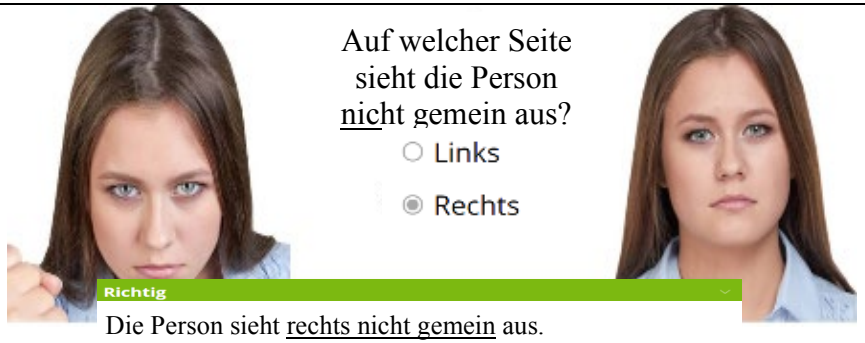
CBM-I method	1. Ambiguous face next to hostile face	2. Ambiguity resolution
Valence selection (Participant receives positive feedback for choosing the ambiguous face as the "non-hostile" face)		

Figure 5. Control training example trial

Control training method example	1. Presentation of face (without contrasting hostile and ambiguous face)	2. Solution
Participant is presented with an ambiguous face and asked a factual question (e.g. find error in photo)	Es gibt einen Unterschied zwischen dem linken und dem rechten Bild. Klicke auf die Stelle im rechten Bild, wo du einen Fehler findest. 	

6.3 Results and Discussion

Three short sessions of inclusive online CBM-I trained lower secondary school pupils from inclusive schools to interpret ambiguous scenarios or faces in a non-hostile manner. Compared to an active control training that involved attention and memory exercises and no ambiguity resolution, CBM-I significantly reduced hostile attributions and self-reported reactive aggression. This finding indicates that the previously reported positive impact of CBM-I targeting hostile attributions on aggression in CYP (van Bockstaele et al., 2020; Vassilopoulos et al., 2015) can also be found in a setting representative of the inclusive school environment.

Unlike in van Bockstaele et al. (2020), the differential effect of CBM-I on hostile attributions reached significance in the current study. However, while they were able to show that training effects on behaviour were specific to reactive aggression, as opposed to proactive aggression (van Bockstaele et al., 2020), the current study's analyses relating to the training effects on proactive aggression were limited by violations of the assumptions for the desired statistical analyses. No alternative nonparametric tests were conducted because our primary outcomes of interest, namely COB and reactive aggression, met the normality assumptions and because mixed ANOVA was important for our study design which aimed to take into account the covariates R-PEQ and SDQ.

Follow-up interviews showed that the use of audio-visual support, tablets, animated videos and interactive exercises, which represented minor adaptations to CBM-I methodology to adjust for potential intellectual, reading or motivational deficits of participants with neurodevelopmental disorders or special educational needs, were perceived as positive. Feedback conveying high likeability of training content and delivery, good training adherence, and requests for longer and more frequent training sessions further supported the acceptability of the training. Voluntary completion of training sessions at home demonstrated the flexibility of online training delivery and indicated that participants' motivation for CBM was unlikely to be merely based on their preference of training over regular school lessons.

6.4 Strengths and Limitations

Compared to previous CBM studies targeting hostile attributions in CYP (van Bockstaele et al., 2020; Vassilopoulos et al., 2015), strengths of the current CBM relate to the use of a randomised controlled design and an active control group, rather than a test-retest control group, the use of online training delivery to increase training accessibility, and the use of qualitative interviews to ascertain training acceptability. Such qualitative feedback is rare and, while the design of the

current study did not involve an assessment and comparison of regular CBM and adapted CBM, findings indicate that the use of audio-visual support, videos and an interactive avatar might make CBM particularly acceptable.

Since less than a third of those participating in the training took part in the interviews, no conclusions can be drawn about whether CBM-I was acceptable for all those who participated in the training. Moreover, since the interview groups did not contain pupils that had previously refused to take part in the training, the study's aim to explore potential barriers to participating in CBM-I could not be adequately addressed.

Information about the proportion of pupils per class who, according to their teachers, presented with such disorders or needs was important for ensuring that participating classes were representative of inclusive classes. However, since this demographic data was only collected at the class-level before the start of the CBM-I, it cannot be linked to particular participants and it cannot be determined how many pupils participating in the follow-up interviews had neurodevelopmental disorders or special educational needs. On the other hand, the intention of the study was to evaluate the acceptability of the training in inclusive settings, not specifically in participants with neurodevelopmental disorders or special needs. Nevertheless, it may be viewed as a limitation that we did not link participants' randomised controlled trial data with their follow-up data. Moreover, it would have been informative to accurately measure treatment adherence and to assess whether actual completion matched the completion that was self-reported at follow-up.

The comparability of the current paper's findings with previous studies is complicated by the fact that a new attribution measure was used which, despite tentative evidence for its psychometric properties provided by piloting it in University students (n=185), still needs to be validated in a larger sample of pupils of inclusive secondary schools (see Paper 4).

Given the similarity of assessment and training items relating to hostile attribution of intent in the current study, and given the use of some training items relating to hostile interpretation of faces, the CBM-I would have benefited from additionally being evaluated using previously published measures of HAI and hostile interpretation of faces. Furthermore, while the study was limited to self-report and only assessed short-term effects, it still needs to be assessed whether the intervention's positive impact is long-term and whether it generalises to improvements in aggression that is additionally rated by teachers or parents or based on behavioural observations.

7. Paper 4: Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP): validation of a new attribution measure (Schmidt & Vereenooghe, submitted)

7.1 Theoretical background and objectives

Research on aggression-related attribution bias has so far focused on hostile intent attributions, namely aggressive individuals' tendency to interpret other people's behaviour as hostile in a specific situation (e.g. "they were trying to be mean", van Dijk et al., 2019), and has paid less attention to whether aggressive individuals also perceive another person's character as mean in general (e.g. "the other child is not a nice person", Haas et al., 2015). Therefore, while attribution of blame to one's own character, referred to as CSB, represents an internal, stable and global attribution that has been linked to depression (e.g. Anderson et al., 1994; Quiggle et al., 1992), the role of attribution of blame to other people's characters, here referred to as COB, is still unclear.

There is some indication that CYP with neurodevelopmental disorders, who have an increased risk for both internalising and externalising problems, might not be characterised by biases in the attribution of intent, but by biases in the attribution of causality or blame (Paper 1). For instance, children with ASD or ADHD were more likely than TD controls to make global attributions ("you get in most kid's way", Flood et al., 2011) or self-blaming attributions (Colalillo et al., 2014). However, research on the combined assessment of other-blaming and self-blaming attributions is scarce, especially in CYP with neurodevelopmental disorders. Moreover, the attribution measures completed by CYP identified in Paper 1 are heterogeneous and rarely included visual presentations of vignettes to adapt cognitive demands to this group.

We therefore developed the VASAPP questionnaire that assesses both COB, CSB, as well as a neutral form of attribution involving no blame (NB), based on pupils' interpretations of ambiguous social vignettes. In order to adjust for potential cognitive or verbal difficulties of people with neurodevelopmental disorders or special educational needs, the VASAPP used simplified language, short sentences and pictorial representations of the Likert-scale and included scenarios that were visualised by colourful cartoons. The use of such an accessible measure is important because it would parallel the increasing inclusiveness of the school environment that educates pupils with special educational needs and pupils without special needs alongside each other (Niendorf & Reitz, 2020). Moreover, the use of an inclusive measure would facilitate meta-analytic comparisons of different cognitive bias studies.

Having used the VASAPP to evaluate the effectiveness of our pilot CBM-I on other-blaming attributions in Paper 3, the aim of this paper (Paper 4) was to assess the psychometric properties of the VASAPP in a larger sample of inclusive secondary school pupils with or without neurodevelopmental disorders or special educational needs. The reliability of the questionnaire will be assessed by examining the equivalence of the two VASAPP sets, as well as the internal consistency and alternate-form reliability of both sets' items. The questionnaire's validity was examined by assessing its content validity, while the construct validity of the three attribution subscales (COB, CSB and NB) was examined using exploratory factor analysis.

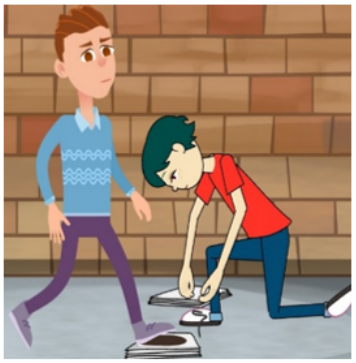
Correlational analyses were used to assess the subscales' convergent validity with aggression, as measured by, to my knowledge, the first German translation of the reactive-proactive aggression questionnaire (RPQ; Raine et al., 2006) which distinguishes between proactive and reactive aggression (Walters, 2005). This RPQ-Deutsch was also assessed in terms of its internal consistency and test-retest reliability. Given closer links between hostile attributions and reactive aggression, relative to proactive aggression (Martinelli et al., 2018; van Bockstaele et al., 2020) and between self-blame and depression, relative to aggression (Quiggle et al., 1992), we expected other-blaming attributions (COB), not self-blaming attributions (CSB), to be positively related to aggression, specifically to reactive aggression.

7.2 Methods

Recruiting from four inclusive lower secondary schools in the Northwest of Germany resulted in a sample of 267 pupils (mean age: 11.28 years, SD = .72, % female = 43.6), 16.10% of whom had special needs in cognition, learning, communication or emotional and social development. Following informed consent, participants generated an anonymous participant code and first completed one VASAPP set (i.e. set A) and the RPQ-Deutsch (see the appendix of Paper 3) followed by the other VASAPP set (i.e. set B) and the RPQ approximately three months later. The two complete sets of the original (German) VASAPP questionnaire can be found in supplemental material 1 of Paper 4 (Appendix D).

Figure 6 presents the items of the two VASAPP sets (A and B) that were previously piloted in a student sample (n = 185) and used to evaluate the efficacy of CBM-I in inclusive secondary school pupils in Paper 3. The six ambiguous social vignettes of each set involved a protagonist, presented in a red shirt in those vignettes that were displayed as cartoons (generated with CrazyTalk® Animator 3), who experiences undesirable social outcomes that are ambiguous as to whether they result from other people's hostile intentions or from an accident or coincidence.

Figure 6. VASAPP vignettes of both sets

	Unfair teacher	Social rejection/ exclusion	Social ridicule	Property damage	Physical harm	Theft
Set A	Samson & Wehby (2019):	Lester, Field, & Muris (2011):	Micco, Henin, & Hirshfeld-Becker (2014):	Hudley & Graham (1993):	Conduct Problems Prevention Research Group (1995):	Miers, Blöte, Bögels, & Westenberg (2008):
	In der Schule stellst du mit deinem Sitznachbarn euer Gruppenprojekt vor. Du hast dir viel Mühe gegeben. Die Lehrerin gibt dir aber eine schlechtere Note als deinem Nachbarn.				Du spielst mit anderen Leuten in der Schule Fußball und stehst im Tor. Du drehst dich um und als nächstes trifft dich einer der Spieler mit dem Ball genau am Kopf. Der Ball trifft dich hart und es tut sehr weh.	Du hast dein Fahrrad vor dem Schulhof abgestellt. Als du nach dem Unterricht das Fahrrad suchst, kannst du es nicht finden.
Set B	Samson & Wehby (2019):	Leff et al. (2006):	Leff et al. (2006):	Petermann, Natzke, Gerken, & Walter (2006):	Troop-Gordon et al. (2018):	McGlothlin & Killen (2006):
	Du und deine Freundin sitzen in einem Fach immer zusammen und schreiben eine wichtige Hausarbeit. Ihr habt beide Probleme mit dem Thema und fragt die Lehrerin um Hilfe. Sie antwortet jedoch nur deiner Freundin.		Du gehst einkaufen und kaufst dir ein neues Oberteil. Am folgenden Tag wirst du nach der Pause an die Tafel gerufen. Als du aufstehst, ruft dir ein Junge aus der Klasse zu, dass du Schmutz auf deinem Oberteil hast. Du hörst, wie seine Sitznachbarin lacht.		Du willst im Klassenraum zu deinem Platz gehen. Plötzlich stolperst du über den Fuß von einem Mitschüler, der sich lachend unterhält und dabei gerade sein Bein ausstreckt.	

Participants were asked to imagine that each event happened to them and to rate, on a scale from 1 (*no, definitely not*) to 5 (*yes, definitely*), how much they agreed with three different explanations for why the undesirable outcome happened. Figure 7 illustrates the water-glass visualisation of the 5-point Likert rating scale. Neutral explanations (i.e. NB) indicated that the situation presented an unintended coincidence or accident, such as that the other boy in Figure 7 "accidentally bumps against" the protagonist's school supplies, as indicated by answer option a). Attribution of blame to one' own character is captured by CSB, as exemplified by answer option b) "I deserve that this happens". Answer option c) reflects COB, namely attribution of blame to another person's character, such as that the other person is generally "a mean guy who treats other people's stuff badly."

Figure 7. VASAPP example vignette with answer options

B. Schulsachen

Schau dir rechts das Bild an und stell dir vor,

du bist die Person rechts im roten T-Shirt.

	1 = **nein, auf keinen Fall**	2 = **eher nein**	3 = **vielleicht ja, vielleicht nein**	4 = **eher ja**	5 = **ja, auf jeden Fall**
Warum passiert dir das? a) Weil der Junge versehentlich gegen meine Sachen stößt.	1	2	3	4	5
b) Weil ich es verdient habe, dass das passiert.	1	2	3	4	5
c) Weil der gemeine Typ die Dinge von anderen schlecht behandelt.	1	2	3	4	5

If a participant rated COB as 5 (*yes, definitely*) in all six scenarios, then this participant's Mean COB score would be 5. While Paper 3 used difference scores to calculate attribution bias (i.e. COB minus NB; CSB minus NB), Paper 4 validated both participants' difference scores (i.e. COB minus NB; CSB minus NB) and participants' raw scores (i.e. COB, CSB and NB). For

instance, the internal consistency for each subscale was calculated both for each subscale's raw scores (e.g. COB) and for each subscale's difference score (e.g. COB minus NB).

To analyse alternate-form reliability, equivalence between the two sets, correlation between subscale scores and subscale difference scores, as well as covergent validity with aggression, we calculated the Mean of each subscale's raw scores across the six vignettes (e.g. Mean COB), as well as the Mean of each subscale's difference score (e.g Mean COB minus Mean NB).

To analyse construct validity with exploratory factor analysis, we combined the items of both sets and used the three subscales' raw scores (i.e. COB, CSB, NB).

In addition, the RPQ total scale and its reactive and proactive subscales were assessed in terms of their internal consistency and test-retest reliability.

7.3 Results and Discussion

Reliability of the two VASAPP sets

Cronbach's alpha values for COB were above .7 in each of the sets, both when using the raw scores of COB and the subscale difference scores of COB (i.e. COB minus NB). Such acceptable internal consistency of other-blaming attributions is comparable with that found for HAI in the studies reviewed by Verhoef et al. (2019; Mean Cronbach's alpha= .73).

Cronbach's alpha values for CSB in the current study were .54 for set A and .63 for set B, which is comparable to the internal consistency of 'self-blame' items in Perren et al. (2013). NB was the weakest subscale, as indicated by poor internal consistency of NB items of set A and a lack of correlation between half of NB items in set A with corresponding NB items of set B (see supplemental material 2 of Paper 4 in Appendix D).

Correlations between subscale scores and subscale difference scores in each separate set were strong for both COB and CSB. When correlating scores between the two sets, correlations were strong for COB and moderate for CSB and NB.

Wilcoxon Signed-Rank Tests showed that the overall COB score of sets A and B were equivalent, which was also the case for the overall CSB difference scores of sets A and B, but not for any of the other scores.

Given the lack of strong evidence for the equivalence of the two VASAPP sets and the comparatively stronger parametric properties of set B, we recommend that future studies, which choose to use only one of the VASAPP sets, should use set B.

Validity of the two VASAPP sets

Content validity of each set was demonstrated by showing how the vignettes' content was based on previous literature.

Exploratory factor analyses of the combined 36 items of both sets rendered some support for the construct validity of the VASAPP, with the emergence of three factors COB, CSB and NB. The factor loadings relating to COB all emerged as expected, but two factor loadings relating to CSB or NB in each set were not anticipated. Suggestions for how to improve the construct validity can be found in the complete manuscript in Appendix D.

Findings also supported the convergent validity of the VASAPP scores with aggression, as measured by the RPQ-Deutsch, the internal consistency and test-retest reliability of which was comparable to that of previous studies (Raine et al., 2006; Cima, Raine, Meesters, & Popma, 2013). Strongest and most consistent associations were found between aggression and the VASAPP subscale COB. As predicted, a greater tendency to attribute hostile character (i.e. COB) was significantly associated with higher levels of aggression, both when using the overall COB score and when using the overall COB difference score (i.e. COB minus NB). This association was stronger and more consistent with reactive aggression than with proactive aggression, which is consistent with Martinelli et al. (2018) who found evidence for a stronger relation of hostile intent attributions with reactive aggression, than with proactive aggression. Our findings have implications for treating reactive aggression, since the link between hostile attributions (i.e. COB) and reactive aggression may be causal, as indicated by van Bockstaele et al.'s (2020) finding that CBM-I targeting hostile attributions specifically improved reactive aggression, but not proactive aggression.

The finding that aggression was also generally associated with self-blaming attributions (i.e. CSB) may be explained by previous findings which showed that aggression, as well as anxiety, fear and depression, was linked to negative information processing biases that are pervasive, rather than specific, and thus for instance relate to both hostile intent attributions and to internal causal attributions (Reid et al., 2006).

Taken together, this paper provides evidence for the validity and reliability of the VASAPP, but in particular for its COB subscale. The VASAPP gives researchers the option to assess the three different attribution styles with a single measure, which is more economical from a research perspective than administering three different measures but still leaves researchers with the option to omit one of the subscales. Reasons for keeping CSB in the questionnaire,

despite comparatively weaker psychometric properties than COB, include the possibility that it provides a more complete picture of someone's interpretation of social ambiguity and that its role in explaining psychiatric comorbidity in individuals with or without neurodevelopmental disorders has yet to be clarified (Colalillo et al., 2014; Reid et al., 2006; Sharma et al., 2014). While future studies may consider dropping the weakest subscale, namely NB, a reason for the retention of this subscale is that it allows the calculation of subscale difference scores (e.g. COB minus NB) which is in line with previous research and controls for neutral interpretations and extreme answer patterns (Orobio de Castro et al., 2002; Yiend et al., 2019).

7.4 Strengths and Limitations

Since the VASAPP is based on self-report and on hypothetical vignettes, it may not accurately capture attributions that individuals actually make for ambiguous events with undesirable outcomes in real life. In addition, responses might be influenced by a social desirability effect which may cause individuals to endorse the socially desirable no-blame (NB) items, as opposed to the other-deprecating COB items. However, the addition of CSB items might make it less obvious which responses are socially desirable and the counterbalanced order of items was designed to reduce the risk of order effects.

While this paper validated the German translation of the self-report aggression measure RPQ and provided evidence for its convergent validity with the VASAPP, it would have been beneficial to additionally validate VASAPP with other aggression measures, including ones based on proxy-report or behavioural observations. Moreover, since the VASAPP also measured self-blaming attributions (CSB), which are known to be associated with depression (Anderson et al., 1994), future studies may improve upon the current study by also including a depression measure and assess its association with CSB.

A much larger sample would be required to investigate whether the results are generalisable to CYP with specific special needs or neurodevelopmental disorders. As there were no reports of children having difficulties understanding or completing the VASAPP in our inclusive sample, a larger study comprising more CYP with neurodevelopmental disorders or special needs would likely be feasible. Alternatively, reading demands could be further reduced by only using colourful cartoons to present vignettes, as indicated by piloting the VASAPP in pupils with special needs in mental development (Sievert, 2019). Given the accessibility and psychometric properties of the VASAPP, it has the potential to make cognitive bias research more inclusive and representative of CYP with and without neurodevelopmental disorders or special needs.

8. General discussion

This chapter discusses and integrates the results and implications of the four papers, in light of this dissertation's four objectives. The first two objectives were to examine evidence for (i) cognitive bias and its associations with mental health outcomes in CYP with neurodevelopmental disorders, and evidence for (ii) the efficacy of CBM in CYP with neurodevelopmental disorders and the extent of their exclusion from CBM. The next two objectives were to examine (iii) the efficacy and acceptability of a newly developed CBM-I targeting hostile attributions, assessed using a novel cognitive bias measure, in an inclusive sample of secondary school pupils with or without neurodevelopmental disorders, as well as to assess (iv) the psychometric properties of the new cognitive bias measure in a larger sample of pupils in inclusive secondary schools.

8.1 Interpretation bias in CYP with or without neurodevelopmental disorders

This section summarises the evidence that this thesis gathered regarding previous studies' assessment and modification of different types of biased interpersonal ambiguity processing in CYP with neurodevelopmental disorders (Papers 1-2), and regarding our own novel attempt to assess and modify hostile attributions in inclusive samples of pupils with or without neurodevelopmental disorders (Paper 3-4).

Hostile attribution of intent

Table 13 shows how many of the studies reviewed in Paper 1 found differences in cognitive bias between CYP with neurodevelopmental disorders and TD CYP and how many found associations between cognitive bias and mental health outcomes in CYP with neurodevelopmental disorders. Moreover, Table 13 shows how many of the CBM studies identified in Paper 2 included CYP with neurodevelopmental disorders.

Given previous reports of increased rates of aggression in neurodevelopmental disorders (Dekker et al., 2002; Fitzpatrick et al., 2016; King & Waschbusch, 2010), it was expected that a bias commonly associated with aggression in TD individuals, namely HAI (Verhoef et al., 2019), would be associated with aggression in CYP with neurodevelopmental disorders and would be higher in CYP with neurodevelopmental disorders than in TD controls. Contrary to predictions, reviewed studies in Paper 1 overall did not find increased HAI in the neurodevelopmental disorders group, when compared to the TD group (Table 13). However, the interpretation of findings in Paper 1 is complicated by the fact that reviewed studies did not

generally assess or account for the possible effect of participants' comorbidity with externalising disorders on cognitive bias.

Table 13. The extent and modification of hostile intent attributions in CYP with NDD

Assessment (Paper 1)				Intervention (Paper 2)	
No group difference	Higher in NDD	Lower in NDD	Mental health link	Included	Explicitly excluded
ADHD = TD: 4/4 ASD = TD: 1/2 ID = TD: 1/3 SLD = TD: 1/1	ID > TD: 1/3	ASD < TD: 1/2 ID < TD: 1/3	ADHD: 0/1 (*)	ADHD: 1/6 (++)	ASD: 1/6

Note. The table presents the number of studies with a particular finding or characteristic, out of all the relevant identified studies. For instance, 'ASD=TD: 1/2' means that one out of the two studies assessing HAI in ASD found no group difference. Likewise, 'ASD: 1/6' in the 'explicitly excluded' column means that one out of six identified CBM-I studies targeting HAI excluded CYP with ASD.

++ improved bias and mental health outcomes (here, aggression, conduct problems and anger)

* Positive association of HAI with aggression was only found in TD girls without ADHD

Due to previous evidence for the link between ADHD and reactive aggression (Card & Little, 2006) and for the link between hyperactive-aggressive symptoms and HAI (Milich & Dodge, 1984), HAI was expected to be higher in ADHD than in TD controls, which was however not supported by the four studies conducted in CYP with ADHD that were identified in Paper 1 (Table 13).

While HAI was expected to be associated with aggression in neurodevelopmental disorders in Paper 1, only one identified study assessed such associations. This study found HAI to be associated with aggression in girls without ADHD, not in girls with ADHD (Mikami et al., 2008). However, it is important to point out that Mikami et al. (2008) did not assess associations of HAI with reactive aggression in particular and that findings relating to girls with ADHD might not generalise to boys with ADHD who may be more likely than girls with ADHD to show hyperactivity and externalising problems (Biederman et al., 2002; Gershon, 2002), even though gender differences have not been consistently reported (E. B. Owens et al., 2015).

If future studies do not consistently find increased HAI in CYP with ADHD, compared to TD CYP, or do not find links between aggression and HAI in the ADHD group, this would indicate that HAI does not characterise ADHD and that HAI does not underlie the frequent occurrence of aggression in this group. Even though the ADHD symptoms inattention, hyperactivity and impulsivity, as well as frequent emotion dysregulation, likely represent factors that increase the risk of reactive aggression in this group (Barkley, 2015), lack of evidence for an aggression-related cognitive bias (i.e. HAI, Table 13) in ADHD might be interpreted as supporting the conception that ADHD and reactive aggression represent two dimensions of externalising problems that are correlated but distinct (King & Waschbusch, 2010; Waschbusch, 2002).

Moreover, Verhoef et al.'s (2019) finding that the proportion of participants with ADHD in aggressive samples did not moderate the strength of the relationship between HAI and aggression also indicates that having ADHD may not make individuals more prone to showing HAI, over and above having aggression. On the other hand, their finding was based on only 10% of all effect sizes and therefore, as Verhoef et al. (2019) suggested, true effects of ADHD as a moderator of the link between HAI and aggression may be more likely to be detected if more studies include participants with ADHD or assess ADHD comorbidity.

With regards to another type of neurodevelopmental disorder, namely ID, that was also expected to show increased HAI due to its frequent comorbidity with externalising problems (Dekker et al., 2002; Douma et al., 2007; Emerson et al., 2011), evidence was inconsistent (Table 13). Only van Nieuwenhuijzen et al. (2011) found higher HAI in the ID group than in TD controls, namely in children with mild ID or borderline intellectual functioning. Their finding is in line with a study that emerged since the systematic review of Paper 1 was completed and that reported higher HAI in the low IQ group, relative to the average IQ group (van Rest et al., 2020). In contrast to Pert et al.'s (1999) finding of increased HAI in aggressive adults with ID, compared to non-aggressive adults with ID, HAI in Nieuwenhuijzen et al. (2011) did not distinguish the ID group with behaviour problems from the ID group without behaviour problems.

While Paper 1 found no evidence for more hostile intent attributions when processing interpersonal ambiguity in CYP with ASD, compared to TD controls (Table 13), evidence for increased HAI in this group has been mixed when studies measured HAI as the combined score for both ambiguous and accidental scenarios (Mazza et al., 2017; Meyer et al., 2006; Russo-Ponsaran et al., 2018; Ziv et al., 2014), as shown in Table 3 (see section 1.5). Therefore, in order to better understand the social-cognitive processes that may underlie increased aggression

in ASD (Fitzpatrick et al., 2016), it may be important to also consider this group's processing of unambiguously benign information, as discussed in section 8.2 below.

With regards to hostile intent attributions in CYP with SLD, studies have been scarce and evidence for increased HAI in this group was weak (Tables 3 and 13).

In summary, studies assessing the cognitive bias HAI in CYP with neurodevelopmental disorders have not distinguished between reactive and proactive aggression and have not taken into account this group's frequent comorbidity with externalising disorders in their analysis. Considering the scarcity of research on associations between HAI and mental health outcomes in CYP with neurodevelopmental disorders, future research still needs to examine and clarify the link between HAI and reactive aggression in this group.

As outlined in Paper 2 and displayed in table 13, only one identified CBM-I study that specifically targeted hostile intent attributions with the aim of reducing aggression in CYP included participants with neurodevelopmental disorders. Sukhodolsky et al. (2005) successfully reduced HAI and externalising problems in a sample referred for excessive anger, aggressive and disruptive behaviour, one third of which had either ADHD, oppositional defiant disorder or depression. However, authors did not specify the exact number of participants who had ADHD and excluded those with ASD without providing an explanation (Sukhodolsky et al., 2005).

While Hudley et al.'s (1998) attribution training targeting HAI "specifically excluded" pupils with special educational needs, van Bockstaele et al.'s (2020) CBM-I that has been published since we conducted the review of Paper 2 reduced reactive aggression in adolescents recruited from special schools for pupils with average IQ and learning difficulties or social-emotional problems. However, van Bockstaele et al. (2020) excluded individuals with ASD and did not specify if any of their participants had neurodevelopmental disorders or special educational needs. Therefore, to our knowledge, CBM-I studies have not yet trained non-hostile interpretation of ambiguous interpersonal events in CYP with ID, ASD or SLD (Table 13).

In order to address this gap in the literature regarding cognitive bias assessment and modification that are inclusive towards CYP with neurodevelopmental disorders, a pilot randomised controlled trial with qualitative interviews was conducted in Paper 3 to examine the efficacy and acceptability of our newly developed accessible CBM-I in inclusive school pupils, one fourth of which presented with the neurodevelopmental disorders ADHD or SLD or with special educational needs relating to learning, social-emotional development or speech.

Using audio-visual support, animated videos, an avatar and online training delivery, our inclusive CBM-I trained pupils to interpret ambiguous scenarios or faces in a non-hostile manner, which led to significant reductions in hostile attributions and self-reported reactive aggression, when compared to an active control training that involved attention and memory exercises without resolving ambiguity. The training thus replicates previous evidence for the impact of CBM-I targeting hostile attributions on reducing self-reported aggression (van Bockstaele et al., 2020; Vassilopoulos et al., 2015), while improving upon these studies through the use of randomised controlled design and online training delivery.

While Lisk et al. (2018) represents a rare example of a CBM study that conducted interviews to provide evidence for their training's acceptability, they used a case series design and only included 19 participants. In contrast, our CBM-I in Paper 3 was compared to an active control group, used audio support, online delivery and a larger sample size (n=71). According to our follow-up interviews, which included a similar number of participants (n=23) to Lisk et al. (2018), pupils perceived the use of audio-visual support, an avatar, animated videos and interactive exercises as positive, frequently completed sessions at home if they missed them at school and were motivated for more sessions.

While interviews thus supported the acceptability of the training, it remains to be determined if participants' motivation for training remains high when it does not substitute regular lesson time. Moreover, to ensure that training is acceptable for CYP with different types of neurodevelopmental disorders or special educational needs, systematically gathered qualitative feedback would need to take into account how many of the interviewed participants have neurodevelopmental disorders, as well as the specific type of disorder or special need they have.

Since SLD and ADHD were the only types of neurodevelopmental disorders present in the sample in Paper 3, results are not generalisable to other types of neurodevelopmental disorders like ID or ASD. In order to assess the generalisability of this CBM-I's effects to clinical and neurodevelopmental disorders groups, its efficacy would need to be assessed in a clinically aggressive sample or in a sample containing a higher proportion of CYP with neurodevelopmental disorders, preferably confirmed by diagnostic interviews to ensure the validity and reliability of diagnoses. On the other hand, using inclusive samples rather than samples consisting only of people with specific disorders increases ecological validity and likely facilitates the distribution of interventions like this CBM-I.

Hostile interpretation of faces

Paper 2 identified one CBM that targeted a cognitive bias related to HAI, namely hostile interpretation of faces, in a clinically aggressive male sample mostly consisting of participants with ASD, ADHD or both, which successfully improved hostile interpretation of faces, however not HAI, anger or aggression (Hiemstra et al., 2019). Given that hostile interpretation of faces was previously reported in young people with disruptive mood dysregulation disorder, 87% of whom had ADHD, this cognitive bias might represent a suitable treatment target in ADHD (Stoddard et al., 2016).

However, since Hiemstra et al.'s (2019) CBM-I did not improve anger or aggression, it is possible that exclusively training non-hostile interpretation of ambiguous faces does not generalise to improvements in mental health outcomes. In contrast, our CBM-I intervention in Paper 3, which included both trials relating to ambiguous scenarios and relating to faces or bodily postures, might have yielded training effects on self-reported aggression because the combination of these items is more representative of daily interactions leading to aggression. Since Paper 3 did not include a cognitive bias measure that specifically assessed hostile interpretation of faces, it is unclear whether our CBM-I modified this type of bias.

Attributions of causality

Most research on aggression-related interpretation bias in CYP of typical development or neurodevelopmental disorders has focused on whether other people's behaviour in a specific situation is interpreted as hostile (i.e. HAI), and not on whether the cause of another person's behaviour is perceived to be stable or global.

The only study identified in Paper 1 that assessed both intent attributions and the internality, stability and globality of attributions in CYP with neurodevelopmental disorders was Flood et al. (2011). While their ASD group was not more likely than the TD group to attribute hostile intent or to attribute negative outcomes of ambiguous scenarios to external rather than internal, or stable rather than unstable causes, they showed an increased tendency to make global rather than specific attributions (Table 14).

Whether or not a global attributional style is characteristic of CYP with ASD and whether it is related to externalising or internalising problems in this group still needs to be clarified.

Table 14. The extent of causal attributions in CYP with NDD, compared to TD controls

Assessment (Paper 1)		
No group difference	Higher in NDD	Lower in NDD
<u>Internal:</u> ASD = TD: 1/1	<u>Internal:</u> ADHD > TD: 2/2*	
<u>External:</u> ADHD = TD: 2/2	<u>Global:</u> ASD > TD: 1/1	
ASD = TD: 1/1		
<u>Stable:</u> ASD = TD: 1/1		

Note. The table presents the number of studies with a particular finding, out of all the relevant identified studies. For instance, 'Internal: ADHD>TD: 2/2' means that two out of the two studies assessing internal attributions in ADHD found increased cognitive bias in ADHD.

* ADHD (with conduct problems and callous-unemotional traits)>TD CYP (Haas et al., 2015)

As shown in Table 14, the only two studies identified in Paper 1 that assessed attributions of causality in CYP with ADHD did not find this group to attribute more blame for ambiguous events to their peers or parents, compared to TD controls (Colalillo et al., 2014; Haas et al., 2015). The assessment of external attributions ("the other child is not a nice person") in Haas et al. (2015) is a rare example of the assessment of hostile attribution of other people's character which resembles the VASAPP's other-blaming attribution subscale that we labelled COB (Papers 3-4). While Haas et al. (2015) found no evidence for increased other-blame in ADHD, they found increased attribution of blame to internal causes ("I have problems and can't control myself") for ambiguous events with negative outcomes in boys that had both ADHD, conduct problems and callous-unemotional traits, compared to TD controls. Results relating to self-worth however indicated that this ADHD group did not feel bad about their own behaviour problems (Haas et al., 2015).

Boys with ADHD in Colalillo et al. (2014) were not more likely than controls to blame their parents for not wanting to play with them or help them, but made more internal attributions than TD boys (e.g. "My mom doesn't help me because of something I did''). However, regardless of whether the outcome of scenarios was positive (i.e. parents played with them) or negative (i.e. parents did not play with them), the ADHD group showed an increased tendency to attribute outcomes to their own behaviour. Authors theorised that this might reflect an "egocentric" interpretation bias in ADHD that could be related to ToM deficits or that it might

reflect a positive illusory bias that some studies have linked to ADHD, namely a tendency to overestimate one's own competence (Colalillo et al., 2014; Hoza, Pelham, Milich, Pillow, & McBride, 1993; J. S. Owens, Goldfine, Evangelista, Hoza, & Kaiser, 2007). On the other hand, increased self-blame for negative outcomes is characteristic of depression (Anderson et al., 1994) and may therefore also play a role in explaining increased levels of internalising problems in ADHD (Angold et al., 1999; Pliszka, 2015).

With regards to the findings of Papers 1 and 2, evidence pointing to a tendency towards internal, stable or global attributions in CYP with neurodevelopmental disorders needs to be replicated because it is based on a small number of studies that provided little information about the relation between such attributions and externalising or internalising problems.

While Paper 1 did not identify studies assessing attributions of causality in CYP with ID, a previous study found that adults with mild ID comorbid with depression made more internal, stable and global attributions, compared to adults that had mild ID and no depressive disorder (Hartley & Maclean, 2009). Moreover, evidence for the link between internal attributions and anxiety in children with ASD was provided by a study which was not included in the review of Paper 1 because it used vignettes describing "frustrating" events, such as being rejected by peers or arguing with siblings, without stating whether events were ambiguous (Sharma et al., 2014). They showed that, in addition to being more likely than TD controls to hold negative expectancies about the outcomes of events and to have low confidence in their ability to deal with events' adverse consequences, children described by authors as displaying "high-functioning" ASD, were more likely to take responsibility and thus blame themselves for the events, which was related to higher anxiety.

Given the frequently high rates of internalising problems like anxiety and depression in neurodevelopmental disorders (Emerson, 2003; Iverach et al., 2016; Nelson & Harwood, 2011; Pliszka, 2015; Simonoff et al., 2008), self-blaming attributions might be particularly relevant in this group. In spite of this, research is lacking.

In light of the scarcity of research on attributions of causality in CYP with neurodevelopmental disorders, one objective of this thesis was to develop an accessible measure that assessed both other-blaming and self-blaming attributions, namely the VASAPP, which was validated in Paper 4 and used to evaluate the efficacy of CBM-I targeting hostile attributions in Paper 3. Using simplified language, images and visualisation of the Likert scale, the VASAPP was designed to account for potential difficulties with cognitive or verbal skills of some participants

and thus to represent an accessible attribution measure that could be completed by everyone. Paper 4 found evidence for the validity and reliability of the VASAPP, particularly for the COB subscale, in a larger sample of lower secondary school pupils, one sixth of whom had SLD, ADHD or special needs in cognition, learning, communication or emotional and social development.

Findings supported the convergent validity of the VASAPP with aggression, as measured by the RPQ-Deutsch, which showed internal consistency and test-retest reliability that was comparable to that of previous studies (Raine et al., 2006). As predicted, a greater tendency to attribute hostile character (COB) was significantly associated with higher levels of aggression. This association was stronger and more consistent with reactive aggression than with proactive aggression, which is in line with the review by Martinelli et al. (2018) who found evidence for a stronger relation between hostile intent attributions and reactive aggression, than proactive aggression.

While the samples of studies reviewed in Paper 1 consisted entirely of CYP with ID, ASD, ADHD or SLD, the sample in Paper 4 only contained a small number of CYP with neurodevelopmental disorders, primarily with SLD or ADHD. Therefore findings of Paper 4 cannot be directly compared to those of Paper 1 and do not provide information about whether cognitive bias is higher in neurodevelopmental disorders and whether it explains increased rates of aggression in this group. In order to assess whether VASAPP scores and associated aggression scores differ between TD individuals and those with neurodevelopmental disorders, or between different neurodevelopmental disorders groups, a larger sample size would be needed containing a larger proportion of participants with neurodevelopmental conditions.

Furthermore, even though the current thesis set out to look at all types of neurodevelopmental disorders that are grouped together in the DSM-5, Papers 1 and 2 only identified studies on cognitive bias in CYP with ADHD, ASD, ID and SLD, and no studies on cognitive bias in CYP with motor or communication disorders. Moreover, neurodevelopmental disorder status or special educational needs status reported by teachers for pupils participating in Papers 3 and 4 were only related to ADHD, SLD, learning, social-emotional development, mental development and speech. This thesis therefore likely did not do full justice to the different types of neurodevelopmental disorders or special educational needs. For instance, no attention was paid to people with the special need ‘hearing’ who are equally entitled to inclusion and may also show biases and deficits in social information processing (Torres, Saldaña, & Rodríguez-Ortiz, 2016). Given that items of the VASAPP are presented as text or pictures, it would likely

have been feasible in deaf individuals, but would have to be limited to audio-narrated text if it was to be completed by individuals with the special educational need 'seeing' who are visually impaired or blind.

The use of more homogenous samples, such as samples only including TD individuals or only including one type of neurodevelopmental disorder, would reduce the variation between participants and thus allow the generalisation of results to specific groups. On the other hand, heterogeneous samples like the ones used in Paper 4 have the advantage of being a more accurate representation of the real-life school environment that is becoming increasingly inclusive and heterogeneous.

Paper 3 showed that our CBM-I which trained non-hostile interpretations of ambiguous events significantly improved other-blaming attributions (i.e. COB) and self-reported reactive aggression, when compared to an active control training. While the effect of our CBM-I on cognitive bias was assessed using a measure assessing different attributions of blame (i.e. COB and CSB), the intervention was not specifically designed to train participants to attribute less blame to others' or one's own character, but more generally trained non-hostile attributions of other people's actions. Since the CBM-I studies identified in Paper 2 also did not target attributions of causality, but negative or hostile interpretations (Tables 13-15), it would be interesting to also assess the effects of CBM-I targeting stable external attributions (i.e. COB) or stable internal attributions (i.e. CSB).

For instance, the CBM by Lisk et al. (2018) that targeted both interpretation bias and attention bias in TD adolescents showed how to incorporate a component targeting negative internal attributions. First, they presented participants with ambiguous scenarios, such as a photo of a group of peers standing together and looking at the protagonist, and then asked them to resolve a written explanation of the scenario in a positive direction using word fragment completion (e.g. "They have been w_iti_g to walk to school with you", Lisk et al., 2018). After a comprehension question that reinforced the positive interpretation ("Do your friends want to chat on the way to school?), participants were trained to make positive internal attributions about this positively resolved outcome, such as by being asked to type a reply to the open question "what makes you good to talk to?". It is possible that incorporating such a component in our MIKA training (Paper 3) would have helped bring about improvements in self-blaming attributions (e.g. CSB).

Social threat interpretations

In the only study identified in Paper 1 that assessed associations between cognitive bias and anxiety in ID (Table 15), evidence was found for content-specific interpretation bias in CYP with mild ID, whose negative interpretations of ambiguous social threat scenarios, not physical threat scenarios, predicted symptoms of social anxiety (Houtkamp et al., 2017). Such findings are in line with previously reported specific links between social threat interpretation bias and social anxiety in TD individuals (Mobach et al., 2019) and support the use of CBM to target such bias to improve social anxiety in mild ID.

The possibility that social threat interpretation bias is not only a suitable, but also a feasible treatment target in mild ID, was indicated by findings that both social threat interpretation and social anxiety improved in CYP with mild ID as a result of CBM-I adapted for use in this group (Klein et al., 2018). Future studies need to assess whether these effects can also be found in pupils with moderate or severe ID.

Table 15. The extent and modification of social threat interpretations in CYP with NDD

Assessment (Paper 1)				Intervention (Paper 2)	
No group difference	Higher in NDD	Lower in NDD	+ve association with mental health outcomes	Included	Explicitly excluded
	ASD>TD: 1/1*		ID: 1/1**	ID: 1/20 (++)	ID: 2/20 ASD: 2/20 SLD: 3/20

Note. The table presents the number of studies with a particular finding or characteristic, out of all the relevant identified studies. For instance, 'ASD>TD: 1/1' means that the only study that assessed this bias in ASD found higher bias in ASD. Likewise, 'ASD: 2/20' in the 'explicitly excluded' column means that one out of twenty CBM-I studies targeting this bias excluded CYP with ASD.

++ improved cognitive bias and mental health outcomes (here, social anxiety in mild ID)

* in ASD comorbid with anxiety

** positive association of bias with social anxiety in CYP with mild ID

Since no studies compared social threat interpretation bias between TD individuals and those with ID, it is unclear whether this bias is particularly pronounced in this neurodevelopmental disorder group. However, given Klein et al.'s (2018) evidence for CBM-I's beneficial effects

on social anxiety in a group which has an increased risk for mental health problems (Dekker et al., 2002; Emerson, 2003) and therefore an increased need for interventions targeting the processes associated with these problems, it is problematic that none of the other 19 identified CBM studies targeting this bias included those with ID and that two explicitly excluded them (Table 15).

Apart from Houtkamp et al. (2017), the only other identified paper assessing social threat interpretation bias in neurodevelopmental disorders was Hollocks et al. (2016) who found that boys with ASD and comorbid anxiety showed an increased tendency to make negative interpretations of ambiguous social threat scenarios, but not physical threat scenarios, compared to TD boys. Since none of the other studies identified in Paper 1 assessed associations between cognitive bias and anxiety in ASD, no clear conclusions can be drawn about the role of cognitive bias in explaining the increased risk of anxiety in ASD (J. A. Kim, Szatmari, Bryson, Streiner, & Wilson, 2000; Simonoff et al., 2008).

Despite the previously reported high rates of social anxiety in ASD, which might partly be explained by social threat interpretation bias in this group, none of the 20 CBM-I studies identified in Paper 2 that targeted this cognitive bias included participants with ASD and two even explicitly excluded them (Table 15). The only study that gave a reason for excluding those with neurodevelopmental disorders or special needs stated that participants with pervasive developmental disorders, ID or dyslexia were excluded from their CBM because of their study's reading demands (Micco et al., 2014). This demonstrates the frequent categorical exclusion of CYP with neurodevelopmental disorders.

While studies assessing social threat interpretation bias in Paper 1 did not assess associations with aggression, it would be interesting to see whether this bias is linked to reactive aggression and whether CBM-I targeting this bias also improves reactive aggression. Reactive aggression is closely linked to anxiety (Bubier & Drabick, 2009; Card & Little, 2006; Marsee et al., 2008; Vitaro, Brendgen, & Tremblay, 2002) and, as pointed out by Bubier and Drabick (2009), reactive aggression and anxiety share risk factors, including their style of information processing. Moreover, Reid et al. (2006) showed that negative interpretation of ambiguity is linked to aggression, anxiety and depression.

Comparing the content of CBM-I targeting social threat interpretation bias (e.g. Klein et al., 2018) with that of CBM-I targeting hostile attributions (e.g. Paper 3), illustrates that certain items are likely relevant to both social anxiety and reactive aggression, namely those that could

be interpreted as reflecting social rejection or ridicule. For instance, one item in Klein et al. (2018) trained participants to interpret classmates' smiles during the protagonist's presentation as an indication that they liked the presentation, while one item in our CBM-I in Paper 3 involved a video of two classmates laughing during Mika's presentation and pointing to the fact that they were laughing about something on their phones, rather than about Mika. It should be explored whether the MIKA training can also reduce social anxiety.

8.2 Theoretical and practical implications

Overall, the four papers of this thesis showed that valence-specific interpretation of interpersonal ambiguity may be linked to aggression or anxiety in CYP with or without neurodevelopmental disorders, and can be improved in both groups using CBM-I, with beneficial effects on externalising or internalising problems.

Specifically, the reviews of Papers 1 and 2 found some evidence for increased internal or global attributions in CYP with ADHD or ASD, and for links between social threat interpretation bias and anxiety in ASD and mild ID, as well as for the potential of CBM-I to improve both bias and anxiety in mild ID. However, these findings are based on a small number of heterogeneous studies. While HAI was the cognitive bias type that was most frequently researched by studies assessing valence-specific ambiguity processing in CYP with neurodevelopmental disorders, HAI was not consistently found to be higher in this group than in TD controls and was rarely targeted in CYP with neurodevelopmental disorders by CBM-I studies (Paper 2).

Paper 3 showed that inclusive CBM-I that trained non-hostile interpretations of ambiguous events and that was designed to adjust for potential processing needs of pupils with neurodevelopmental conditions or special needs, was feasible, effective and acceptable in a sample that was representative of the inclusive school environment.

Paper 4 tested the psychometric properties of our new attribution measure VASAPP in a larger sample of inclusive school pupils and provided evidence for the validity and reliability of questionnaire, in particular for the other-blame (i.e. COB) subscale which showed good internal consistency, construct validity and convergent validity with aggression.

The findings of this thesis have implications for understanding psychiatric comorbidity in CYP with neurodevelopmental disorders, for the inclusion of this group in CBM research and for optimising the accessibility, acceptability and representativeness of CBM research.

CBM in neurodevelopmental disorders

The thesis has shown that it is feasible to implement CBM-I in CYP with neurodevelopmental disorders (Papers 1-2) and in CYP with and without neurodevelopmental disorders or special educational needs in inclusive settings (Paper 3). Given its brevity, accessibility and acceptability, our CBM-I evaluated in Paper 3 represents a promising form of attribution and aggression retraining that could easily be integrated into the school curriculum and flexibly be completed at a location and time of one's choosing, on a computer, laptop or mobile device. The anonymity, multimedial delivery and consistent feedback associated with a computerised intervention like our MIKA training may increase young people's motivation to participate in psychological interventions, especially if the social interaction involved in face-to-face intervention represents a barrier for them. The positive feedback that pupils of inclusive schools gave about our CBM-I in Paper 3 supports our efforts to make the training engaging.

Given that CBM-I is feasible in neurodevelopmental disorders, findings of a general lack of inclusiveness of CBM studies towards neurodevelopmental disorders and the frequent unjustified exclusion of this group (Paper 2) are problematic because those with neurodevelopmental disorders are in particular need of psychological interventions and because they may benefit from this type of intervention (Hiemstra et al., 2019; Klein et al., 2018). Arguably, cognitive demands of CBM-I are not an adequate justification for categorically excluding those with neurodevelopmental disorders or special educational needs because, firstly, studies would need to show that this group cannot meet these demands and, secondly, such demands may easily be reduced and thus adapted to this group using audio-visual support and simplified language, as illustrated by Klein et al. (2018) and Paper 3.

Moreover, excluding CYP with neurodevelopmental disorders or special educational needs from cognitive bias research is in conflict with the rights of people with disabilities to equal treatment. According to the UN Convention on the Rights of Persons with Disabilities, governments that have ratified the convention need to ensure the realisation of equal rights of people with disabilities, which not only includes equal access to education, but also to health services and new assistive technologies (United Nations General Assembly, 2006).

Furthermore, the Convention requires its member states to conduct the research that is necessary to successfully implement inclusion. This points to the importance of including CYP with disabilities in research and making adjustments for this group to facilitate their participation (Niendorf & Reitz, 2020; UN Committee on the Rights of Persons with Disabilities, 2016).

There are further reasons why the general lack of inclusiveness of cognitive bias research toward CYP with neurodevelopmental disorders is problematic. For instance, given the high rates of aggression in neurodevelopmental disorders and the relative scarcity, heterogeneity and inconclusiveness of findings relating to HAI in this group, this cognitive bias may still represent a plausible mechanism explaining increased externalising and internalising problems in this group and thus a potential treatment target to improve these problems in this group,

Aggression in neurodevelopmental disorders

While the role of biased interpersonal ambiguity processing in neurodevelopmental disorders is underresearched and still unclear, lack of consistent evidence for increased biases in the interpretation of interpersonal ambiguity in neurodevelopmental disorders (Paper 1) indicates that we have to at least consider the possibility that alternative mechanisms might better explain the comparatively higher prevalence of internalising and externalising problems in this group. These mechanisms include biases and deficits in the encoding of unambiguous information, inaccuracies in the interpretation of neutral intent, difficulties with the response generation and evaluation stages of social information processing, as well as impairments in general or social cognition, as outlined next.

General encoding difficulties

Social information processing studies that have assessed encoding in CYP with neurodevelopmental disorders most frequently assessed the total number of cues encoded, regardless of the valence of cues (Table 1 in section 1.5), and showed that CYP with ASD, ADHD, ID or SLD encoded fewer cues in total than controls (Andrade et al., 2012; Bauminger et al., 2005; Bauminger & Kimhi-Kind, 2008; Bauminger-Zviely et al., 2019; Matthys et al., 1999; Mazza et al., 2017; Tur-Kaspa & Bryan, 1994; van Rest et al., 2020; Ziv et al., 2014). Moreover those with SLD, ASD or ID were more likely than controls to encode irrelevant cues not mentioned in scenarios (Bauminger & Kimhi-Kind, 2008; Meyer et al., 2006; Tur-Kaspa & Bryan, 1994; van Nieuwenhuijzen et al., 2011).

Such findings point to a general deficit in encoding social cues which may be due to inattention or working-memory deficits (Andrade et al., 2012; Ferretti, King, Hilton, Rondon, & Jarrett, 2019). For instance, Andrade et al. (2012) suggested that the reason why children with ADHD encoded fewer neutral, positive and negative cues than controls may be because they failed to notice cues due to attention problems or failed to adequately encode them due to impairments

in working memory. In line with this reasoning, better cue encoding was linked to higher levels of working memory in CYP with mild ID or borderline intellectual functioning (van Rest et al., 2019) and worse cue encoding was linked to externalising problems in this group (van Nieuwenhuijzen et al., 2009).

As a result of general encoding difficulties, individuals with in neurodevelopmental disorders may be more likely to base their interpretation of a situation and their reaction to it on incomplete information, which may increase the risk of an aggressive response (Andrade et al., 2012). Therefore, in order to prevent a negative impact of such encoding difficulties on other social information processing steps, it may be important to train the encoding of social cues in this group. One way to achieve this is via the *Making Choices* program which uses the social information processing model to reduce aggression (Fraser et al., 2001). Unit two of this program involves explaining the concept of a social cue to participants and teaching them to actively look for social cues in interpersonal vignettes, including emotional cues like body language and tone of voice, in order to adequately understand the situation (Fraser et al., 2001). Since the ability to recognise emotions is important to encode relevant social cues, people with emotion recognition problems, such as CYP with the neurodevelopmental disorder ASD (Mikami et al., 2019), may benefit from an intervention component that trains people to correctly identify emotions (Garrigan et al., 2018), especially given that the encoding of erroneous or irrelevant information was linked to problems recognising visually or auditorily expressed emotions in ASD (Meyer et al., 2006).

Individuals with neurodevelopmental disorders may also benefit from *Making Choices* exercises that teach participants about the importance of looking for contextual cues to correctly interpret situations, such as by discussing the difference between encountering a group of boys with baseball bats in the street, compared to encountering such a group on the playground (Fraser et al., 2001). Another exercise involves thinking about at vignette in which a girl called "Sadie looks up from her desk to find the teacher and all the other kids looking at her" and understanding that the school location and lesson context indicate that everyone is most likely looking at Sadie because they are waiting for her to reply to a question (Fraser et al., 2001).

Biased encoding of unambiguous information

All of the attention and memory bias studies identified by the review of Paper 1 used unambiguous stimuli and therefore had to be excluded. While Paper 1 therefore provided no information about the role of attention bias and memory bias for unambiguous information in

explaining increased externalising and internalising problems in neurodevelopmental disorders, additional findings of Paper 1 and Table 1 in section 1.5 provide some indication that CYP with ASD, ID or ADHD may encode fewer neutral cues than controls when processing unambiguously neutral (i.e. accidental) scenarios (Carothers & Taylor, 2004; Leffert et al., 2000). However, since these studies assessed encoding in terms of recall, it is unclear whether these processing differences reflect attention bias or memory bias.

In contrast, two recent reviews focusing on ASD reported that cognitive bias relating to attention or memory in CYP or adults with ASD did not differ from that of TD controls (Bergman et al., 2020; Fan et al., 2020). Bergman et al. (2020) set out to review cognitive bias in ASD, with a focus on the role of cognitive bias in explaining comorbidity with depression in this group. They did not use the ambiguity criterion to define cognitive bias and only identified studies assessing attention and memory bias, not interpretation bias. Based on the findings of 31 studies, they reported that attention and memory bias in children and adults with ASD did not differ from those in controls in half of the studies and were in fact lower than in controls in most of the remaining studies (Bergman et al., 2020). As suggested by the authors, the lack of group differences might have been due to false negatives as a result of the small sample sizes of identified studies, while studies reporting comparatively lower negative bias in ASD were of low methodological quality (Bergman et al., 2020).

The eight studies that controlled for anxiety indicated that cognitive bias in ASD was not influenced by anxiety symptoms, while the only study adjusting for depressive symptoms in their analyses found a bias away from faces displaying disgust in individuals with ASD and higher internalising problems (K. Kim et al., 2015).

One of the few other studies reporting attention bias in ASD also used faces expressing disgust (Zhao, Zhang, Fu, & Maes, 2016), in contrast to the use of threatening or angry faces in most other reviewed studies (Bergman et al., 2020). They found that, compared to the TD group, children with ASD were initially hypervigilant to disgust faces and, following normal disengagement, were more likely to avoid looking back at any of the faces regardless of whether they expressed disgust, happy or neutral emotions (Zhao et al., 2016).

Further evidence for avoidance of threat was reported by García-Blanco et al. (2017) who found children with ASD to show a bias away from threatening faces when faces were presented for 1500ms, not for presentation durations of 500ms. If individuals with ASD avoid threat (García-Blanco et al., 2017), or emotional faces in general (Zhao et al., 2016), this may limit their ability

to accurately encode and interpret faces and to habituate to them, which could be linked to interpersonal difficulties in ASD, as indicated by García-Blanco et al.'s (2017) finding that avoidance of threatening faces in ASD was associated with impairments in social communication. Overall, findings suggest that future research still needs to clarify the specific differences between CYP with ASD and CYP without ASD on the three components of attentional bias, namely hypervigilance, disengagement and avoidance (Bergman et al., 2020), as well as their links to interpersonal problems in ASD.

Fan et al. (2020) reviewed 21 studies focusing on the role of attention bias in CYP and adults with ASD, of which more than half were also reviewed by Bergman et al. (2020), and reported that both ASD and TD groups showed an attentional bias toward threatening faces over happy faces when emotional faces were schematic and presented for less than 500 ms during the dot-probe task. Only six of the reviewed studies assessed the link between attention bias and mental health outcomes, namely anxiety, with only one study finding evidence for increased attention bias and anxiety in ASD (Hollocks et al., 2016).

Research on attention bias in CYP with neurodevelopmental disorders other than ASD has been even scarcer, but has provided some support for increased bias in atypically developing individuals. For instance, one study found both enhanced hypervigilance for threatening faces and avoidance of such faces in adolescents who stutter (Rodgers, Lau, & Zebrowski, 2020) and one study reported attention bias to words conveying social threat in CYP with Tourette's disorder (Pile, Robinson, Topor, Hedderly, & Lau, 2019).

While studies addressing attention bias in ADHD have been rare and used heterogeneous methodology (Melvyn, Chow, Vallabhajosyula, & Fung, 2020), one eye-tracking study reported increased attention to unpleasant scenes in CYP with ADHD (Pishyareh, Tehrani-Doost, Mahmoodi-Gharaie, Khorrami, Anahita, & Rahmdar, 2015). Another study's finding that children with SLD were more anxious than controls and more likely to avoid looking at words relating to "reading", without showing a bias for general threat or for SLD stereotypes ("stupid"), indicates that cognitive bias in this group may be specifically related to material that is relevant to their educational impairment, in this case reading ability (Haft, Duong, Ho, Hendren, & Hoeft, 2019).

The attention and memory bias studies presented above have not provided information about the link between cognitive bias and aggression. In contrast, one recent study found evidence for attention bias toward negative pictures in adults with ID who had committed serious criminal

offenses, compared to adults who had ID without a criminal history (Sadek et al., 2021). It should be assessed whether such a bias can also be found in CYP with ID, whether it is associated with aggression and whether training individuals with ID or other types of neurodevelopmental disorder to attend to non-threatening pictures via attention bias modification can improve aggression.

On the other hand, given that reactively aggressive children showed a bias away from threat (Schippell et al., 2003) and that aggressive children in fact spent more time looking at non-hostile cues than controls (Horsley et al., 2010), increasing people's attention to non-threatening social cues may not be sufficient to reduce their aggression. For instance, attention bias modification that successfully made people more attentive to non-hostile cues failed to make them less aggressive (AlMoghrabi et al., 2019).

It has been suggested that, when aggressive individuals process ambiguous provocation, they do not rely on the available social cues, but instead rely on their hostile schema that includes an expectation that other people are mean (Troop-Gordon et al., 2018). This might explain why people high in aggression are generally inattentive to social cues and why, despite giving non-hostile cues prolonged attention due such cues' inconsistency with their hostile schema, aggressive individuals may fail to adequately encode and interpret non-hostile cues (Dodge & Tomlin, 1987; Horsley et al., 2010; Troop-Gordon et al., 2018).

As suggested by Calvete et al. (2012), it may therefore be important for interventions targeting aggression to include a component that modifies hostile schemas. Preliminary findings show that behaviour problems in adolescents with disruptive behaviour problems were improved using schema therapy which targets maladaptive schemas by, for instance, challenging beliefs, confronting a person's behaviour towards the therapist ("here and now", Bernstein, Clercx, & Keulen-De Vos, 2019) and practising alternative beliefs and behaviours (van Wijk-Herbrink, Broers, Roelofs, & Bernstein, 2017).

Inaccurate interpretation of unambiguous information

While this thesis has focused on biased processing of interpersonal ambiguity, there is some evidence to suggest that CYP with neurodevelopmental disorders, at least ID and ASD, may instead be characterised by inaccurate interpretation of unambiguously non-hostile information.

According to Table 3 in section 1.5 and according to the additional exploration (Paper 1) of studies that separately reported findings relating to ambiguous scenarios but that defined

cognitive bias more broadly to also include unambiguous stimuli, CYP with ID and Asperger syndrome were less accurate at interpreting scenarios with clearly accidental intent than controls (Carothers & Taylor, 2004; Gomez & Hazeldine, 1996; Leffert et al., 2000; Leffert et al., 2010; van Rest et al., 2020).

Given that those with ASD have a tendency to interpret statements in a literal way, it may be surprising that children with Asperger syndrome apparently did not take benign statements like people's apologies literally and instead were more likely than controls to reject such cues and to interpret accidental scenarios as hostile in Carothers et al. (2004). In contrast, CYP with ID in Leffert (2000) apparently took accidental cues in fact more literally than controls as they rejected fewer neutral cues than controls. Such increased literal interpretation in CYP with ID might also explain why they were more likely than controls to interpret another person's apology as sincere even though the apology was potentially insincere (Leffert et al., 2010).

Therefore it is possible that difficulties understanding sincerity generally makes individuals more inaccurate at interpreting intent, which may, in some situations, cause them to interpret insincere intent as sincere and, in other situations, lead them to mistakenly interpret sincerity as insincere (Gomez & Hazeldine, 1996; Leffert et al., 2010). While the latter tendency may increase the risk of showing aggression in non-hostile situations, as supported by findings that inaccurate interpretation of neutral intent was linked to aggression in ID (Leffert et al., 2010), the former may make this group more vulnerable to being deceived by others.

Given that Persicke and colleagues showed that it is possible to train children with ASD to detect when statements are sarcastic and when other people are lying to them (Persicke, Tarbox, Ranick, & St. Clair, 2013; Ranick, Persicke, Tarbox, & Kornack, 2013), such a training component may be important for improving this group's accuracy at interpreting intent.

The ability to accurately distinguish between hostile and non-hostile intent may also be improved using games that involve identifying intent from facial expression or that demonstrate differences between hostile, ambiguous, accidental or prosocial intent, as in one component of Hudley and Graham's (1993) attribution training. Alternatively, the *Making Choices* program includes a 'detective' game in which participants are provided with different clues that may help explain whether a boy in a hypothetical vignette deliberately or accidentally broke the protagonist's clay sculpture. While listening to a list containing cues of varying valence and relevance, children can make their decision about the other boy's intent at any point or decide to keep listening for more cues, which aims to teach them that some non-hostile cues like the

boy's apology, the bruise on his elbow or the puddle on the ground that may have caused him to slip and break the sculpture, are particularly relevant for understanding that a situation was accidental rather than hostile (Fraser et al., 2001).

Arguably, incorporating non-hostile cues into one's interpretation may similarly be trained using one of the three CBM-I methodologies of our MIKA training (Paper 3) which involved drawing attention to potentially non-hostile social cues such as the water glass to explain why another person bumped against the protagonist while drawing (Figure 3). As suggested by the combined cognitive bias hypothesis, targeting the encoding of cues and the interpretation of cues together may be more likely to bring about change in mental health outcomes than targeting only one of the biases (Everaert et al., 2012; Hirsch et al., 2006; Lisk et al., 2018).

There are other possible reasons why individuals with neurodevelopmental problems may have problems accurately processing accidental intent. For instance, due to problems with working memory, they may have problems integrating negative outcomes cues (e.g. ruined painting) with non-hostile intent cues (e.g. water glass, van Rest et al., 2019; Klingberg et al., 2010).

Moreover, if they have problems with inhibition, they may have difficulties inhibiting hostile interpretations that may be automatically activated (Orobio de Castro, 2004; Rosset, 2008; Rosset & Rottman, 2014). In line with this reasoning, problems in inhibition predicted more hostile attributions in CYP with mild ID or borderline intellectual functioning (van Nieuwenhuijzen & Vriens, 2012) and in ASD (Meyer et al., 2006). Therefore it may also be important to train this group to inhibit hostile responses, such as by encouraging individuals to question their initial intent attributions and generate alternative explanations for people's behaviours, as in the CBM-I using self-persuasion methods in van Dijk and colleagues (2019; "Can we be sure that the boy/girl tried to be mean? What else could have happened?").

Deficits in later social information processing stages

Given that the review on cognitive bias in neurodevelopmental disorders in Paper 1 and the two previous reviews on attention and memory bias in ASD (Bergman et al., 2020; Fan et al., 2020) did not provide consistent evidence for increased levels of biased information processing in neurodevelopmental disorders, a broader approach to understanding enhanced rates of externalising and internalising problems in neurodevelopmental disorders might consider deficits in the later processing stages, including goal clarification (step 3), response generation (step 4) and response decision (step 5). As illustrated in section 1.5 of this thesis, findings

relating to these social information processing steps in neurodevelopmental disorders are based on a small number of studies with frequently mixed findings (Tables 4-10). However, as outlined below, there is some evidence to suggest that deficits worth targeting in this group include an increased tendency to generate and positively evaluate aggressive responses, as well as difficulties generating and appreciating competent responses.

The fact that the relation between working memory and aggression in CYP with mild ID or borderline intelligence was not only mediated by HAI, but also by aggressive response generation and self-efficacy for aggressive responses, suggests that these processing steps might also be important for explaining aggression in neurodevelopmental disorders, at least in ID (van Nieuwenhuijzen et al., 2006; van Rest et al., 2019). Yet evidence for deficits with these steps in this group was mixed. While three studies reported CYP with ID to be more likely than TD controls to generate aggressive responses (Gomez & Hazeldine, 1996; Leffert et al., 2000; van Nieuwenhuijzen et al., 2011), three found no group differences (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004; van Rest et al., 2020). Likewise, two studies found increased self-efficacy for aggressive responses in CYP with ID compared to controls (van Nieuwenhuijzen et al., 2011; van Rest et al., 2020), while one found no group differences (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004).

More consistent evidence emerged for response evaluation, with the ID group generally evaluating aggressive responses more positively than controls (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004; van Rest et al., 2020). One study found no significant group differences across all vignettes, but found more positive evaluations of aggressive responses in CYP with mild ID or borderline intellectual functioning, with or without clinical behaviour problems, when vignettes were presented on cards (van Nieuwenhuijzen et al., 2011). Moreover, authors reported that those with both mild ID or borderline intellectual functioning and behaviour problems were characterised by goals aimed at internal relief and revenge (van Nieuwenhuijzen et al., 2011), which is in line with Pert and Jahoda's (2008) finding that aggressive adults with ID more often aimed to "show strength" in their social responses than non-aggressive adults with ID (Pert & Jahoda, 2008), but needs to be replicated.

With regards to role of these processing steps in other types of neurodevelopmental disorders, CYP with ADHD or SLD did not consistently differ from controls in their generation and evaluation of aggressive responses. While there was also no consistent evidence for CYP with ASD to generate more aggressive responses, to evaluate them more positively or feel more

confident enacting them, the ASD group was characterised by generating more passive-avoidant responses than controls (Flood et al., 2011; Meyer et al., 2006; Ziv et al., 2014).

Since a tendency to evaluate aggressive responses positively was most consistently found in CYP with ID, this process may need to be targeted in this group, especially given that changes in aggressive response evaluation have been shown to mediate the impact of an aggression prevention training on antisocial behaviour (Dodge & Godwin, 2013). Jacobs and Nader-Grosbois (2020b) implemented an eight-session social information processing training in 15 children with mild to moderate ID in special needs schools in Belgium. Compared to the 15 pupils in the waitlist control group, the training improved pupils' ability to judge the appropriateness of social behaviour, assessed using a problem-solving task that presented participants with pictures displaying inappropriate or appropriate behaviours and that asked them whether and why presented behaviours are good or bad (Barisnikov & Hippolyte, 2011).

The impact of Dodge and Godwin's aggression prevention training (2013) on antisocial behaviour was also mediated by its impact on the generation of competent responses, as well as by its impact on HAI, which indicates that training people to generate competent responses may also be important to reduce aggression. The possibility that competent response generation might represent a particularly important treatment target in CYP with neurodevelopmental disorders is supported by evidence pointing to increased difficulties generating competent responses in this group (Table 7 in section 1.5), especially in CYP with ID (Leffert et al., 2000; van Nieuwenhuijzen et al., 2004; van Nieuwenhuijzen et al., 2011) or with ASD (Bauminger-Zviely et al., 2019; Mazza et al., 2017; Meyer et al., 2006; Ziv et al., 2014).

Larkin et al. (2013) theorised that individuals with ID and high aggression may generate fewer competent responses because they may be concerned that such responses will make them look weak. In line with this suggestion, findings relating to the response decision step (Table 10) indicated that CYP with ID were less likely than TD controls to evaluate competent responses positively (Embregts & van Nieuwenhuijzen, 2009; van Nieuwenhuijzen et al., 2004; van Nieuwenhuijzen et al., 2011).

With regards to the other types of neurodevelopmental disorders, research on the response decision step in ADHD is scarce (Matthys et al., 1999), while evaluation of competent responses was adequate in CYP with SLD, but less positive in ASD than in TD controls (Embregts & van Nieuwenhuijzen, 2009; Flood et al., 2011; Ziv et al., 2014).

As suggested by van Nieuwenhuijzen et al. (2011), it may therefore be important for CYP with neurodevelopmental disorders like ID to experience the positive outcomes of competent behaviours, for instance by practising competent behaviours using role-plays, as in the multicomponent intervention called *Standing Strong Together (SST)* that successfully targeted externalising problems in CYP with mild ID or borderline intellectual functioning (Schuiringa, van Nieuwenhuijzen, Orobio de Castro, Lochman, & Matthys, 2017).

Another way for this group to learn that non-aggressive behaviours can have positive consequences is exemplified by Philips and Lochman (2003) who reduced both reactive and proactive aggression in aggressive boys by rewarding participants' prosocial behaviour during a computer game.

It should be examined whether training the generation and positive evaluation of competent behaviours can reduce aggression, especially reactive aggression, in CYP with neurodevelopmental disorders. Rather than exclusively focusing on behaviour problems and deficits, it may also be important to take a strength-based approach and, for instance, additionally assess and promote the development of prosocial behaviours and competencies (Cosden, Koegel, Koegel, Greenwell, & Klein, 2006; Raley, Shogren, & Cole, 2021)

Deficits in ToM or Executive Functions

When trying to reduce aggression, specifically reactive aggression, it is likely important to target ToM, namely the ability to cognitively infer intentions or feelings. Renouf et al. (2010) showed that low ToM was related to high levels of reactive aggression. Since the relation of ToM and reactive aggression was moderated by experiences of victimisation, interventions like bullying prevention trainings may need to be implemented in order to reduce such experiences (for a review see Gaffney, Farrington, & Ttofi, 2019).

As theorised by Renouf et al. (2010), the link between ToM and reactive aggression in victimised CYP may be explained by cognitive bias. Given that ToM at pre-school age predicted HAI at school-age and that this prospective relation was moderated by emotional control, it is possible that ToM deficits, in interaction with emotion dysregulation and victimisation, make people vulnerable to HAI which increases the risk of reactive aggression (Choe et al., 2013; Renouf et al., 2010).

If it is confirmed that ToM interacts with these different constructs to increase the risk of aggression, it would point to the importance of targeting multiple processes to reduce

externalising problems. For instance, Houssa and Nader-Grosbois (2016) showed that combining ToM training with social information processing training improved participants' perspective taking and ToM abilities and their ability to judge und understand the appropriateness of social behaviours, and reduced participants' anger and irritability as perceived by their parents. Such training may also be feasible and beneficial in CYP with neurodevelopmental disorders, as indicated by the recent finding that, when compared to a no-training control group, both SIP training and ToM training improved the ToM skills and the ability to judge inappropriate social behaviours in children with ID in special needs elementary schools in Belgium (Jacobs & Nader-Grosbois, 2020a).

Furthermore, understanding and targeting aggression in neurodevelopmental disorders may also require a focus on executive functions. Working memory, focused attention and inhibition are frequently impaired in this group (Craig et al., 2016; Crisci et al., 2021; Leonard & Hill, 2015; Peng & Fuchs, 2016; van der Molen et al., 2007) and were, for instance, related to aggression in adolescents with mild ID or borderline intellectual functioning (van Rest et al., 2019). Moreover, the relation between working memory and aggression and the relation between focused attention and aggression were mediated by social information processing skills, including HAI (van Rest et al., 2019).

Contrary to expectations, van Rest et al. (2019) did not find that HAI mediated the relation between inhibition and aggression, which authors theorised may have been because they assessed behavioural inhibition rather than cognitive inhibition. Given that Ellis et al. (2009) found that deficient response inhibition related to reactive aggression, more strongly than to proactive aggression, and that the tendency to encode hostile cues moderated the relation between inhibition and reactive aggression (Ellis et al., 2009), encoding problems may interact with difficulties in inhibition to predict reactive aggression.

As suggested by van Rest et al. (2019), it should be examined whether interventions targeting social information processing biases to reduce aggression may be enhanced by adding a training component that targets executive function. For instance, Sukhodolsky et al.'s (2005) attribution training, which successfully improved aggression, conduct problems and anger in a sample with an unspecified number of CYP with ADHD, included some sessions that targeted perspective-taking and some that trained inhibiting their automatic hostile intent attributions.

Recently, Honoré et al. (2020) combined the social cognition training by Houssa and Nader-Grosbois (2016), which targets both ToM and social information processing, with the inhibition

training by Volckaert and Noël (2017). The inhibition component of the program involved games that trained pupils to think before acting, inhibit distractors and control their body parts (Honoré et al., 2020; Volckaert & Noël, 2017). This classroom-based inhibition and social cognition training improved participants' ToM, their ability to judge und understand the appropriateness of social behaviours, for instance by referring to social rules and social consciousness (Barisnikov & Hippolyte, 2011) and their executive functions inhibition, selective attention and flexibility, when compared to a control group that did not receive the training (Honoré et al., 2020). However, this intervention's impact on aggression and its effectiveness in in CYP with neurodevelopmental disorders still needs to be investigated.

8.3 Future research

Given the findings of Papers 1-4 and the above evidence relating to links between cognitive biases, ToM and executive functions, I make the following suggestions for the road ahead.

Processes underlying psychiatric comorbidity in NDD

Future research needs to clarify the cognitive and social-cognitive processes underlying the enhanced risk for externalising and internalising problems in this group. Since reactive aggression and HAI appear to be interlinked with ToM and executive functions (Ellis et al., 2009; Renouf et al., 2010; van Rest et al., 2019), future studies should assess these constructs together and thus shed more light on how they might interplay to explain aggression in CYP with or without neurodevelopmental disorders. For instance, in order to test Renouf et al.'s (2010) theory that ToM deficits make people vulnerable to HAI and thus increase their risk for reactive aggression, longitudinal research should assess whether HAI mediates the relation between ToM and aggression, while also taking into account the influence of victimisation experiences and emotion dysregulation (Choe et al., 2013; Perren et al., 2013).

Moreover, the fact that HAI and other SIP steps mediated the link of working memory and focused attention with aggression in CYP with ID (van Rest et al., 2019) and that hostile encoding moderated inhibition's link with reactive aggression (Ellis et al., 2009) needs to be replicated by future studies. This would help explain how these different risk factors for aggression interact to make CYP with neurodevelopmental disorders more vulnerable to externalising problems and it would help identify relevant treatment targets in this group.

While the different types of neurodevelopmental disorders show heterogeneity in their diagnostic symptoms (APA, 2013), they frequently co-occur and show overlap in their

increased comorbidity with externalising and internalising problems, which still causes debate about whether they should be regarded as lying on a spectrum or as distinct disorders (Dewey, 2018; Gillberg, 2010; Kern et al., 2015).

Therefore, given that different neurodevelopmental disorders also share difficulties in cognitive and social-cognitive functions of varying severity, I recommend that future studies examining the neuropsychological level to explain interpersonal problems like aggression in this group take a transdiagnostic approach rather than focusing on specific subtypes of neurodevelopmental disorders.

Impact of inclusive education on CYP with or without neurodevelopmental disorders

Having shown that hostile attributions of inclusive school pupils can be assessed and linked to reactive aggression (Paper 4) and can be modified with positive effects on reactive aggression (Paper 3), a relevant next step would be use longitudinal studies to compare attribution bias (e.g. COB), as well as other social information processing steps, aggression, victimisation, executive functions and ToM, of pupils with neurodevelopmental disorders in inclusive settings with those of pupils with neurodevelopmental disorders in special needs settings, in order to examine the consequences of inclusion for this group's development and social adjustment. Initial findings of better ToM development in CYP with mild ID in inclusive classrooms, relative to special needs classrooms (Smogorzewska, Szumski, & Grygiel, 2019) indicate that inclusion may be beneficial for individuals' social cognition, but need to be replicated and assessed in relation to aggression and peer interactions.

Moreover, preliminary findings have pointed to increased aggression in inclusive schools and special needs schools, compared to regular schools, as well as to increased cognitive bias in special needs schools relative to regular schools (Kipp, 2018; Kunz, 2018; Schmidt & Vereenooghe, 2018). The school comparison findings relating to these pilot studies were not included in the current thesis because a previous validation paper assessing the psychometric properties of three VASAPP sets (n = 185; Lause, 2019) found that the VASAPP set used in the pilot studies was not equivalent to the other two VASAPP sets (i.e. A and B) that were used in Papers 3 and 4.

Therefore, a future study should repeat such a school comparison using the validated VASAPP set that showed good psychometric properties in Paper 4 (i.e. set B), so as to provide information about how growing up in inclusive school environments affects individuals who have special educational needs and also how it affects those who do not have special needs.

Such a study may additionally assess aggression, executive functions and ToM, in order to assess the impact of inclusive education on these different constructs in both CYP with special educational needs or developmental disorders and in CYP of typical development without special needs, ideally using longitudinal studies that track individuals from kindergarten to adulthood.

9. Conclusion

In light of the scarcity and heterogeneity of studies assessing and modifying biased processing of interpersonal ambiguity in neurodevelopmental disorders, such research is clearly still in its infancy and has to further clarify the role of cognitive bias in explaining this group's high prevalence of externalising and internalising problems. Studies need to use standardised and inclusive methodology to replicate tentative findings of increased and content-specific interpretation bias in this group. The current thesis provided evidence for the feasibility of conducting CBM-I in CYP with neurodevelopmental disorders and no adequate justification exists for their systematic exclusion. Even if future studies do not find increased levels of cognitive bias in neurodevelopmental disorders, the inclusion of this group in CBM is necessary to make samples representative of the general population which includes both typically and atypically developing individuals, as well as to realise the rights of people with disabilities or special educational needs to be included in research in particular and in society in general.

10. References

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11. Statement of Authorship

Hiermit erkläre ich, dass ich die vorliegende Dissertation “Assessment and modification of cognitive biases in children and young people with or without neurodevelopmental disorders” weder in der gegenwärtigen noch in einer anderen Fassung einer anderen Fakultät vorgelegt habe oder hatte.

Ich versichere, dass ich die Dissertation selbstständig und ohne unerlaubte Hilfe angefertigt sowie unter ausschließlicher Verwendung der von mir angegebenen Quellen verfasst und wörtlich oder sinngemäß aus der Literatur entnommene Textstellen kenntlich gemacht habe.

Ferner bestätige ich, dass ich den federführenden Beitrag zu den unter gemeinschaftlichen Autorenschaften entstandenen Manuskripten geleistet habe.

Bielefeld, im Juni 2021

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Nora Bettina Schmidt

12. Overview of published and submitted work

Paper 1 (see Appendix A for a pre-peer review version of the submitted manuscript):

Schmidt, N. B., & Vereenooghe, L. (2021). *Interpersonal cognitive biases in children and young people with neurodevelopmental conditions: a systematic review* [Manuscript submitted for publication]. Department of Psychology, Bielefeld University.

Paper 2 (see DOI link for the published paper):

Schmidt, N. B., & Vereenooghe, L. (2020). Inclusiveness of cognitive bias modification research toward children and young people with neurodevelopmental disorders: A systematic review. *International Journal of Developmental Disabilities*, 1-16. https://doi.org/10.1080/20473869.2020.1720156

Paper 3 (see Appendix C for a pre-peer review version of the submitted manuscript):

Schmidt, N. B., & Vereenooghe, L. (2020). *Targeting hostile attributions in inclusive schools through online cognitive bias modification: a randomised experiment* [Manuscript submitted for publication]. Department of Psychology, Bielefeld University.

Paper 4 (see Appendix D for a pre-peer review version of the submitted manuscript):

Schmidt, N. B., & Vereenooghe, L. (2021). *Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP): validation of a new attribution measure* [Manuscript submitted for publication]. Department of Psychology, Bielefeld University.

Appendix A: Paper 1

This is a pre-peer review version of the manuscript and of two of its appendices that were submitted for publication to Current Developmental Disorders Reports on 23.06.2021.

Interpersonal cognitive biases in children and young people with neurodevelopmental disorders: a systematic review

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[Note. Please note that, for reasons of standardisation and printing, the formatting of this paper has been slightly adapted compared to the submitted version. No changes have been made to its content.]

Interpersonal cognitive biases in children and young people with neurodevelopmental disorders: a systematic review

Abstract

Purpose of Review

Interpersonal cognitive biases have been linked to externalising and internalising problems. This systematic review investigates their role in children and young people with neurodevelopmental disorders (NDD), who have a high risk of experiencing such problems.

Recent findings

With 16 identified studies, this is a widely under-recognised research area. The three studies conducted within the last five years focused on threat interpretation and its association with anxiety. No difference between children and young people with and without NDD was found in the eleven studies investigating hostile attribution of intent, of which the most recent is nearly a decade old. No studies addressed attention or memory bias towards ambiguous interpersonal information.

Summary

The scarcity and heterogeneity of research highlighted in this paper demonstrates the urgency to use standardised and accessible research methods to develop a strong evidence base regarding the potential content-specific interpretation bias in individuals with NDD.

Introduction

Different neurodevelopmental disorders (NDD), which include intellectual disability (ID), autism spectrum disorders (ASD), attention-deficit and hyperactivity disorder (ADHD), specific learning disorders (SLD), and motor and communication disorders, frequently co-occur and show overlap in their psychiatric comorbidities with both externalising and internalising problems and in their cognitive and social-cognitive deficits [1–9]. Aggressive behaviour problems, which are frequently higher in children and young people (CYP) with NDD than in typically developing (TD) controls [10–13], are increasingly approached in individuals with NDD using the social information processing (SIP) model, most commonly in individuals with ID [14–16•]. The SIP model views aggression as the result of a tendency to show biased or deficient encoding and interpretation of interpersonal cues, to select antisocial rather than prosocial goals and to generate, positively evaluate, select and enact incompetent rather than competent behavioural responses [17–20].

People may show attention bias or memory bias at the encoding stage of SIP if they selectively attend or recall negative social cues when being asked to imagine a hypothetical scenario in which the protagonist experiences an undesirable outcome as a result of another person's actions [21–24]. The tendency to attribute hostile intent to the other person, when that person's actual intent is ambiguous or non-hostile, points to a bias at the interpretation stage referred to as hostile attribution of intent (HAI) [25].

Attention, memory and interpretation biases may play a role in causing or maintaining externalising and internalising problems [26–28]. For instance, individuals high in aggression are characterised by HAI [29•] and people high in social anxiety show social threat interpretation bias, such as interpreting the sound of other people laughing as negative social evaluation, which illustrates how a disorder's specific aspects may be reflected in the cognitive bias content, referred to as content-specificity [30•, 31].

The risk of cognitive biases like HAI is increased by deficits in executive functions like working memory [18 • , 32]. When people with impaired working memory process a vignette in which a boy steps on the protagonist's dropped homework while walking past [33], they may struggle to integrate subtle ambiguous intent cues, like the boy looking in a different direction when stepping on the homework, with more salient negative outcome cues like the dirty footprint on the homework [16•, 34, 35]. Given that executive functions are frequently impaired in individuals with NDD, particularly in ID, ADHD and ASD [7, 9, 36], we might expect to find increased HAI in this group. Evidence for the role of HAI in mediating the relation between working memory and aggression [16•] and the relation between victimisation and aggression [37, 38] suggests that this cognitive bias may represent an important mechanism linking different risk factors to aggression.

While different types of NDD are difficult to distinguish at the neuropsychological level, more severe problems with Theory of Mind in individuals with ASD [39•] might make this group particularly vulnerable to HAI by making it difficult for them to envision that another person's intent may be non-hostile when the outcome is negative [20, 40]. This might explain the link between Theory of Mind and social anxiety or aggression [41–43].

The role of cognitive biases in explaining the increased risk for mental health problems in ASD was explored by two previous reviews which, however, only identified attention or memory bias studies and provided no evidence to suggest that cognitive biases in CYP or adults with ASD are higher than in TD controls or linked to internalising problems [44••, 45••]. The current paper distinguishes itself from these previous reviews by investigating the role of cognitive biases across all NDD and by integrating findings from the wider cognitive bias field and the SIP field that differ in how they assess and define cognitive bias.

Valence-specific processing and ambiguity of interpersonal situations

While interpretation bias is generally defined as valence-specific (e.g. negative) interpretation of ambiguity [46, 47•], some SIP studies have defined HAI as the attribution of hostility to other people, both when other people's intent is ambiguous and when it varies between being ambiguous, hostile and non-hostile across presented situations [25, 29•]. If a scenario depicts other people's behaviours as non-hostile, for instance indicated by their surprised facial expression or sincere apology, then its hostile interpretation arguably represents an inaccuracy rather than a bias in information processing [48, 49]. In order to distinguish biased from inaccurate processing, the current paper therefore defines cognitive bias as valence-specific processing of interpersonal information that is ambiguous.

A specific focus on the processing of ambiguous information may be important for distinguishing individuals with and without aggression [50]. For instance, adolescents with mild ID were more likely than those with average IQ to feel angry, to evaluate aggressive responses positively and to select aggressive responses, when processing ambiguous scenarios, not accidental or hostile scenarios [51].

Objective

The primary objective of the current review is to identify whether CYP with NDD show valence-specific processing of interpersonal ambiguous information. As a secondary objective and within the identified evidence base, we aimed to determine whether potential cognitive biases in CYP with NDD can be associated with internalising or externalising problems.

Methods

Search Strategy

We conducted a systematic database search in PsycINFO, PsycARTICLES, MEDLINE, Cochrane Central Register of Controlled Trials (CENTRAL) and Science Citation Index using a combination of MeSH terms and synonyms of "children and young people", "neurodevelopmental disorder", "cognitive bias" and "modification". The complete search string can be found in Appendix A.1. Initial searches were conducted on 17.04.2017 and the updated final search was on 05.07.2020. The review protocol was registered on PROSPERO (reference number: CRD42017058346).

Eligibility Criteria

Inclusion criteria applied to participants, assessment of cognitive biases, and publication characteristics.

Participants. We included only studies with human participants under the age of 18 with NDD. The list of eligible NDD was drawn up from the index of the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; [5]). For each condition identified in this way, studies were allowed to use diagnostic criteria from earlier versions to account for changes in diagnostic criteria over time.

Cognitive bias. Three criteria applied to select cognitive biases for this review. Biases eligible for review had to be (i) valence-specific, (ii) concern either interpretation, memory, or attention bias, and (iii) be directed towards ambiguous interpersonal stimuli.

Stimuli were defined as interpersonal when they related to the behaviours or emotions of other people, such as their intent or facial expressions.

Ambiguity referred to the unresolved overall meaning of the stimuli due to the presence of unclear social cues relating to intent or emotion. For example, a scenario in which

the protagonist wants to join a game would be unambiguous if his peers gave a neutral reason for not letting him join, such as being told by the teacher that the number of players is fixed [52], but would be ambiguous if peers simply gave no reply because, as this would represent an intent that is neither clearly hostile, nor clearly non-hostile. The absence of clear intent then makes the scenario open to being processed in a valence-specific manner, such as interpreting ambiguous information as either positive or negative. In order to qualify as ambiguous, unclear social cues had to exist within the same stimulus (e.g. scenario, image, face or text). Thus, morphed faces with both negative and positive facial features would meet the ambiguity criterion [53•] , while presenting neutral faces next to a negative one would not [54].

For valence-specificity, the unclear intent would make a stimulus open to being processed in a valence-specific manner. This refers to the tendency to selectively process the valence of a stimulus. Take the example of an ambiguous scenario with a negative outcome (like a football next to a broken window) which is presented with both hostile and non-hostile social cues relating to intent [22]. In this case, a valence-specific cognitive bias would be a tendency to selectively encode hostile cues (like the person's leg pointing in the direction of the window), while neglecting to encode non-hostile cues (like the person looking into a different direction) [22].

For a study to be eligible for review, its outcome data regarding the processing of ambiguous interpersonal stimuli had to be reported separately and not as an overall bias score including both ambiguous and unambiguous stimuli. This is in contrast with Verhoef and colleagues who also included studies whose bias measures had a mixture of ambiguous and unambiguous social situations and therefore included effect sizes based on composite scores [29•].

Publication characteristics. The review included articles in English, Dutch, French and German from 1980 onward, as we anticipated a dearth of literature. No limitations were placed on study design. Comparisons of interest were between the different NDD, as well as between CYP with NDD and their TD peers.

Study Selection

Double reviewing was performed in two steps with an initial cut-off after 30% of identified records to calculate Kappa before proceeding with reviewing the remaining 70% of articles. Disagreements were resolved through discussion. The same procedures applied to reviewing the selected full-length articles, with reasons for excluding full-length articles being recorded by each reviewer.

The systematic search was complemented through contact with authors of studies meeting the review eligibility criteria and through use of the ancestry method, whereby references and citations of included studies were checked for potential new studies which the search strategy may have missed.

Outcomes

The primary outcome of interest was the potential presence and extent of biased processing of interpersonal ambiguous stimuli. To that extent, we extracted data regarding the type of bias (memory, attention, or a specific interpretation bias), assessment method (e.g. questionnaire, vignette, interview), and quantitative outcome data for the relevant bias measure. Included data and summary findings refer only to ambiguous interpersonal stimuli, for which the separate reporting of these outcomes was a requirement to be included in this review. Hence, if studies only presented integrated findings of the processing across ambiguous and unambiguous stimuli, or both interpersonal and non-interpersonal stimuli, then that study would be excluded as it would not be possible to deduct to what extent participants demonstrated biased memory, attention or interpretation specifically for

ambiguous interpersonal stimuli. Depending on the measures used, this could result in data reported for a single ambiguous interpersonal vignette, a sub-set of ambiguous interpersonal stimuli, a subscale including the ambiguous stimuli, depending on how the data in the original studies were presented.

For secondary outcomes, data was extracted regarding the association of cognitive biases with measures of internalising and externalising problems.

Findings were summarised using a narrative synthesis.

Quality Assessment

This study adheres to PRISMA reporting guidelines for systematic reviews [55] (Appendix A.2). Methodological quality and risk of bias of individual studies was evaluated using an adaptation of the Appraisal Tool for Cross-sectional Studies (AXIS; 56) with additional items from the Cochrane Collaboration guidelines for intervention studies [57]. Potential publication and reporting biases were addressed to assess the risk of bias across studies.

Results

The initial systematic search yielded 2369 records, whereas the repeated searches on 05.07.2020 to catch studies published since 2016 identified 4220 records. Following removal of duplicates and exclusion of reviews, commentaries, and studies in non-eligible languages, 5499 titles and abstracts were screened for inclusion by both reviewers.

For the initial search, 77 studies proceeded to full-text review by both reviewers. For the first twenty records, all inter-rater disagreements concerned how primary studies defined or presented ambiguous stimuli. To handle this great variability and lack of clarity in the original studies, we refined our description of the review eligibility criteria. Where the original review protocol already focused on ambiguous stimuli, the text was revised to more

clearly define ambiguity and to account for studies that presented both ambiguous and non-ambiguous data. This did not constitute a diversion from the original protocol but rather a further clarification. This clarification was followed by an overall agreement of K = .936 for the remaining 57 studies.

For the most recent searches in 2020 to catch studies published since 2016, an inter-rater agreement of 99.76% agreement or K=.895 for all articles was observed. Upon removing studies that were already included in the initial search (so published in 2016 or 2017), the reviewers reached an agreement of 99.78% with 44 agreements and one disagreement. For this step, Kappa could not be calculated as reviewer 1 included no studies, which resulted in a lack of variability in the ratings of reviewer 1.

The primary reason for exclusion was that ambiguous stimuli were either absent or not separately reported. Figure 1 shows the combined results of the initial and final database searches and selection processes.

[Figure 1 about here]

Sixteen studies met all inclusion criteria, of which six addressed interpretation biases in CYP with ID, six in CYP with ADHD, three in ASD and one in LD. The majority of the identified studies, nearly 70%, addressed hostile attribution of intent (HAI). Table 1 presents study characteristics and outcomes. Despite having a wider search remit to catch attention, memory and interpretation bias, the search yielded only interpretation bias studies. This was because none of the identified attention or memory bias studies used ambiguous stimuli and therefore had to be excluded. Other studies were excluded for reporting cognitive bias as the combined bias score for ambiguous and unambiguous stimuli. Examples of excluded papers are shown in appendix A.3.

Study Characteristics

All sixteen studies assessed interpretation bias using vignettes, but they differed in terms of task design, total number of vignettes and proportion of ambiguous scenarios. Ten studies measured bias by coding participants' replies to SIP interviews. This involved asking participants open questions to recall and describe what happened in the vignettes or whether they regarded the actions of other people in a particular scenario as mean or threatening. Six studies instead assessed bias using forced-choice responding by asking participants to rate their agreement of possible interpretations on a Likert scale or to choose one of multiple interpretations. Across studies, the number of ambiguous vignettes ranged from one to 31, with a mean of 7.31 (SD=6.750) and most studies either adapted previous bias measures or developed new ones.

[Table 1 about here]

While there were no substantial differences in risk of bias between the studies, Table 2 demonstrates that potential sources of bias are due to the absence of a sample size justification, and insufficient information about response-rates and non-responders.

The narrative synthesis of these studies is structured according to population characteristics and strength of the evidence, thereby integrating the findings of the quality assessment (Table 2).

[Table 2 about here]

Interpretation Bias and Intellectual Disabilities

Six studies assessed interpretation bias in ID. One study reported that HAI in children with and without mild ID was higher for ambiguous than for accidental vignettes, although no exact statistics were provided [58]. Compared to controls, children with ID showed less hostile interpretations of potential insincerity, such as someone's ambiguously sincere

apology [35]. The only gender-balanced but smallest of the six studies, restricted participation to those with sufficient verbal skills and found no HAI differences between CYP with mild ID and matched controls [69]. In a sample that was 71.6% male, higher HAI was found for children with ID, behaviour problems, or both, when compared to TD controls [59].

In contrast to these four studies assessing HAI using open questions, two high quality studies assessed threat interpretations using a Likert-scale measure, namely the Interpretation Recognition Task (IREC-T). Houtkamp et al. found that social anxiety in 631 young people with mild ID was significantly predicted by negative interpretations of scenarios relating to social anxiety, as opposed to other anxieties [31]. Using a subsample of this study, threat interpretation biases were reduced following a three-week positive cognitive bias modification training for interpretations (CBM-I), relative to a text-reading control involving non-emotional unambiguous scenarios [60••]. While IREC-T scores were also decreased at 10-week follow-up in the neutral CBM-I group, only the positive CBM-I group showed reduced social anxiety symptoms at follow-up.

Interpretation Bias and Autism Spectrum Disorder

Three studies assessed cognitive bias in CYP with ASD and had predominantly male samples. Carothers et al. compared twenty children with Asperger syndrome (AS) with twenty TD peers and reported lower HAI in the former [52]. Excluding participants with dual diagnoses of other NDD like ADHD or LD, Flood and colleagues found that children with AS did not differ from controls in HAI or internality and stability of attributions, but made more global than specific attributions [61]. Boys with ASD, compared to those without ASD, held more negative interpretations of social-threat situations, as demonstrated in the methodologically strongest study, however using an all-male sample [62].

Interpretation Bias and Specific Learning Disorder

Bryan et al. present the only study including CYP with SLD which was eligible for this review and reported no differences in HAI between participants with and without SLD [63]. Inducing positive affect through happy music did lower HAI, relative to inducing a negative affect through music and relative to positive memory recall.

Interpretation Bias and Attention-Deficit/Hyperactivity Disorder

Six studies assessed interpretation bias in CYP with ADHD, including one study with an all-male sample, and one with an all-female sample. Adolescent girls with ADHD, recruited through a research summer camp, did not differ in HAI from female controls and, unlike controls, showed no association of HAI with aggression [64]. Likewise, boys with ADHD did not differ from controls in their external attributions of parental behaviour, but made more internal attributions to child responsibility [65]. Three gender-mixed studies that directly compared HAI between CYP with and without ADHD failed to find group differences for HAI [66, 67]. Finally, children with comorbid ADHD, conduct problems and callous-unemotional traits did not differ from those without callous-unemotional traits or from TD controls in external attributions, but instead were more likely to attribute negative outcomes to own behaviour problems [68].

Additional exploration

Considering the studies' data relating to the accuracy of processing neutral stimuli, in contrast to ambiguous stimuli, we found that CYP with ID [35, 69] or AS [52] were less accurate at interpreting neutral intent and encoded less neutral cues than controls. The latter was also found in children with ADHD, who encoded fewer cues, irrespective of cue valence [66]. When rejecting neutral cues, children with ID did this at a lower rate [58], and children with AS at a higher rate [52] than controls.

Discussion

Our primary objective was to examine the evidence regarding biased processing of ambiguous interpersonal information in CYP with NDD. In contrast to the extensive cognitive bias research literature relating to TD individuals, only 16 studies met our eligibility criteria, all of which focused on interpretation bias and not on memory or attention bias. The majority of identified studies assessed whether participants with NDD were more likely than controls to interpret others' behaviours as more hostile. Only one study found evidence for higher HAI in children with mild to borderline ID [59], in line with a study that emerged since the systematic review's completion which reported higher HAI in the low IQ group, relative to the average IQ group [51]. However, contrary to our hypotheses, overall evidence for increased HAI in NDD was inconsistent. By contrast, there were indications that attributions of causality differed between CYP with and without NDD, as shown by increased globality of attributions in AS [61], or internality of attributions in CYP with ADHD [65].

In light of our second objective regarding mental health outcomes, HAI was expected to be associated with aggression in NDD. However, the only identified study that assessed such associations found HAI to be associated with aggression only in girls without ADHD, not in girls with ADHD [64]. Meanwhile, evidence for biases associated with internalising disorders in individuals with NDD was more consistent. Houtkamp et al. found a content-specific interpretation bias associated with social anxiety in CYP with mild ID, whose biases and symptoms were improved through positive CBM-I [31, 60••]. Hollocks and colleagues (2016) finding that interpretations of ambiguous social threat scenarios were more negative in CYP with ASD and comorbid anxiety than in TD controls indicates that biased ambiguity processing might also be a suitable CBM target for anxiety in individuals with ASD [62].

Although we focused on the distorted processing of ambiguous information, some of the included studies presented separate analyses for ambiguity processing (as per our

inclusion criterion), but generally defined cognitive bias more broadly to also include unambiguous stimuli. An additional exploration of these studies' findings showed that, compared to controls, CYP with ID and ASD were less accurate at interpreting scenarios with clearly accidental intent and at encoding neutral cues [35, 52, 69]. While we acknowledge that such deficits in encoding and interpreting unambiguous information are also important for understanding the cognitive processes associated with specific NDD, the ambiguity criterion was essential to our study because it enables us to distinguish biased from erroneous processing [48–50].

The ambiguity criterion was also essential in our study because of its potential to help understand psychiatric comorbidities. Initial evidence for this was found in both CYP with mild ID [31] and ASD [62]. The proposed link between biased ambiguity processing and mental health in NDD was further supported by evidence that specifically targeting interpretations of ambiguous scenarios through CBM-I improved anxiety in people with mild ID [60••].

As a result of our ambiguity criterion for cognitive bias, we excluded a large body of evidence that only used unambiguous stimuli, such as studies assessing attention bias in CYP with NDD. While it might therefore be regarded as a limitation of this review that we did not cover all possible available cognitive bias research in NDD, it is important to note that our search strategy was inclusive (see Appendix A.1). Our ambiguity criterion did not per se exclude attention bias studies, because it is possible to study attention bias with ambiguous stimuli, such as through tracking eye movements to social cues in ambiguous scenarios [22, 70] or in ambiguous facial expressions [71]. Nevertheless, without our ambiguity criterion we could have reviewed more research and could have drawn conclusions about the role of attention bias in NDD.

Since evidence for the role of cognitive bias in NDD was inconsistent in the current review and in previous reviews [44••, 45••], a broader approach to understanding increased aggression in NDD might be to consider deficits in later stages of the SIP model. For instance, the tendency to generate and feel confident about aggressive responses moderated the relation between working memory and aggression in CYP with mild ID [16•] and was found to be higher in individuals with ID compared to controls [51, 58, 59, 69]. While increased rates of aggression in NDD might therefore partly be due to an increased generation and positive evaluation of aggressive responses, it might also be linked to impairments in the generation of competent responses, which were identified in CYP with ID [58, 59, 72] and in CYP with ASD [73–75]. Since the effect of an aggression prevention training on antisocial behaviour was mediated by its impact on children's ability to generate competent responses, as well as by its impact on HAI and aggressive response evaluation, all three steps may represent causes of aggression and therefore important treatment targets [76].

Conclusions

Only a small number of studies investigated interpersonal cognitive biases in CYP with NDD, despite the potential importance of such biases in understanding the increased risk of developing mental health problems in this population. There was some evidence to suggest that threat interpretation bias may explain anxiety in CYP with ID or ASD and represent a suitable intervention target for CBM-I in these groups. Regardless of whether future studies find cognitive bias to differ between CYP with NDD and TD individuals, the inclusion of both groups in CBM is necessary to make samples more representative and the frequent categorical exclusion of this group from cognitive bias research needs to be justified [77•].

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•• Of major importance

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Table 1.

Characteristics and outcomes of included studies (n = 16)

Study	Participants	Measure	Outcomes
Intellectual disabilities (ID)			
Gomez and Hazeldine (1996) [69]	N = 39 Male: 69 % Age range: 5 years 4 months - 12 years 4 months G1 (n = 13): mild ID G2 (n = 13): chronological age-matched controls G3 (n = 13): mental age-matched controls Setting: mainstream schools, Australia	Bias: HAI <u>Social Perception task:</u> 6 Vignettes - **2 ambiguous**, unclear intent - 2 clear, negative intent - 2 clear, neutral intent Method: Interview	HAI: no group differences after controlling for aggression and hyperactivity, F(2,36) = .31 Intent attribution accuracy: G1 < G2 for clear, neutral intent scenarios (not controlled for aggression and hyperactivity)
Houtkamp et al. (2017) [31]	N = 631 Male: 57.7 % Age range: 12 – 18 years (M = 14.35, SD = 1.46) Mild ID Setting: SEN Schools, Netherlands	Bias: Threat interpretation <u>Interpretation Recognition Task (IREC-T):</u> 2x 8 ambiguous vignettes: - 4 on social anxiety - 4 on other anxieties Method: Likert scale	Positive correlations between: - social anxiety and negative interpretations of social anxiety scenarios (r = .34, p < .001) - social anxiety and negative interpretations of other anxiety scenarios (r = .18, p < .001) Only interpretation of social anxiety scenarios predicted social anxiety (B =0.30, p< 0.001).
Klein et al. (2018) [60••]	N = 69 Male: G1 = 36.4 %; G2 = 30.6 % Age range: 12 – 18 years (G1: M = 14.4, SD = 1.6; G2: M = 14.4, SD = 1.5) RCT Design: C1 (n = 33): positive training group (CBM-I) C2 (n = 36): text-reading control Mild to borderline ID Setting: SEN Schools, Netherlands	Bias: Threat interpretation <u>IREC-T</u> <u>Ambiguous scenarios task (AST):</u> 16 ambiguous social threat related scenarios Method: Multiple choice	IREC-T: - C1: reduced interpretation bias, t(30) = 3.33, p = .002, compared to C2, t(34) = -0.19, p > 1 - 10 week follow-up: reduction in IREC-T for both C1, t(30) = 5.54, p < .00, and C2, t(33) = 2.17, p = .037 AST: - C1: reduced interpretation bias, t(30) = -4.16, p < .001, compared to C2, t(33) = -.11, p > .1. - 10 week follow-up: no change Social anxiety: - C1: reduced social anxiety at 10-week follow-up, not at post-training
Leffert et al. (2000) [58]	N = 117 Male: G1 = 47.5 %, G2 = 48.3 % Age range: 7.0 – 11.9 years G1 (n = 59): mild ID (mean IQ = 65.2, SD = 6.1) G2 (n = 58): no ID Setting: special education classrooms and general classrooms, USA	Bias: HAI 18 Vignettes: - **6 ambiguous**, unclear intent - 6 clear, neutral intent - 6 clear, negative intent Method: Interview	HAI: - Both G1 and G2: HAI for 64% of items. - HAI for ambiguous scenarios higher than for clear, neutral intent scenarios and lower than for clear, negative intent, F(2,102) = 148.90, p < .001 Intent attribution accuracy: G1 < G2 for clear, neutral intent Encoding neutral intent cues: G1 < G2 Discounting neutral intent cues: G1 < G2

Leffert et al. (2010) [35]	N = 248 Male: G1 = 60 %, G2 = 50 % Age range: 7-12 years (G1: M = 9.7, SD = 1.3; G2: M = 8.5, SD = 1.5) G1 (n = 58): ID G2 (n = 189): no ID Setting: 6 urban public elementary and middle schools, USA	Bias: HAI <u>Social Perception Task:</u> 13 peer vignettes: - **4 ambiguous**, unclear ("insincere benign") intent - 4 clear, neutral intent and salient negative outcome (2 also with salient neutral intent) - 5 clear, neutral intent (no salience) Method: Interview	HAI: G1: lower HAI than in G2, $t(245) = 2.06$, $p < 0.05$, $d = 0.26$ Intent attribution accuracy: G1 < G2 for all scenario types
van Nieuwenhuijzen et al. (2011) [59]	N = 142 Male: G1 = 82.1%, G2 = 77.5 %, G3 = 95.5%, G4 = 40.5 % Age range: 8-12 years (G1: M = 11.15, SD = 1.34; G2: M = 10.27, SD = 1.63; G3: M = 10.0, SD = 1.45; G4: M = 10.57, SD = .94) G1 (n = 38): mild to borderline ID (mean IQ = 80.48, SD = 9.72) G2 (n = 25): Clinical (mild to borderline ID and behaviour problems; mean IQ = 77.61, SD = 11.08) G3(n = 19): Disruptive behaviour disorders (DBD; mean IQ = 88.75, SD = 5.80) G4 (n = 40): TD controls (mean IQ = 105.08, SD = 8.62) Setting: SEN schools, centre for psychiatry and regular schools, Netherlands	Bias: HAI <u>Social Problem-Solving Test for children with MID (SPT-MID):</u> 9 peer vignettes: - **6 ambiguous**, unclear intent - 2 clear, negative intent - 1 clear scenario, neutral intent Method: Interview	HAI: - Higher HAI in G1, G2 and G3, compared to G4, $F(66, 360) = 8.98$, $p=.000$ [Group differences in attributions (G1,G2,G3 > G4) only for ambiguous scenarios]
Autism Spectrum Disorder (ASD)			
Carothers and Taylor (2004) [52]	N = 40 Male: G1 = 90%, G2 = 90% Age: G1, M = 9.6; G2, M = 9.35 G1 (n = 20): Asperger Syndrome G2 (n = 20): TD controls Setting: Elementary school, USA	Bias: HAI 18 vignettes: -**6 ambiguous**, unclear intent - 6 clear, neutral intent - 6 clear, negative intent Method: Interview	HAI: - G1: lower HAI than in G2 ($F = .21$, $p = .65$) Intent attribution accuracy: G1 < G2 for clear, neutral intent Encoding neutral intent cues: G1 < G2 Discounting neutral intent cues: G1 > G2
Flood et al. (2011) [61]	N = 50 Male: G1 = 84.6%, G2 = 79.2% Age range: 11-15 years (G1: M = 162 months, SD = 16.2; G2: M = 160 months, SD = 13.3) G1 (n = 26): Asperger Syndrome G2 (n = 24): TD controls	Bias: HAI and attributions of causality <u>SIP Interview (SIPI):</u> 4 ambiguous, unclear intent Method: Likert Scale Attributional Style: internal/external, global/specific, stable/unstable	HAI: - No group differences ($z = 1.312$, $p = .095$) - (Mentioned in discussion: difference between ASD school subtype and G2, [$\chi 2 = 6.120$, $df = 2$, $p = .047$], with higher HAI in ASD specialist school, compared to ASD mainstream school [$z = 2.230$, $p = .026$] and G2 [$z = 2.171$, $p = .03$])

	Setting: specialist ASD schools, mainstream school (G1: 50% in each school type)	Method: Multiple Choice	Attributional style: - G1: Higher global attributions than in G2 ($z = 3.074$, $p = .002$)
Hollocks et al. (2016) [62]	N = 83 Male: all groups = 100% Age range: 10-16 years (G1: M = 13.0, SD = 1.9; G2: M = 12.8, SD = 1.9; G3: M = 13.9, SD = 1.8) G1 (n = 21): ASD G2 (n = 34): ASD with comorbid anxiety G3 (n = 28): TD controls Setting: specialist autism schools, local schools, UK	Bias: Threat interpretation <u>Ambiguous Situations Interview:</u> 12 ambiguous vignettes: - 6 social threats - 6 physical threats Method: Multiple choice	Threat interpretation: - Group differences in interpretation bias, $F(2, 76) = 4.75$, $p = .01$, G2: more negative interpretations than G3 ($p \leq .01$), but not compared to G1
Specific Learning Disorder (SLD)			
Bryan et al. (1998) [63]	N = 96 Male: G1 = 56%, G2 = 52% Age: G1, M = 13.22 years (SD = .59); G2, M = 12.66 (SD = .47) G1 (n = 45): LD G2 (n = 50): 50 average achieving controls RCT Design: C1: Negative affect (heavy metal music) condition C2: Self-induced positive affect (happy memory) condition C3: Neutral affect condition C4: Positive affect (happy music) condition Setting: middle schools, USA	Bias: HAI One ambiguous peer vignette Method: Interview	HAI: - No group differences in HAI, $F(6, 65) = .629$, $p < .707$. - C4: lower HAI than C1 ($p < .007$) and C2 ($p < .009$)
Attention-Deficit/Hyperactivity Disorder (ADHD)			
Andrade et al. (2012) [66]	N = 64 Male: G1 = 76.9%, G2 = 64.0% Age range: 6-12 years (G1: M = 9.4, SD = 1.6; G2: M = 9.2, SD = 1.9) G1 (n = 39): ADHD G2 (n = 25): TD controls Setting: treatment program, Canada	Bias: HAI 35 vignettes: - **31 ambiguous**, unclear intent with either unclear (10), positive (14) or negative (7) outcome. - 4 clear (2 positive intent and outcome and 2 negative intent and outcome). Method: Interview	HAI: - No group differences in HAI for any ambiguous scenarios Positive intent attribution: - Higher positive intent attribution in G1 than G2 for ambiguous scenarios with negative outcome ($p = .020$) or positive outcome ($p = .003$) Positive outcome attribution: - G2 > G1 for ambiguous scenarios with positive outcome ($p = .006$) Negative outcome attribution: - G1 = G2 for all ambiguous scenarios Intent attribution accuracy: G1 > G2 for all clear scenarios Encoding of cues: G1 < G2 for all types of cues (controlled for conduct problems)

Colalillo et al. (2014) [65]	N = 66 Male: 100% in all groups Age range: 7.7-12.2 years (G1: M = 9.85, SD = 1.19; G2: M = 9.68; SD = 1.09) G1 (n = 28): ADHD G2 (n = 38): TD controls Setting: Canada	Bias: External and internal attributions <u>Children's Attribution Measure (CAM):</u> 8 ambiguous parent-child vignettes: - 4 unclear intent, negative outcome - 4 unclear intent, positive outcome Attribution dimensions: child responsibility, task difficulty, or parent's effort or ability Method: Likert scale	Internal attributions: - G1: higher attribution of child responsibility than in G2, $F(1,64) = 4.50$, $p = .038$ External attributions - G1 = G2 for other attribution dimensions
Haas et al. (2015) [68]	N = 72 Male: G1 = 82%, G2 = 80%, G3 = 59% Age range: 7.0-12.9 years (G1: M = 9.7, SD = 1.8; G2: M = 9.9, SD = 1.6; G3: M = 9.7, SD = 1.6) G1 (n = 40): CP/ADHD-only G2 (n = 15): CP/ ADHD-CU G3 (n = 17): TD controls Setting: clinically referred for treatment, USA	Bias: External and internal attributions <u>The Peer Social Attribution Questionnaire (PSAQ):</u> 8 ambiguous vignettes: - 4 unclear intent, positive outcome - 4 unclear intent, negative outcome Attribution dimensions: (Other Child Nice, Other Child's Mood, Self Nice, Ability, Effort, Self Mood, Task difficulty, Luck, Behaviour problems). Method: Likert scale	External and internal attributions: - For negative outcomes, G2: higher attribution to own behaviour problems than G1 or G3, $F = 3.87$, $p < .05$, G1 = G2 = G3 for other attributions. -For positive outcomes, G1 = G2 = G3
King et al. (2009) [67]	N = 75 Male: G1 = 75.0%, G2 = 90.5%, G3 = 64.7% Age range: 6–12 years (G1: M = 9.82, SD = 2.02; G2: 8.93, SD = 2.04; G3: 8.91, SD = 1.93) G1 (n = 20): ADHD (placebo) G2 (n = 21): ADHD (medicated) G2 (n = 34): TD controls Setting: Summer treatment program, USA and Canada	Bias: HAI 8 ambiguous vignettes Method: Interview	HAI: - No group differences, $F(2,70) = .45$, $p = .641$
Mikami et al. (2008) [64]	N = 228 Male: G1 = 0%, G2 = 0% Age range: 11–18 years (M = 9.5 years at baseline) G1 (n = 140): ADHD G2 (n = 88): TD controls Setting: Summer camp, USA	Bias: HAI 5 ambiguous vignettes with unclear intent, Method: Interview	HAI: - No group differences, Cohen's $d = .07$ - Significant associations between HAI and aggression in G2, $\beta = .73$; $p = .02$, but not G1, $\beta = -.15$; $p = .13$

Sibley et al. (2010) [78]	N = 45 Male: G1 = 33.3%, G2 = 66.7% Age: G1, M = 12.36, SD = 1.04; G2, M = 12.22, SD = .81 G1 (n = 27): ADHD G2 (n = 18): TD controls Setting: local middle schools, research centre, USA	Bias: HAI 10 ambiguous vignettes with unclear intent, Method: Interview	HAI: - No group differences, F(1,42) = .05, n.s

Note. Unless otherwise specified, outcomes of cognitive bias relate to ambiguous items only (printed in bold). M, Mean; SD, Standard deviation; G_i, group i; C_i, condition i; CP, conduct problems; HAI, hostile attribution of intent. Studies in bold are included in the meta-analysis.

Table 2.

Quality appraisal of included studies

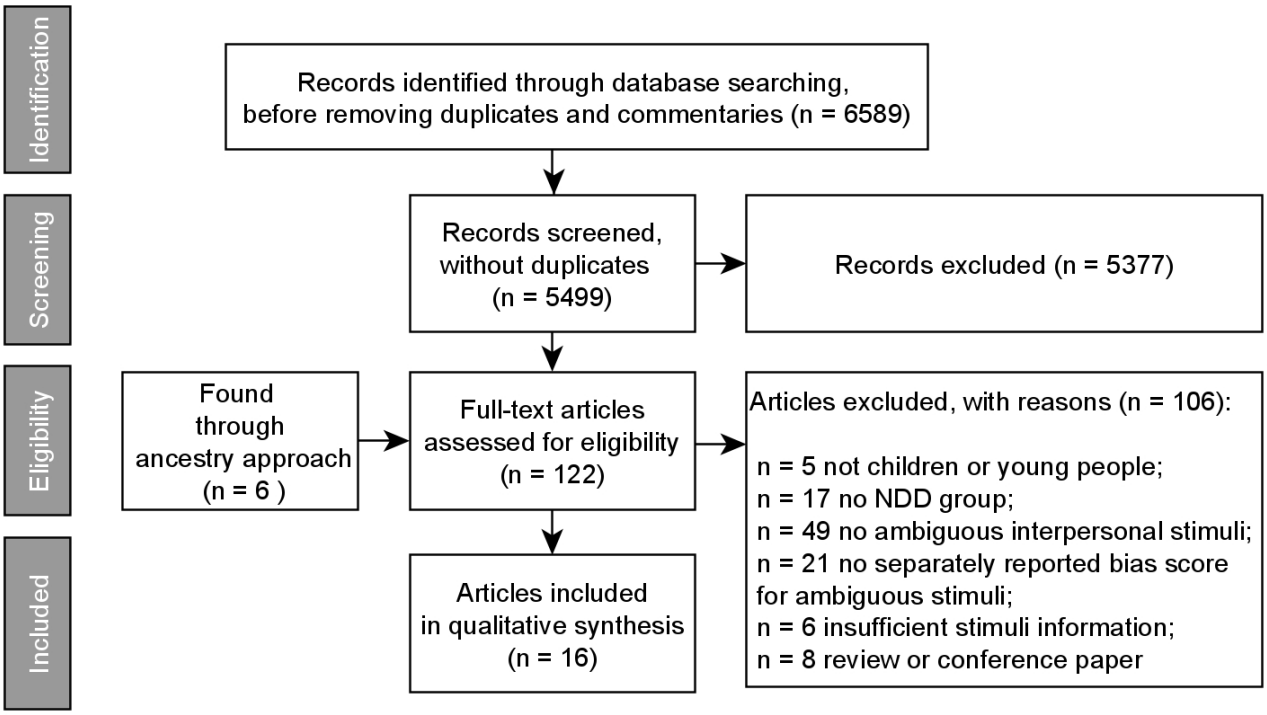
Study	Clear aims	Appropriate study design	Justified sample size	Clear and representative target population, sampling frame and [illegible]	Appropriate and previously piloted measures	Repeatable methods (including statistical methods)	Adequately described data	Sufficient information about response rate and non-responders to draw	internally consistent and comprehensive results	Justified discussion and conclusion	Discussion of limitations	Mentioning of no conflicts of interest	Ethical Approval or consent attained and mentioned	Randomisation [a]	Blinding described [a]
ID															
Gomez and Hazeldine (1996)	+	+	-	+/-	+	+	+	-	+	+	+	-	-		
Houtkamp et al. (2017)	+	+	+/-	+/-	-	+	+	-	+	+	+	+	+		
Klein et al. (2018)	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-
Leffert et al. (2000)	+	+	+/-	+/-	+	+	-	-	-	+	-	-	-		
Leffert et al. (2010)	+	+	+/-	+/-	-	+	+	-	+	+	+	-	-		
van Nieuwenhuizen et al. (2011)	+	+	+/-	+	+	+	+	-	-	+	+	-	-		
ASD															
Carothers and Taylor (2004)	+	+	-	+/-	+	+	+	-	+	+	+	-	-		
Flood et al. (2011)	+	+	+	+/-	+	+	+	-	+	+	+	-	-		
Hollocks et al. (2016)	+	+	+/-	+/-	+	+	+	-	+	+	+	+	+		
SLD															
Bryan et al. (1998)	+	+	+/-	+	-	+	+	-	+	+	+	-	-	+	+
ADHD															
Andrade et al. (2012)	+	+	+/-	+/-	+	+	+	-	+	+	+	+	-		
Colalillo et al. (2014)	+	+	+/-	-	-	+	+	-	+	+	+	-	+		
Haas et al. (2015)	+	+	+/-	+/-	+	+	+	-	+	+	+	+	+		
King et al. (2009)	+	+	+/-	+/-	+	+	+	-	+	+	+	-	+		
Mikami et al. (2008)	+	+	+/-	-	+	+	+	+/-	+	+	-	-	-		
Sibley et al. (2010)	+	+	+/-	+/-	+	+	+	-	+	+	+	-	+		

Note. If a study partly fulfilled a quality criterion, +/- was used. For example, when sample size was appropriate, but not justified in the original study, or when the sample was representative of the target population in terms of its eligibility criteria but convenience sampling strategies were employed.

[a] Additional Cochrane criterion for intervention studies

Figure 1.

Flow diagram for study selection, following the PRISMA statement



Appendix of Paper 1 (A.1): Electronic search strategy for all databases

	Category	Actual search terms
1	Children and young people	child* OR young people* OR youth* OR adolescen* OR teenage* OR school* OR minors* OR pediatric* OR paediatric*
2	Neuro-developmental disorders	neurodevelopmental disorder* OR intellectual* disab* OR intellectual developmental disorder* OR global developmental delay* Or learning disab* OR mental* retard* OR communication disorder* OR language disorder* OR speech sound disorder* OR childhood-onset fluency disorder* OR stutter* OR autism* OR autistic*OR asperger* OR pervasive developmental disorder* OR attention*deficit*hyperactivity disorder* OR ADHD* OR ADD* OR specific learning disorder* OR motor disorder* OR developmental coordination disorder* OR stereotypic movement disorder* OR tic disorder* OR tourette* disorder*
3	Cognitive biases	cognitive* bias* OR cognitive* distort* OR cognitive* error* OR cognitive* style* OR cognitive* apprais* OR interpret* bias* OR attribution* bias* OR appraisal* bias* OR negativ* bias* OR hostil* bias* OR attention* bias* OR encoding* bias* OR memory* bias* OR recall* bias* OR information* processing* bias* OR negativ* interpret* OR negativ* attribut* OR negativ* apprais* OR negativ* atten* OR negativ* encod* OR negativ* recall* OR negativ* information* processing* OR hostil* interpret* OR hostil* attribut* OR hostil* apprais* OR hostil* atten* OR hostil* encod* OR hostil* recall* OR hostil* information* processing* OR selectiv* interpret* OR selectiv* attribut* OR selectiv* apprais* OR selectiv* atten* OR selectiv* encod* OR selectiv* recall* OR selectiv* information* processing* OR interpret* intent* OR attribut* intent* OR social* information* processing* OR interpersonal* information* processing* OR social* problem*solv* OR interpersonal* problem*solv*
4	Cognitive bias modification	modif* OR CBM* OR ABM* OR attribution* retraining* OR retrain* OR attribution* training* OR interpretation* training* OR train* OR interven* OR treat* OR therap*
Search strategy		1 AND 2 AND [3 OR (3 AND 4)]

Appendix of Paper 1 (A.3): Examples of excluded studies

Study	Participants	Measure	Outcomes
Excluded because no group is made up of <u>only</u> NDD			
Milich and Dodge (1984)	N = 135 Male: 100% Age range: 6–12 years (G1: M = 11.8, SD = 1.7; G2: M = 12.2, SD = 1.9; G3: M = 12.1, SD = 1.6; G4: M = 11.8, SD = 1.6, G4: M = 11.6, SD = 1.67) G1 (n = 24): hyperactive-aggressive G2 (n = 14): exclusively hyperactive G3 (n = 14): exclusively aggressive G4 (n = 23): psychiatric control (M=11.8 yrs) G5 (n = 60): TD Proportion of NDD and non-NDD reported in Milich, Loney and Landau, 1982: 24% ADHD, 9% ADHD and Conduct Disorder, 24% Conduct Disorder, 43% other diagnosis or no diagnosis	Bias: HAI Method: Open-ended and forced-choice questions <u>Hypothetical attribution task</u> (open-ended and forced-choice): 1 of 2 vignettes: ambiguous, unclear intent <u>Recall task</u> 9 vignettes: -3 benevolent -3 neutral -3 intentional/hostile <u>Detective decision task</u> (response decision biases) 6 vignettes: ambiguous, unclear intent Method: interview	HAI: Higher HAI in G1 compared to G5, $F(1, 81) = 5.99$, $p < .05$ (on open-ended questions of hypothetical attribution task)
Stoddard et al., (2016) study 1	N = 97 (89 with acceptable data) Male: G1 = 58.7%, G2 = 46.2% Age range: 8-18 years (G1: M = 13.4, SD = 2.8; G2: M = 13.9, SD = 2.5) G1 (n = 63): DMDD G2 (n = 26): TD Proportion NDD and non-NDD: 87% ADHD; 73% ODD, 67% Anxiety, 32% MDD	Bias: HIF (balance point shift to interpret faces as angry rather than happy) <u>Interpretation bias task (IBT)</u> 15 ambiguous morphs for each identity	HIF: Higher HIF in G1 than G2
Excluded because no ambiguous stimuli used			
García-Blanco, Yáñez, Vázquez, Marcos and Perea (2017)	N = 50 Male: G1 = 89.7%, G2 = 75.9% Age range: 6-12 years (G1: M = 9.48, SD = 2.50; G2: M = 8.79, SD = 1.37) G1 (n = 25): ASD G2 (n = 25): TD	Bias: threat attention bias <u>Dot probe</u> 84 scenes: -12 happy -12 threatening -12 sad -48 neutral	Attentional bias toward threat: Higher in G1 than in G2, $t(48) = 2.36$, $p = 0.037$

Krauel et al. (2009)	N = 55 Male :100% G1: M = 13.9, SD = 1.3; G2: M = 13.2, SD = 1.2; M = 13.9, SD = 1.8 G1 (n = 14): ADHD only G2 (n= 16): ADHD + ODD/CD G3 (n = 25): TD	Bias: Memory bias <u>Incidental memory paradigm</u> (recognition) 360 emotional pictures: -50% neutral -25% positive -25% negative	Memory bias: No group differences for negative pictures, but lower memory bias for positive pictures in G2 compared to G3 ($t(39) = 2.52$, $p < 0.05$).
Excluded because ambiguous stimuli not reported separately			
Ziv, Hadad and Khateeb (2014)	N = 50 Male: 100% G1: M = 63.08 months, SD = 10.22 G2: M = 67.21 months, SD = 16.63 G1 (n = 25): ASD (either Asperger syndrome or PDD-NOS) G2 (n = 25): TD	Bias: HAI/intent attribution inaccuracy <u>Social Information Processing Interview-Preschool Version (SIPI-P):</u> 4 Vignettes - **2 ambiguous**, unclear intent - 2 clear, neutral intent (scores for ambiguous and unambiguous scenarios <u>combined</u> and so not reported separately) Method: Interview	HAI/intent attribution inaccuracy: Higher in G1 compared to G2, $F = 11.04$, $p < .01$
van Nieuwenhuijzen and Vriens (2012)	N = 79 Male: G1 = 77.5%, G2 = 82.1% Age range 8-12 years (G1: M = 10.27, SD = 1.63; G2: M = 11.15, SD = 1.34) G1 (n = 40): MBID and behaviour problems G2 (n = 39): MBID	Bias: HAI <u>Social Problem-Solving Test for children with MID (SPT-MID):</u> 9 peer vignettes: - 6 ambiguous, unclear intent - 2 clear, negative intent - 1 clear scenario, neutral intent (unlike in van Nieuwenhuizen et al., 2011, scores for ambiguous and unambiguous scenarios were not reported separately) Method: Interview	HAI: Significantly predicted by inhibition ($\beta = 0.33$, $F [1, 46] = 5.52$, $p = .02$). No correlations between HAI and working memory, perspective taking, emotion recognition and general interpretation

Note. M, Mean; SD, Standard deviation; G_i, group i; HAI, hostile attribution of intent; HIF hostile interpretation of faces, DMDD, disruptive mood dysregulation disorder; ADHD, attention deficit/ hyperactivity disorder; ASD, Autism Spectrum Disorders; PDD-NOS, Pervasive Developmental Disorders- Not Otherwise Specified, ODD, oppositional defiant disorder; CD, conduct disorder; MBID, Mild to borderline intellectual disabilities

Appendix B: Paper 2

Schmidt, N. B., & Vereenooghe, L. (2020). Inclusiveness of cognitive bias modification research toward children and young people with neurodevelopmental disorders: A systematic review. *International Journal of Developmental Disabilities*, 1-16. https://doi.org/10.1080/20473869.2020.1720156

Appendix C: Paper 3

This is a pre-peer review version of the manuscript and of one of its appendices that were submitted for publication to Behaviour Research and Therapy on 28.06.2020.

Targeting hostile attributions in inclusive schools through online cognitive bias modification: a randomised experiment

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The authors declare that there are no conflicts of interest.

[Note. Please note that, for reasons of standardisation and printing, the formatting of this paper has been slightly adapted compared to the submitted version. No changes have been made to its content.]

Targeting hostile attributions in inclusive schools through online cognitive bias modification: a randomised experiment

Abstract

The tendency to make hostile attributions in ambiguous social situations has been associated with aggression and may be targeted through cognitive bias modification for interpretations (CBM-I). Despite their high prevalence of aggression and internalising problems, children and young people with neurodevelopmental disorders (NDD) or special educational needs (SEN) are markedly absent from CBM-I studies. Here, we evaluate whether online CBM-I can reduce hostile attributions and reactive aggression in pupils in inclusive schools. In Study 1, 71 pupils (mean age = 12.2, SD = 1.5; 25.4% presented with NDD or SEN) were randomly allocated to complete three sessions of either CBM-I (n = 37) or active control training (n = 34). CBM-I involved interpreting ambiguous scenarios or faces in a non-hostile manner, whereas the control training involved attention and memory exercises without resolving ambiguity. Between-group comparison showed CBM-I to reduce both hostile attributions and reactive aggression. In Study 2, follow-up focus groups with 21 pupils demonstrated the acceptability of training content and delivery. Together, these findings show online CBM-I to be acceptable and effective at reducing both hostile attributions and reactive aggression in an inclusive setting. Replication of these findings and potential long-term intervention effects and behavioural outcomes require further investigation.

Keywords: cognitive bias modification; hostile attribution; children and young people; special educational needs; neurodevelopmental disorders; online

Background

The tendency to interpret other people's ambiguous intentions in situations with negative outcomes as hostile is referred to as hostile attribution of intent (Orobio de Castro, Veerman, Koops, Bosch, & Monshouwer, 2002). In line with the model of social information processing (SIP; Crick & Dodge, 1994), this type of interpretation or attribution bias has been linked to reactive aggression, which refers to aggressive responses to perceived threat, but not to proactive aggression, which is driven by perceived benefit (Martinelli, Ackermann, Bernhard, Freitag, & Schwenck, 2018; Orobio de Castro et al., 2002; Walters, 2005). Due to the role of interpretation bias in causing and maintaining externalising and internalising problems, systematically training people to interpret ambiguous stimuli more positively via cognitive bias modification of interpretations (CBM-I) could improve broad mental health outcomes (Cristea, Mogoaşe, David, & Cuijpers, 2015; Grafton et al., 2017; MacLeod & Mathews, 2012; Mobini, Reynolds, & Mackintosh, 2013). For distinct clinical diagnoses of anxiety and depression a recent network meta-analysis could not identify a sufficient evidence-base for the effectiveness of CBM-I (Fodor et al., 2020). However, for specific symptoms or associated factors such as aggression the evidence is more favourable, with CBM-I for hostile attribution of intent for instance reducing reactive aggression but not proactive aggression in highly aggressive adolescents (van Bockstaele, van der Molen, van Nieuwenhuijzen, & Salemink, 2020). A particularly high vulnerability for both internalising problems and externalising problems like aggression, has been demonstrated for children with neurodevelopmental disorders (NDD), such as intellectual disabilities (ID), attention-deficit-/hyperactivity disorder (ADHD), or specific learning disorders (SLD), and autistic children (ASD), all of which are also often characterised by cognitive, social, motor and executive deficits and special educational needs (American Psychiatric Association, 2013; Durkin, Boyle, Hunter, & Conti-Ramsden, 2013; Hansen, Oerbeck, Skirbekk, Petrovski, & Kristensen, 2018).

Most interpretation bias research for children and young people has focused on those who are typically developing (TD) and has therefore not adequately addressed the potential role of interpretation bias in explaining the high psychiatric comorbidity associated with developmental disorders. To our knowledge, Hiemstra, Castro, and Thomaes (2019) have conducted the only randomised controlled trial (RCT) targeting hostile attributions in children or young people that included those with NDD and that did not use explicit exclusion criteria relating to NDD or special educational needs (SEN). Their CBM-I intervention successfully trained clinically aggressive boys from special needs schools for behaviour problems that mostly consisted of children with ASD or ADHD, to interpret ambiguous faces as happy rather than angry. Meanwhile, Stoddard et al. (2016) showed that the bias towards interpreting ambiguous faces as hostile was significantly higher in young people with disruptive mood dysregulation disorder, 87% of which had ADHD, relative to healthy controls. Meanwhile, findings of studies comparing hostile attributions of intent in children and young people with and without ADHD have been mixed (Andrade et al., 2012; King et al., 2009; Mikami, Hinshaw, Lee, & Mullin, 2008; Milich & Dodge, 1984; Sibley, Evans, & Serpell, 2010), and evidence of a more pronounced hostile attribution of intent in children with ID when compared to TD controls is also inconclusive and contradictory (Gomez & Hazeldine, 1996; van Nieuwenhuijzen, Vriens, Scheepmaker, Smit, and Porton, 2011).

Given that the current evidence of children or young people with specific NDD or SEN making comparatively more or less hostile attributions is inconsistent, there has been little attention to the rationale for excluding them from CBM-I studies. Indeed, most CBM-I studies in children and young people targeting hostile attributions or other negative interpretation biases did not include those with a NDD diagnosis, SEN or intellectual impairment, as reviewed by Schmidt and Vereenooghe (2020). Some studies explicitly excluded them due to their CBM-I's reading demands (Micco, Henin, & Hirshfeld-Becker,

2014), but more often their exclusion was categorical and without explanation. Mixed samples with different NDD-related exclusion criteria also occur. For example, Sukhodolsky, Golub, Stone, and Orban (2005) improved hostile attribution of intent, aggression and conduct problems using hostile attribution retraining in a sample selected for aggressive behaviour problems, for which they included an unspecified number of participants with ADHD, but excluded those with pervasive developmental disorder. Likewise, van Bockstaele et al. (2020) recruited from special schools for pupils with average IQ and learning difficulties or social-emotional problems but excluded participants that were suspected by teachers to also have ASD. As this latter group made up almost one fifth of those selected as aggressive by teachers (van Bockstaele et al., 2020), this exemplifies how people with NDD are regularly and without rationale being excluded from interventions that might be particularly relevant and beneficial for them, considering their high psychiatric comorbidity. Given that van Bockstaele et al.'s (2020) CBM-I used voice-over, pictures and videos to adjust for potential verbal deficits of their participants, it might have been feasible in autistic children. Indeed, small methodological adaptations may be sufficient to make CBM-I both feasible and effective in children and young people with NDD, as has been shown by Klein and colleagues (2018) who incorporated simplified language and audio-support to effectively reduce interpretation bias and social anxiety in adolescents with mild ID.

With most CBM-I studies in children and young people adopting school-based recruitment approaches and the increasing prevalence of inclusive education, new opportunities arise to evaluate the effectiveness of CBM-I using inclusive samples. Therefore, we developed a new online CBM-I programme targeting hostile attributions for use in pupils with and without NDD or SEN as they join each other in inclusive schools. This approach required a study design which adopted both inclusive inclusion criteria and inclusive training methods. To improve the accessibility of our CBM-I, we implemented audio-voiceover and

animated videos that were designed to adjust for potential processing deficits of some participants and to increase adherence of all participants. We also used an avatar which provided positive feedback for non-hostile attributions of ambiguous scenarios and faces and delivered short entertainment in between trials to increase motivation and concentration. The training was delivered online, as in Sportel, de Hullu, Jong, and Nauta (2013), to allow easy and flexible access and to make training more acceptable to this age group (Grist, Croker, Denne, & Stallard, 2019). Unlike previous CBM-I studies for hostile attributions of intent in children and young people that used a test-retest control group (e.g. van Bockstaele et al., 2020; Vassilopoulos, Brouzos, & Andreou, 2015), we used an active control group that closely resembled the experimental group in terms of training delivery, but that contained no ambiguous scenarios and no attempt at modifying interpretations.

In Study 1 of this paper, we evaluate the efficacy of our new online CBM-I at reducing hostile attributions and reactive aggression. It was hypothesised that the CBM-I would lead to significantly greater reductions in hostile attributions compared to the control training. Moreover, in line with van Bockstaele et al. (2020), we expected CBM-I to significantly lower self-reported reactive aggression, but not proactive aggression. In Study 2 we explore the acceptability of the intervention amongst pupils through follow-up qualitative group interviews.

Study 1: RCT – Evaluating training effectiveness

Methods

Design

The study used a randomised controlled comparison with a 2 (Group: CBM-I vs. control condition) x 2 (Time: pre-training vs. post-training) x *S* single blind design. Randomisation procedures were conducted at pre-training assessment by handing out respective URL links to the online interventions, printed in either a blue or yellow folder, and which were handed out

alternately as pupils were sitting in a classroom. Participants were informed that the colours represented two different training groups, but it was not disclosed which colour was assigned to which condition or what CBM-I would entail. By contrast, the researchers involved in outcome assessments and responsible for updating the link to each of three weekly training sessions became unblinded to treatment allocation by the time of post-training assessment as most participants brought their folders to their training and testing sessions and URL links included the words "blue" or "yellow" for the respective groups. Pre-training assessments measured interpretation bias, aggression, victimisation experiences and emotional and behavioural problems, while post-training assessments, taking place one week after completing the three-week training, only measured the first three outcomes. A power analysis with G*Power 3.1.9.2 (Faul, Erdfelder, Buchner, & Lang, 2009) of repeated measures ANOVA, within-between interaction, indicated that 27 participants for each condition were needed to yield statistical power of $1 - \beta = 0.95$ at $p = .05$ (two-tailed) for a medium effect size ($F = 0.25$). The CONSORT 2010 checklist can be found in Appendix B.

Participants

Seventy-one pupils were recruited from two inclusive secondary schools in Germany. These schools are characterised by having both pupils with and without special needs or NDD attending the same class. Participants were between 9.6 and 15.7 years old (mean age = 12.2, SD = 1.5, % female = 49.3) and were recruited across 8 classes from 3 year groups. Thirty-seven pupils received the CBM-I training (mean age = 12.4, SD = 1.3) and 34 the control training (mean age = 12.0, SD = 1.6), as shown in the participant flow diagram in Figure 1. One participant in the CBM-I group and two participants in the control group were ill at post-training assessment.

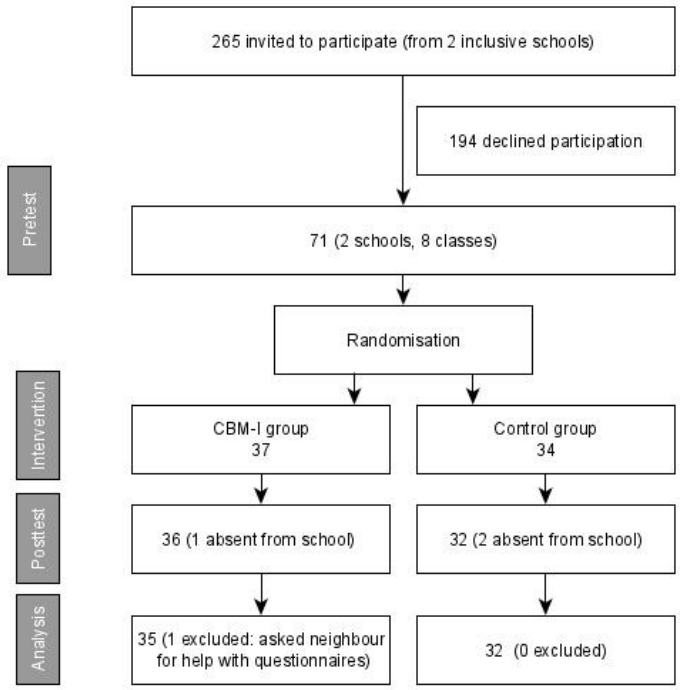

Figure 1. Participant flowchart.

According to teacher reports, one fourth of all participants (n = 18) had a type of NDD or SEN. Of those, twelve had some form of learning difficulties, such as dyslexia (n = 5), dyscalculia (n = 1) or a SEN related to learning (n = 6). The remaining six participants with NDD or SEN had ADHD (n = 2), or SEN relating to social-emotional development (n = 3) or speech (n = 1). Frequencies of NDD and SEN for each group are presented in table 1.

Table 1 Participant demographics and characteristics at pre-test.

	CBM-I (n = 37)	Control (n = 34)
n (%)		
female	18 (48.6%)	17 (50%)
NDD or SEN	9 (24.3%)	9 (26.5%)
ADHD	1 (2.7%)	1 (2.9%)
Dyslexia	2 (5.4 %)	3 (8.8%)
Dyscalculia	0 (0%)	1 (2.9%)
SEN learning	4 (10.8%)	2 (5.9%)
SEN social-emotional development	2 (5.4 %)	1 (2.9%)
SEN speech	0	1 (2.9%)

Interventions and materials

Both the CBM-I and the active control training consisted of three online sessions lasting 10 to 15 minutes each. Sessions were self-administered once a week, primarily during class times, on computers, laptops, tablets, or phones for a period of three weeks. Both trainings were created and delivered using the e-learning software iSpring Suite (iSpring Solutions, Version 9.7.6.18006) and designed to be similar in delivery, length, complexity, stimuli presentation and variation so that potential training effects could be attributed to the specific ingredient of CBM-I, namely ambiguity resolution. Both interventions consisted of six trials per session.

The CBM-I intervention was called 'Modifying Interpretations in Kids and Adolescents (MIKA)', but participants only knew it as the "blue group". Each session comprised six trials: four containing ambiguous scenarios and two containing ambiguous faces.

Ambiguous scenarios were presented as animated videos or cartoon pictures, showing how the protagonist (also named Mika) experienced a negative or potentially negative outcome. Such outcomes could be rejection, potential ridicule, property damage or loss, or bodily harm in a peer context, or unfair treatment by a teacher. The intentions of the other people involved in the scenarios causing these outcomes were designed to be unclear, so that there was ambiguity about whether their actions were hostile or non-hostile. Participants were asked to imagine themselves as the protagonist Mika. Three different CBM-I methodologies were used to resolve ambiguous scenarios. Like previous CBM-I studies using valence selection (Vassilopoulos et al., 2015), some scenarios required participants to choose between a hostile and a non-hostile interpretation and feedback was given that reinforced the latter, as exemplified by the CBM-I scenario in Figure 2. Response options throughout training were presented in randomised order. The second resolution method used persuasion techniques, similar to the ones used in attribution retraining (Hudley et al., 1998), by drawing attention to

social cues like the indistinct water puddle on the ground in Figure 2 that could be interpreted as evidence that the other person's behaviour was accidental and therefore non-hostile. Thirdly, as in imagery-based CBM-I studies (Burnett Heyes et al., 2017), some scenarios consisted of ambiguous pictures positively resolved by positive captions, such as a the word "friends" written underneath a picture of a group of kids pointing at Mika. The content of training scenarios was either adapted from previous studies (Conduct Problems Prevention Research Group, 1991; Horsley, Castro, & van der Schoot, 2010; Lau, Pettit, & Creswell, 2013; Micco et al., 2014; Recchia, Rajput, & Peccia, 2015; Samson & Wehby, 2019) or created especially for this study.

The two trials with ambiguous faces involved the presentation of a photo of an adolescent with an ambiguous facial expression or bodily posture next to one where the adolescent looked hostile. Participants in the CBM-I group received positive feedback for identifying the ambiguous face as the non-hostile one.

In contrast, the control training, known to the participants as the "yellow group", involved attention and memory exercises, such as factual questions (see Figure 2). Participants only received positive feedback for correctly rating a hostile face as such, but were not asked to make comparisons with ambiguous faces. The latter were presented at different points in the session, but instead of interpreting its valence participants were asked to identify errors hidden in the picture. To increase the complexity and educational value of the control training, it additionally taught participants about optical illusions in two trials per session, such as that straight lines may appear bent.

In both trainings, the avatar called Mika narrated all sessions and performed short dances after each trial to enhance motivation and concentration. Videos and cartoons were created by the first author using CrazyTalk® Animator 3 (Reallusion, Pipeline version 3.31.3514.1) software and photos taken from the content library of the e-learning software.

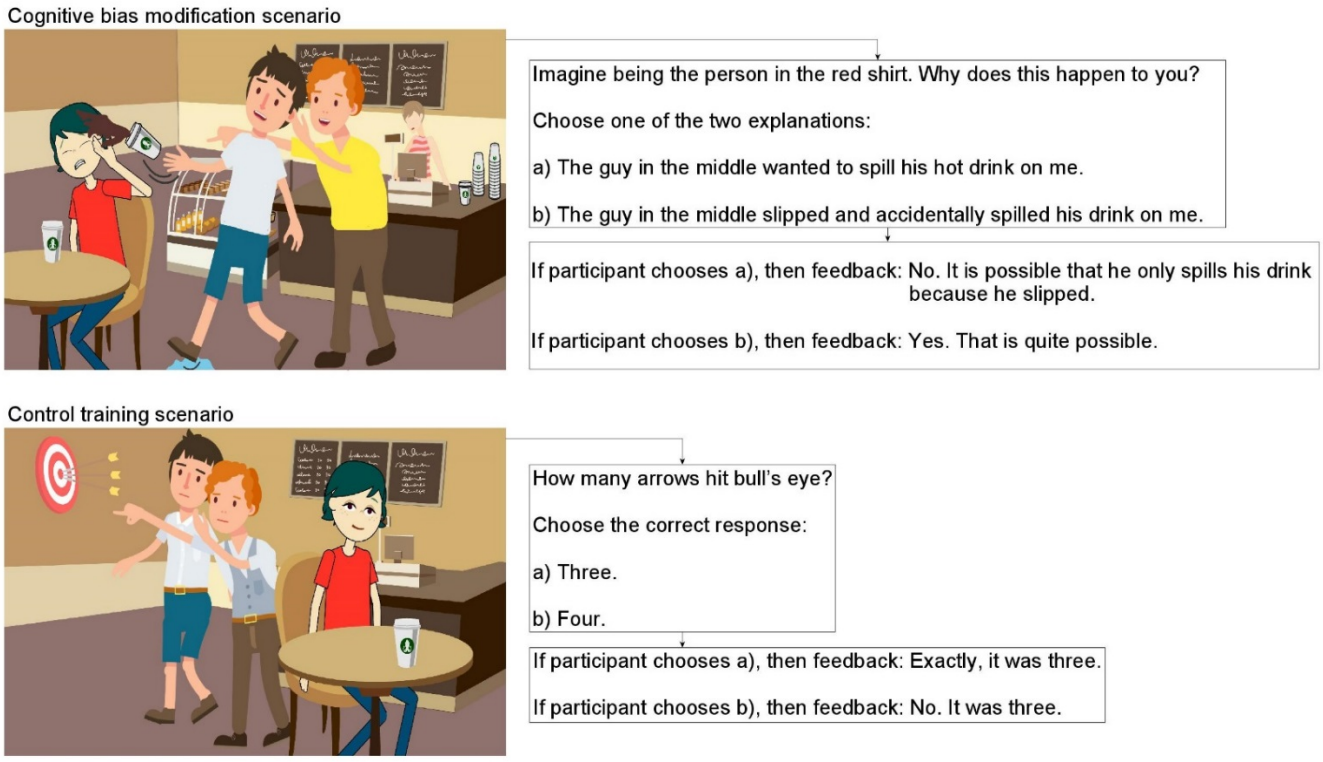

Figure 2. Examples of CBM and control training tasks

Measures

Interpretation bias

We developed the *Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP)* to measure interpretation bias regarding hostile attribution of intent. It consists of six ambiguous social scenarios, two of which were depicted by a cartoon, one by a WhatsApp conversation and three in written text format that was either read out to participants or read by them independently. The protagonist in each scenario was designed to be androgynous. Each vignette conveyed a negative or potentially negative outcome for the scenario's protagonist that could be interpreted as being deliberately caused with hostile intent by other people involved in the scenario. Like typical CBM-I scenarios, these ambiguous interactions involved either physical harm, property damage, potential theft or ridicule, or social exclusion

in a peer context, or the experience of being disadvantaged by a teacher. Participants were asked to imagine being the scenario's protagonist and asked to rate how much they agreed with three different explanations for why the outcome happened.

The VASAPP uses a Likert scale, ranging from 1 "no, definitely not" to 5 "yes, definitely", which was presented visually using the analogy of empty to full glasses of water, respectively. The use of images depicting varying amounts of water to facilitate participants' understanding of the Likert scale has been used in adults with intellectual disability (Hartley & MacLean, 2005). This water glass visualisation was used for all outcome measures. The questionnaire further used simplified language and short sentences to adjust for potential verbal deficits.

Vignette categories and scenario content were adapted from existing literature (Conduct Problems Prevention Research Group, 1995; Dodge, 1980; Hudley et al., 1998; Hudley & Graham, 1993a; Kupersmidt, Stelter, & Dodge, 2011; Leff et al., 2006; Lester, Field, & Muris, 2011; McGlothlin & Killen, 2006; Micco et al., 2014; Miers, Blöte, Bögels, & Westenberg, 2008; Petermann, Natzke, Gerken, & Walter, 2006; Samson & Wehby, 2019; Troop-Gordon, Gordon, Vogel-Ciernia, Ewing Lee, & Visconti, 2018). Figure 3 shows an example where the protagonist in the red shirt bends down to tie their shoelaces, while a boy in a blue jumper steps on the protagonist's homework. This example scenario was adapted from Hudley and Graham (1993) who used no pictorial representation.

Figure 3. Sample picture of a VASAPP item.

The three possible explanations for each scenario and for which participants rated their agreement were: (1) no blame (NB), (2) characterological other-blame (COB), or (3) characterological self-blame (CSB). No blame explanations indicated that the situation presented an unintended coincidence or accident, such as that the boy in the blue jumper did not see the notes on the floor, and are therefore considered non-hostile interpretations. The other two explanations were designed to measure two types of negative attributions. Characterological other-blame (COB) refers to attribution of hostile intent and character, such as assuming that the other boy in the scenario does not care about other people, and thus presents an other-deprecating hostile attribution which captures how blame is attributed to something stable about the other person. The second type of negative attribution is 'characterological self-blame' (CSB; Graham & Juvonen, 1998), a term that has previously been used to refer to the tendency of a person to blame his or her own unchangeable character (e.g. "There is something wrong with me"), frequently associated with depression (Guy, Lee, & Wolke, 2017; Quiggle, Garber, Panak, & Dodge, 1992). Despite not being the initial target of our training, this self-deprecating form attribution was included in the questionnaire to paint a more complete picture of how ambiguous scenarios might be interpreted.

The order of these three answer options was counterbalanced across scenarios. In line with previous studies that calculated bias as the difference between scores on negative and benign trials (Kuckertz, Amir, Tobin, & Najmi, 2013; Yiend et al., 2019), interpretation bias was calculated by subtracting the mean 'no blame' score from the mean 'blame' score. For instance, a participant with a mean COB score of 5 and a mean NB score of 1, would have a hostile attribution bias score of 4.

Two sets of the six-item questionnaire were created to be used for pre- and post-training assessments respectively. Validating the two sets in a sample of 185 university students showed the sets to be equivalent and produced acceptable internal consistency of both COB (set1: $\alpha = 0.66$, set2: $\alpha = 0.60$) and CSB (set1: $\alpha = 0.68$, set2: $\alpha = 0.62$). In the current study, the second set used at post-training assessment produced good internal consistencies (COB: $\alpha = 0.71$, CSB: $\alpha = 0.76$), whereas the first set used at pre-test showed poor internal consistency for COB ($\alpha = 0.50$) and unacceptable internal consistency for CSB ($\alpha = 0.26$).

Aggression

We translated the Reactive-Proactive Aggression Questionnaire (RPQ, Raine et al., 2006) into German (RPQ-Deutsch, Appendix A), which consists of 11 items assessing reactive aggression (e.g. "Reacted angrily when provoked by others") and 12 items assessing proactive aggression (e.g. "Hurt others to win a game"), self-rated on a three-point Likert scale (0 = never, 1 = sometimes, 2 = often) that we visualised using water glasses with increasing amount of water. To ensure the accuracy of the German translation, the back-translation was checked by the creator of the original questionnaire (Raine et al., 2006). In the original study, Cronbach's alpha values for the reactive and proactive scales were .84 and .86, respectively (Raine et al., 2006). For the present study, we found internal consistency at pre-training assessment to be .78 and .67, for the reactive and proactive aggression scales, respectively. A Dutch version of this measure was recently used to evaluate the effect of

hostile attribution modification on aggression in van Bockstaele et al. (2020), who reported specific effects of the training on reactive aggression, as opposed to proactive aggression.

Emotional and behavioural problems

The German version of the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) was used to measure self-rated emotional and behavioural problems at pre-training assessment. The SDQ consists of 25 items, divided into four difficulties subscales (conduct problems, hyperactivity-inattention, emotional symptoms, peer problems) and one strength subscale (prosocial behaviour), each containing five items that are rated on a three-point Likert-scale (0 = not true, 1 = somewhat true, or 2 = certainly true). The scores of the four difficulties subscales were added to calculate a total difficulties score, which was used as a covariate in our analysis. Goodman (2001) reported satisfactory internal consistency (mean α = .73) and retest stability after 4 to 6 months (mean $\alpha = 0.62$). In a study on the psychometric properties of the German version of the SDQ (Lohbeck, Schultheiß, Petermann, & Petermann, 2015), internal consistency ranged from .55 to .77 and was highest for the total difficulty score ($\alpha = 0.77$).

Peer victimisation

Pupils' experiences of peer victimisation were assessed using the Revised Peer Experiences Questionnaire (R-PEQ; De Los Reyes, Andres de & Prinstein, 2004). While the questionnaire can be used to assess experiences both of being victimised and of bullying others, we only used the victim version and left out the prosocial scale. The remaining nine-item self-report measure consisted of three items reflecting overt victimisation (e.g., ''A girl or a boy hit, kicked, or pushed me in a mean way"), three items reflecting relational victimisation (e.g., ''A girl or a boy left me out of what they were doing''), and three items reflecting reputational victimisation (e.g., ''A girl or a boy said mean things about me so that other people would think I was a loser''). Participants were asked to rate how frequently they

experienced each item on a five-point Likert-scale, ranging from 1 (“never”), visualised by an empty water glass, to 5 (“a few times a week”), depicted by a full glass. At pre-test assessment the frequency of experiences related to the last 6 months, whereas at post-training assessment it related to the last month in order to reflect the time interval since pre-training assessment. Siegel, La Greca, and Harrison (2009) previously also used different intervals for different time points. Item scores are added for each subscale, with higher values reflecting a higher frequency of experiencing a given form of victimisation. De Los Reyes, Andres de and Prinstein (2004) reported good internal consistency for the three subscales (overt: $\alpha = .78$, relational: $\alpha = .84$, reputational: $\alpha = .83$). In this study, internal consistency results at baseline were acceptable for overt victimisation ($\alpha = .64$) and for reputational victimisation ($\alpha = .77$), but poor for relational victimisation ($\alpha = .53$), while they were acceptable for all three at post-training assessment (overt: $\alpha = .64$, relational: $\alpha = .62$, reputational: $\alpha = .78$).

Procedure

After receiving ethical approval from the Psychology ethics committee of Bielefeld University, participants were recruited by directly contacting school staff of seven inclusive secondary schools in the Northwest of Germany. The first author visited the two schools that agreed to take part and informed pupils of classes from year groups 5 to 8 that were suggested by the schools about the study (see fig. 1). The study was presented as aiming to assess which of two online trainings would be more strongly associated with social perception, without specifically mentioning expected benefits. We obtained informed consent from parents and children. In a first meeting, randomisation, pre-test assessment and the first of three training sessions were all conducted during lesson time, taking approximately 90 minutes altogether. Randomised allocation to one of the intervention groups was conducted by handing out alternately blue and yellow booklets to the participating pupils, who themselves had randomly chosen where to sit in the room. After generating an anonymous participant code, participants

completed the VASAPP, RPQ, SDQ and RPEQ. This was instantly followed by the first CBM-I or control training session, lasting 10 to 15 minutes, which participants accessed online via school computers, laptops, tablets or their personal mobile phones, by typing into their browser the URL link printed in their respective coloured booklets. Participants were provided with headphones and navigated through the training by clicking on fields or using the touch screen of their tablet or mobile phone. Participants completed the remaining two sessions over the next two weeks and in accordance with their class schedule, or at home if they missed sessions. The researchers could track treatment adherence on a class level online, but not for individual participants. Hence, researchers could remind teachers if some pupils still needed to complete sessions. Post-test assessments were completed one week after the third training session and comprised the second set of the VASAPP, the RPQ and the RPEQ. Following debriefing, pupils in the control group were provided with the necessary information to retrospectively receive the CBM-I intervention should they wish to do so. All pupils were also invited to take part in Study 2 involving a qualitative interview aimed at assessing training acceptability, and for which informed consent was sought once again.

Statistical Analysis

To assess training effects on interpretation bias, we conducted mixed ANOVAs using IBM SPSS® Statistics (IBM, Version 25) with training group (CBM-I vs. control) as a between-subjects factor, and time (pre-training vs. post-training) as a within-subjects factor. SDQ total scores without the prosocial scale and both RPQ and RPEQ subscale scores were included as covariates in the analyses and VASAPP subscales as outcomes. Subsequent mixed ANOVAs assessed training effects on reactive aggression, while using interpretation bias, proactive aggression, victimisation and strength and difficulties scores as covariates. For significant interaction effects, two-tailed paired t-tests were then carried out to explore training effects in each group.

Results

Demographics and pre-training characteristics of the CBM and control group are presented in Table 1. There were no significant group differences at pre-training in age, gender, interpretation bias, aggression, strength and difficulties scores or victimisation (all *p*-values > 0.05).

A total of 67 participants completed both pre- and post- training measures of interpretation bias and aggression. Mean scores and standard deviations of characterological other-blame (COB), characterological self-blame (CSB) and reactive aggression for each group at each time point are presented in Table 2. Medians and interquartile ranges were provided for proactive aggression and victimisation scores because these variables violated normality assumptions. Proactive aggression, victimisation subscales and CSB scores violated assumptions relating to normal distribution or to homogeneity of variance or covariance.

Table 2. Averages and measures of variability for each group at each point of assessment

	CBM-I (n = 35)		Control (n = 32)	
	Pre	Post	Pre	Post
Mean (SD)				
VASAPP_characterological other-blame	-0.54 (0.94)**	-1.74 (1.07)	-0.70 (0.87)	-0.54 (0.82)
VASAPP_characterological self-blame [ab]	-1.29 (0.59) *	-1.92 (1.19)	-1.27 (0.60)	-1.30 (0.60)
RPQ_reactive aggression	8.20 (3.54) **	5.94 (3.25)	8.31 (4.4)	7.50 (4.52)
SDQ total_without prosocial scale	12.7 (4.1)	n.a.	13.4 (4.4)	n.a.
Median (IQR) [c]				
RPQ_proactive aggression [a]	2.63 (2.20)	2.46 (2.25)	3.10 (2.91)	2.10 (3.35)
RPEQ[d]_overt victimisation	4.50 (4.0)	4.0 (2.0)	6.0 (3.25)	5.0 (2.50)
RPEQ_relational victimisation	5.0 (3.0)	4.0 (2.0)	5.0 (3.0)	4.0 (3.0)
RPEQ_reputational victimisation	5.0 (3.0)	4.0 (3.50)	6.0 (4.25)	4.50 (4.0)

** Difference between pre-training and post-training means is significant, p < .05.*

*** Difference between pre-training and post-training means is significant, p < .001.*

[a] no homogeneity of covariance

[b] no homogeneity of variance

[c] non-normal distribution of residuals

[d] n= 32 for the three RPEQ outcomes in the CBM-I group, as three participants did not complete the RPEQ

For COB scores, the main effect of time was not significant, F(1, 56) = 2.870, p = .096, partial η^2 = .049, but there was a significant main effect of group, F(1, 56) = 8.848, p = .004, partial η^2 = .136, and a significant interaction effect of group and time, F(1, 56) = 28.209, *p* = .000, partial η^2 = .335. Within-group analysis showed that COB significantly decreased in the CBM-I group, t(34) = 5.782, *p* = .000, d = 0.98, but not in the control group, t(31) = -1.233, p = .227, d = -0.22.

For CSB scores, there was a significant main effect of group F(1, 56) = 6.239, *p* = .015, partial η^2 = .100, together with a significant main effect of time, F(1, 56) = 5.514, *p* = .022, partial η^2 = .090, and with a significant interaction effect of group and time, F(1, 56) = 5.081, *p* = .028, partial η^2 = .083. Within-group analyses showed that CSB significantly decreased in the CBM-I group, t(34) = 3.287, *p* = .002, d = 0.56, but not in the control group, t(31) = .350, p = .729, d = 0.06.

There was no main effect of group on the reactive aggression outcome, F(1,52) =.312, p = .579, partial η^2 = .006, nor of time F(1, 56) = 2.337, p = .132, partial η^2 = .040, but the interaction effect of group and time was significant, F(1, 56) = 4.754, *p* = .033, partial η^2 = .078. Reactive aggression significantly decreased in the CBM-I group, t(34) = 4.957, *p* = .000, d = 0.84, but not in the control group, t(31) = 1.597, p = .120, d = 0.28.

The analysis of proactive aggression and victimisation scores showed no significant interaction or main effects.

Discussion

Summary and interpretation of results

This study assessed whether three brief online CBM-I sessions, designed to train participants to make more positive interpretations of ambiguous social stimuli, could reduce hostile attributions and reactive aggression in pupils attending inclusive secondary schools, when compared to a control training. In line with our first hypothesis, there was a greater reduction in hostile attributions considering characterological other-blame (COB) after CBM-I than after the control training, as indicated by a significant interaction of time and group producing a large effect size. Analyses also showed significantly greater improvements of characterological self-blame (CSB) in the CBM-I group, but these analyses were subject to violations of the assumptions of homogeneity of variance and covariance. Consistent with our second hypothesis, there was also a greater reduction in reactive aggression from pre- to post-training assessment in the CBM-I group than in the control group. Analyses did not point to differential effects of training on proactive aggression or victimisation, but again these analyses were subject to violations of assumptions. Taken together, our findings are largely in line with those of van Bockstaele et al. (2020), who also found beneficial effects of hostile attribution modification on reactive aggression. Where van Bockstaele and colleagues (2020) recruited participants selected for high aggression, we refrained from such study eligibility criteria and reported generally low hostile attributions in our sample. In spite of this, reactive and proactive aggression scores at pre-test in this study were as high as those reported by van Bockstaele et al. (2020). It is unclear whether the high rates of aggression in our sample can be explained by the recruitment in inclusive schools, or due to recruitment bias (e.g. where schools with higher baseline of aggressive behaviours amongst students were more willing to participate). Together, these studies suggest that CBM-I can reduce both hostile attribution and reactive aggression.

Study 2: Exploring training acceptability

This qualitative follow-up study aimed to assess the acceptability of our CBM-I intervention for future implementation in inclusive school settings. We set out to explore what participants liked or disliked about the online trainings, and if there were any barriers to their participation. To that purpose, pupils of one of the inclusive schools recruited in Study 1 were asked to participate in this study, regardless of whether they had accepted or declined participation in Study 1. The audiovisual approach to our CBM-I training was intended to increase the training's accessibility and included the use of audio-voiceovers to reduce reading demands, and the use of avatars, pictures and animated videos to maximise user engagement. Hence, we expected the general acceptability of our training to be high, but further sought to explore whether students identified any aspects associated with the training content, design and delivery that could act as a barrier to participating or completing all sessions.

Methods

Participants

Twenty-three pupils (%female=56.5) agreed to take part in qualitative group interviews. Of these participants, eight pupils had completed the CBM-I training, twelve had completed the control training, and three had not participated in Study 1. We scheduled two group interviews to fit the class timetable of pupils who had consented to participate in this study. The first group comprised 14 pupils of two different classes: five of which had participated in the CBM-I intervention, six in the control intervention and three pupils were new to the study. The second group comprised nine pupils from a single class, of which three had participated in the CBM-I training and six in the control training of Study 1. As most participants had participated in Study 1, thereby meeting that study's eligibility criteria, we did not collect any new demographic data for this study sample.

Measures

A structured interview was conducted containing both closed and open questions regarding training likeability, adherence, user experience, delivery, content, expectations, and barriers to participation. Some questions were directed at the CBM-I group and the control training group separately, while other more general questions relating to the delivery and user experience were directed at both training groups. Those who had not previously participated in Study 1 were asked if there were any barriers that had prevented them from participating, after emphasising again that no one had to give a reason for their previous lack of participation.

Procedure

All pupils from one school that had participated in Study 1 were invited to take part in this follow-up study, in addition to pupils from this school that had not previously participated in Study 1. Following informed consent, two group interviews were conducted at school. Interviews were audio-recorded and later transcribed ad verbatim. The group interview comprised three parts: first, there were questions directed at those who had completed the CBM-I ("blue") training, next there were questions directed to those who had completed the control ("yellow") training, and finally there were questions directed at all participants and to those who had declined to participate in the intervention study.

Plan for Analysis

Responses to interview questions were analysed using frequency and content analysis (Morgan, 1993). We tallied the frequency of specific responses, such as how participants described the training.

Results

Figures 4 and 5 show the percentages of participants giving particular replies to closed and open interview questions regarding training acceptability. With regards to the closed interview questions (Figure 4), all participants stated that they liked the intervention and that they would participate again. With regard to adherence to the intervention, 88% of those in the CBM-I group and 83% of those in the control group reported completing all three sessions. The remaining participants indicated missing the last session due to illness or time constraints. At least one session was conducted at home by 75 % of participants in the CBM-I group and by 41.7 % in the control group, either because they missed one session at school or because they enjoyed doing it at home. Participants chose tablet computers as the primary mode for completing the intervention, which everybody preferred over using paper and pen. Eight participants used their phones to complete some of the sessions, mainly because they indicated the training loaded faster on their mobile phone (n = 6). Asked if they would have preferred completing the training of the other group, no participants agreed.

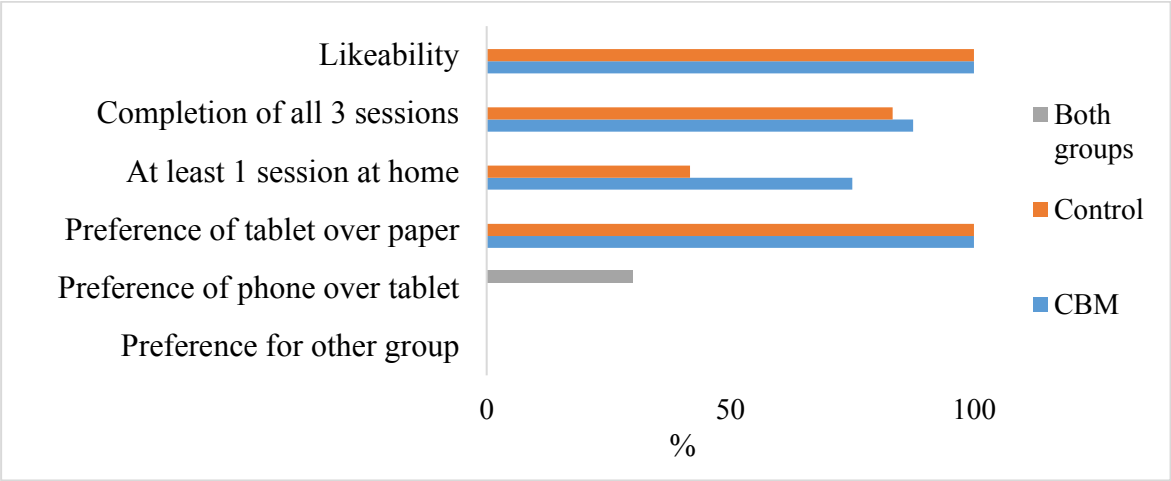

Figure 4. Training acceptability based on closed interview questions

Content analysis of the open interview questions were classified into the following categories: overall experience, content, motivation, tablet use, animated avatar and session duration (Figure 5). In response to the open interview questions, 87.5 % of participant in the

CBM-I group and 66.6 % in the control group described the training as "fun" and varied. While two participants in the CBM-I group mentioned the "easy" nature of the training as a positive, two in the control group criticised that the training had been too easy. Half of participants in the CBM-I group and one participant in the control group stated that the training represented a welcome alternative to school lessons ("Usually, all we do at school is study. This was something new, with animated characters."). Half of participants made comments relating to tablet use, stating that the use of tablets for training was "more fun", "easier" and convenient ("just have to tip screen") than working with pen and paper. Over one third commented on the animated avatar, describing the avatar's dance performances in between trials as enjoyable and the audio-voiceover provided by the avatar as helping them to read and process the information ("It's better to listen to text so that you have to do less reading"). Of the fifty percent of participants that made responses relating to session length, all would have preferred longer and more frequent training sessions and videos ("I would do it every week").

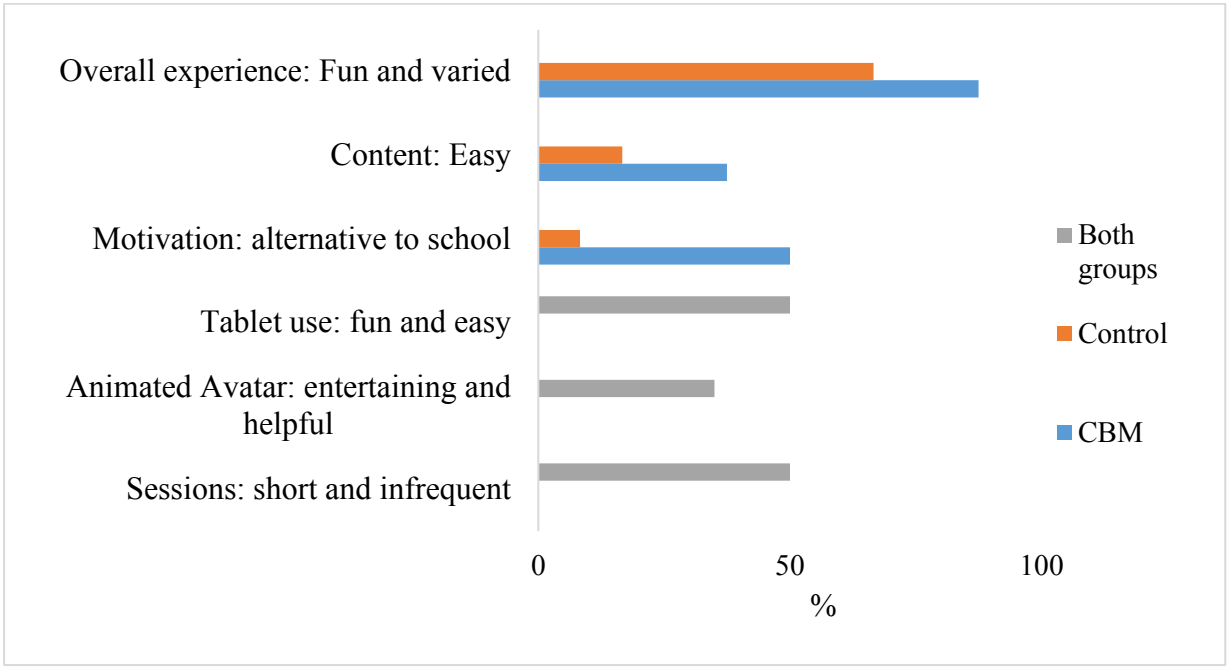

Figure 5. Training acceptability based on open interview questions

Expectations and barriers to participation

When asked about the expected aims of the training, those in the CBM group assumed that it aimed to "teach them about not being mad at others", about "how you react when you are bullied" and about having "no fights". Those in the control groups guessed that the training aimed to "improve their concentration and attention to what they are shown".

No barriers to participation were mentioned. Having been informed that all answers to our questions were voluntary, the three pupils that had not participated in Study 1 freely offered an explanation for their previous lack of participation, namely by stating that they had been ill or only recently joined the school.

Discussion

Participants' responses suggested that they considered the CBM-I intervention to be acceptable, as indicated by high likeability of training content and delivery, good training adherence, and requests for longer and more frequent training sessions. Since it is possible that only those who enjoyed Study 1 agreed to participate in Study 2, feedback might be positively biased. Another possibility is that the interruption of ordinary school lessons, which half of participants in the CBM-I group mentioned as a benefit of the training, played a big part in explaining their positive attitude towards the training and motivation towards more sessions. On the other hand, three quarters of participants in the CBM-I group stated that they voluntarily conducted at least one training session at home, which indicates that participants' appreciation of the training was not just due to their preference for the training over ordinary school lessons. The fact that the two training groups did not clearly differ in how much they liked their respective trainings suggests that differences in the efficacy of the two trainings (Study 1) were unlikely to be associated with motivational differences. Given that our CBM-I only directly targeted cognitions without training participants how to regulate their emotions

or behave in conflict situations, it is interesting to note that participants only mentioned emotional or behavioural effects as expected aims of the training.

However, only 29.9% of those who completed Study 1 participated in this study, so findings may not be representative of all participants of the intervention study. A larger sample and a greater number of participants in Study 2 who previously did not participate in Study 1 would have helped to adequately explore potential barriers to participating in CBM-I and to distinguish the reluctance for participation in this particular intervention from that in research in general. Moreover, it would be relevant to establish whether willingness to participate increases if the intervention is offered as part of the school curriculum.

General discussion

The current studies found new evidence for the potential effectiveness and acceptability of an online CBM-I that was specifically developed to target hostile attributions in secondary school pupils with and without NDD or SEN. Positive and motivating aspects of the training mentioned by participants in Study 2 related to the audiovisual support, avatar, animated videos and interactive exercises that we used to adjust for the potential intellectual, reading or motivational deficits of participants with NDD or SEN, as applied or recommended by previous studies on psychological therapies for NDD (Klein et al., 2018; Rotheram-Fuller & MacMullen, 2011; Verberg, Helmond, & Overbeek, 2018; Wit, Moonen, & Douma, 2011).

As anticipated, CBM-I improved hostile attributions and self-reported reactive aggression in Study 1 and was found to be an acceptable intervention in Study 2. Within an inclusive educational setting, our findings are in line with those of Vassilopoulos et al. (2015) and van Bockstaele et al. (2020) regarding the impact of CBM-I on reducing self-reported aggression, and provide further evidence for the effectiveness of CBM-I in reducing hostile attributions.

In our statistical approach, however, we were limited by our data and violations of several assumptions required for our planned analyses. In keeping with straightforward analyses, we decided against statistical techniques to circumvent this problem. Consequently, for data regarding self-reported proactive aggression, we could not reliably replicate van Bockstaele et al.'s (2020) finding that training effects on behaviour were specific to reactive aggression, as opposed to proactive aggression.

The effectiveness of our CBM-I in reducing aggression may be associated with our training stimuli, which included the targeting of hostile interpretations both of faces and of scenarios. Unlike Hiemstra, Castro, and Thomaes (2019), who trained clinically aggressive pupils in interpreting ambiguous faces as happy instead of angry and found no intervention effects, our combined CBM-I intervention did yield training effect on a measure of self-reported aggression. One potential explanation might be that training materials that integrate both faces and scenarios might be more representative of daily interactions leading to aggression.

Our aim was to deliver CBM-I that was feasible, effective and acceptable for pupils both with and without disability or special needs. Participants with NDD or SEN, who made up one fourth of the sample in Study 1, most frequently had some form of learning difficulty (16.9%), including the specific learning disorders dyslexia (n = 5) and dyscalculia (n = 2). Despite evidence for high comorbidity of learning difficulties with internalising and externalising problems (Visser et al., 2020), the role of interpretation biases in explaining this comorbidity is unclear. To our knowledge, the only study researching interpretation bias specifically in learning difficulties was Bryan, Sullivan-Burstein, and Mathur (1998) who reduced hostile attributions of intent using happy music in pupils with average IQ and academic deficits in one or more area. Apart from the six participants with a specific learning disorder, the only other type of NDD in our sample was ADHD (n = 2). This relatively low

proportion of NDD and the fact that these were reported by teachers and not confirmed by diagnostic interviews imply that the results of Study 1 cannot be reliably generalised to NDD. Moreover, since we did not assess how many of the interviewed pupils in Study 2 had NDD or SEN, it is unclear whether the collected feedback reflects the opinion of those with or without NDD or SEN. While participants' positive attitude towards the training and motivation for more sessions is promising, there is some uncertainty about whether participants would also be motivated if the training did not involve missing class and if they had to complete the whole training during their free time. However, the fact that the majority of participants in the CBM-I group voluntarily completed at least one missed session at home points to their intrinsic motivation for the training. It also demonstrates that one of the benefits of online training is that it enables flexibility regarding the time and location of training completion. Another insight provided by Study 2 is that it showed that most interviewed participants completed all sessions. Study 2 therefore to some extent addressed the problem that Study 1 did not systematically track treatment adherence.

Limitations and strengths

While no harmful or unintended effects were apparent from inspecting the data or identified during the qualitative follow-up study, it might be seen as a limitation that we did not explicitly monitor for harms in each group. The design of our studies evidently has implications for the generalisability and strength of our findings. First, the colour coding relating to our group allocation procedures was very practical for both researchers and participants, but it also led to all researchers inevitably becoming unblinded to treatment allocation as pupils talked about and showed their booklets. However, potential researcher influence on treatment outcomes was considered low as all questionnaires were self-report measures. Second, we cannot reliably compare our findings with those of previous studies as we employed a new bias measure, the VASAPP, for which the current data will be used as

part of a larger study to validate this measure. Since measures used to assess interpretation bias in previous CBM-I studies vary widely (Schmidt & Vereenooghe, 2020) and were not considered sufficiently accessible for use in inclusive schools, we developed a new questionnaire with the specific objective to provide an accessible measure to assess hostile attributions in children and young people with and without NDD or SEN. This involved pictorial representations of the Likert-scale and the inclusion of both visualised and narrated scenarios. Moreover, while internal consistency results of COB and CSB items were good for the second set of our questionnaire used after training, at pre-training assessment they were poor for COB and unacceptable for CSB. These results might be due to the small number of items completed by a relatively small and heterogeneous sample. Hence, the current data will be included with those of a second ongoing study to assess the psychometric properties of the VASAPP in a sample of inclusive secondary school pupils.

While the concept of attributing blame to one's own fixed character and its association with depression is not new to the literature (Graham & Juvonen, 1998; Guy et al., 2017; Quiggle et al., 1992), most hostile attribution studies only assess whether participants attribute hostile intent to other people, not whether they attribute blame to one's own or other people's character. The study could therefore have been improved by also assessing the training's efficacy using a previously published attribution bias measure, especially in light of the similarity of current assessment and training items. Another bias measure could have specifically assessed interpretation bias related to ambiguous faces since some of our CBM-I items gave positive feedback for interpreting ambiguous faces as non-hostile. Moreover, a follow-up assessment would have provided information about whether improvements in hostile attributions and self-reported aggression persist over time, ideally alongside proxy-report measures and behavioural observations.

By contrast, key strengths of our study design include randomised allocation and the use of an active control group. It thereby improves upon studies that so far assessed the efficacy of CBM-I targeting hostile attributions in children and young people using a test-retest control group (van Bockstaele et al., 2020; Vassilopoulos et al., 2015). Moreover, unlike these previous studies, our CBM-I was delivered online, which has the potential to increase the intervention's accessibility for participants with NDD or SEN. While van Bockstaele et al. (2020) made a big step towards making CBM-I more accessible and less monotonous by mixing written, oral, picture and video content, our training additionally used an avatar that narrated the whole training to minimise reading demands and maximise user engagement. Verberg et al. (2018) previously used an avatar for their online mindset intervention in adolescents with intellectual disabilities, but we are not aware of any CBM-I using such avatars. However, the actual impact of using an avatar on task engagement, accessibility and effectiveness has yet to be evaluated.

The qualitative follow-up study exploring user experiences is, in spite of its small sample, of great value as such systematically gathered feedback is necessary to improve training content and delivery. With the exception of Lisk, Pile, Haller, Kumari, and Lau (2018), such qualitative assessments are rarely found in CBM-I literature for children and young people.

Clinical implications

Our research showed that it is possible to reduce hostile attributions and reactive aggression in pupils with and without NDD or SEN via a short, easily implementable and accessible intervention. These results are not generalisable to specific NDD or SEN populations or to TD populations, since we aimed for a sample that was representative of inclusive classrooms. Future studies should investigate potential long-term effects of the intervention and its direct impact on behavioural outcomes. By using simple adaptations to

CBM-I methodology that adjust for potential processing needs of some pupils, it can be assured that cognitive and reading demands represent no barrier for inclusion in CBM-I research. Through adopting inclusive study eligibility criteria and use of inclusive training materials, we demonstrated the feasibility and importance of conducting CBM-I research that is representative of the increasingly inclusive school environment.

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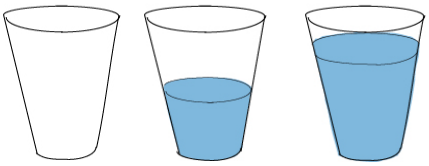
Appendix (A) of Paper 3:

Reactive-Proactive Questionnaire-Deutsch (RPQ-D)

German translation of the Reactive–Proactive Questionnaire (RPQ, Raine et al., 2006)

Es gibt Momente, in denen die meisten von uns sich wütend fühlen oder Dinge getan haben, die wir nicht hätten tun sollen. Beantworte jede der unten genannten Fragen, indem du entweder 0 (nie), 1 (manchmal), oder 2 (oft) einkreist. Verbringe nicht zu viel Zeit an jeder Frage- wähle einfach die Antwort, die dir als erstes treffend erscheint.

	0 = **nie**	1 = **manchmal**	2 = **oft**
			
Wie häufig…			
1…hast du andere angeschrien, weil sie dich geärgert haben?	0	1	2
2…hast du mit anderen gekämpft, um zu zeigen, wer der Stärkere war?	0	1	2
3…hast du wütend reagiert, wenn andere dich provoziert haben?	0	1	2
4…hast du anderen Mitschülern Dinge weggenommen?	0	1	2
5…bist du wütend geworden, weil etwas nicht so geklappt hat, wie du es wolltest?	0	1	2
6…hast du etwas nur zum Spaß beschädigt?	0	1	2
7…hattest du Wutanfälle?	0	1	2
8…hast du Dinge kaputt gemacht, weil du dich sauer fühltest?	0	1	2
9…hattest du einen Gruppenkampf, um cool zu sein?	0	1	2
10…hast du anderen wehgetan, um ein Spiel zu gewinnen?	0	1	2
11...bist du wütend geworden, wenn andere dir nicht gegeben habe du n, was wolltest?	0	1	2

12…hast du körperliche Gewalt angewandt, damit andere tun, was du willst?	0	1	2
13…bist du wütend oder sauer geworden, wenn du ein Spiel verloren hast?	0	1	2
14…bist du wütend geworden, wenn andere dich bedroht haben?	0	1	2
15…hast du Gewalt angewandt, um Geld oder Dinge von anderen zu bekommen?	0	1	2
16…hast du dich besser gefühlt, nachdem du jemanden geschlagen oder angeschrien hast?	0	1	2
17…hast du jemanden bedroht oder gemobbt?	0	1	2
18…hast du jemandem einen „Prank“ (eine Art Streich) übers Telefon oder Internet gespielt?	0	1	2
19…hast du andere gehauen, um dich zu verteidigen?	0	1	2
20…hast du andere gegen jemanden aufgehetzt?	0	1	2
21…hast du eine Waffe getragen, um sie in einem Kampf zu benutzen?	0	1	2
22…bist du wütend geworden oder hast andere gehauen, wenn du gehänselt wurdest?	0	1	2
23…hast du andere angeschrien, damit sie Dinge für dich tun?	0	1	2

Appendix D: Paper 4

This is a pre-peer review version of the manuscript and of its two supplemental materials that were submitted for publication to Psychological Assessment on 27.06.2021.

Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP): validation of a new attribution measure

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Data sets and study materials are available from the corresponding author on request.

[Note. Please note that, for reasons of standardisation and printing, the formatting of this paper has been slightly adapted compared to the submitted version. No changes have been made to its content.]

Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP): validation of a new attribution measure

Abstract

The attribution of hostile intent is linked to aggression and characterological self-blame (CSB) to depression. Less is known about whether attributing hostile character to other people when processing ambiguous interpersonal experiences also plays a role in aggression. Since accessible measures assessing both such other-blaming and self-blaming attributions are lacking, we developed a self-report questionnaire called Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP) that was designed to be accessible for individuals with cognitive difficulties and to measure characterological other-blame (COB), CSB and no blame (NB). This study validates the VASAPP in inclusive secondary schools in Northwest Germany. Two VASAPP sets were completed by 267 pupils with and without neurodevelopmental disorders or special educational needs (Mean age = 11.28 years, SD = .72; %female = 43.6; ethnicity: not assessed) at different timepoints in 2020. Exploratory factor analysis provided support for the construct validity of COB, CSB and NB. Strongest evidence was found for the internal consistency, convergent validity with aggression, and equivalence between sets for hostile attribution of character (i.e. COB). Given the comparatively weaker psychometric properties of CSB and NB, future studies may choose to only use COB or retain CSB and NB to control for neutral attributions and to provide a more complete picture of different attribution biases that may be relevant for understanding externalising and internalising problems. The use of accessible measures like the VASAPP may make cognitive bias research more inclusive and representative of children and young people with and without neurodevelopmental disorders or special needs.

Keywords: Psychometrics, attribution, blame, cognitive bias, aggression

Public Significance Statement: This study confirms that the VASAPP can measure whether pupils of inclusive schools for children with or without special educational needs blame other people's characters for undesirable social outcomes. Since this attribution of blame was related to aggression, it may help us understand why some people react aggressively in social situations.

When people experience undesirable outcomes in social situations involving others, their emotional and behavioural reactions partly depend on the attributions they make to explain the events (Dodge, 1993). For instance, children who tend to attribute hostile intent to other people even though there is ambiguity about whether others' actions were deliberate or coincidental, demonstrate a cognitive bias called hostile attribution of intent (HAI), which is positively associated with aggression (Verhoef, Alsem, Verhulp, & Orobio de Castro, 2019). Depressed children may also show a bias towards attributing hostile intent, but may be more likely to attribute blame to causes that are internal, stable and global (Quiggle, Garber, Panak, & Dodge, 1992; Reid, Salmon, & Lovibond, 2006). In this respect, one's own character represents an internal rather than external feature and is considered stable and global as it generally persists over time and across situations (Abramson, Seligman, & Teasdale, 1978). This type of blame attribution is referred to as characterological self-blame (CSB; Janoff-Bulman, 1979) and has primarily been studied in the context of depression (Anderson, Miller, Riger, Dill, & Sedikides, 1994). In contrast, research on aggression-related interpretation bias has focused on whether other people's behaviour in a specific situation is interpreted as mean, irrespective of whether this external cause is perceived to be stable and global. The current paper aims to explore whether aggression is associated with a tendency to explain ambiguous social situations' undesirable outcomes in terms of an external, stable and global cause, namely in terms of other people's characters. In order to use a term that is analogous to CSB, this type of attribution will here be referred to as characterological other-blame (COB).

Perren, Ettekal, and Ladd (2013) found that specific attributions of hostile intent in ambiguous situations (e.g. "The kids wanted to make fun of me") predicted children's aggressive and delinquent behaviour, as reported by teachers and parents, and that HAI partially mediated the link between victimisation and such externalising problems. Moreover, victimisation was more likely to lead to internalising problems like anxious, depressed and

withdrawn behaviour in children who tended to blame negative outcomes on their own behaviour (e.g. "I must have done something to make it happen", Perren et al., 2013).

As attribution biases may represent causal and perpetuating factors of externalising and internalising problems, and mediators or moderators of the link between victimisation and mental health problems (Perren et al., 2013), they could present a suitable target for psychological interventions like cognitive bias modification for interpretation (CBM-I). When cognitive bias is successfully modified, CBM-I can improve specific mental health outcomes like aggression (Cristea, Mogoaşe, David, & Cuijpers, 2015; Grafton et al., 2017; van Bockstaele, van der Molen, van Nieuwenhuijzen, & Salemink, 2020; Vassilopoulos, Brouzos, & Andreou, 2015).

Given the associations of blame attributions with aggression and depression, attribution biases relating to characterological self- or other-blame might also improve our understanding of the high rates of internalising and externalising problems in children and young people (CYP) with neurodevelopmental disorders (NDD). Different NDD, which include attention-deficit/hyperactivity disorder (ADHD), intellectual disability (ID), autism spectrum disorder (ASD), specific learning disorder (SLD), communication disorders and motor disorders, frequently co-occur and share a vulnerability for cognitive, social, motor and executive deficits, as well as for special educational needs (SEN) and psychiatric comorbidity (American Psychiatric Association, 2013; Emerson, 2003; King & Waschbusch, 2010; Simonoff et al., 2008). For example, CYP with ADHD were ten times more likely to be diagnosed with the externalising disorders conduct disorder and oppositional defiant disorder, both of which involve aggression and anger, and over five times more likely to have major depressive disorder, when compared to typically developing (TD) CYP (Angold & Costello, 1994). Studies on attribution biases in NDD have been too scarce to draw strong conclusions about their role in this group of disorders. The few studies that compared hostile attributions

between CYP with NDD and TD controls have not provided consistent evidence for higher levels of HAI in ID, ASD or ADHD (Andrade et al., 2012; Carothers & Taylor, 2004; Flood, Julian Hare, & Wallis, 2011; Gomez & Hazeldine, 1996; King et al., 2009; Milich & Dodge, 1984; Sibley, Evans, & Serpell, 2010; van Nieuwenhuijzen, Vriens, Scheepmaker, Smit, & Porton, 2011).

When studies measure whether children's attributions were internal, stable or global, differences between children with and without NDD emerge. For instance, when children with Asperger syndrome (AS) were asked to imagine experiencing negative social outcomes in ambiguous situations (e.g. being bumped into by another child in the lunch line), they did not differ from TD children in their attribution of hostile intent nor in their attribution of blame to internal or external causes, or to stable or unstable causes (Flood et al., 2011). Instead, children with AS preferred global over specific attributions, as suggested by higher agreement to statements that they "get in most kids' way", rather than "in that kid's way" (Flood et al., 2011). Such a global attributional style may cause children to perceive undesirable social outcomes as unavoidable and may thus partly explain potential difficulties in initiating and maintaining positive social relationships (Flood et al., 2011; Mikami, Miller, & Lerner, 2019).

Another study asked participants to imagine vignettes in which their parents refuse to play with them or help them and found that boys with ADHD were not more likely than boys without ADHD to attribute parents' ambiguous behaviours to external causes such as their parents' effort, but were more likely to make internal attributions of child responsibility like "My mom doesn't help me because of something I did'' (Colalillo, Williamson, & Johnston, 2014). However, evidence for a tendency towards internal or global attributions in CYP with ADHD or ASD is based on a small number of studies and provides little information about the relation between such attributions and externalising or internalising problems.

Due to the scarcity of cognitive bias research involving CYP with NDD, the role of attribution biases in explaining increased aggression in NDD remains unclear and therefore requires further investigation. If more evidence was found for increased cognitive bias in NDD or associations with mental health problems, this process should be directly targeted by interventions like CBM-I in this group. So far, this group is rarely included in CBM-I research and frequently explicitly excluded without an explanation (Schmidt & Vereenooghe, 2020), even though CBM-I may be feasible and effective in CYP with NDD or SEN (Hiemstra, Orobio de Castro, & Thomaes, 2019; Klein et al., 2018; van Bockstaele et al., 2020).

The attribution measures completed by CYP with NDD in the studies mentioned above are heterogeneous and may be insufficiently accessible for pupils with neurodevelopmental conditions or SEN, given that no visual presentation of vignettes was used to reduce the questionnaires' potential cognitive demands. The fact that studies comparing attribution bias between typically and atypically developing individuals, or between different types of NDD, are rare and vary widely in their attribution measures (Larkin, Jahoda, & MacMahon, 2013), complicates comparisons of these groups. Hence, sensitive and accessible measures that can be completed by everyone would allow for future meta-analytic comparisons of findings relating to cognitive bias in TD individuals and different neurodevelopmental conditions. Moreover, the educational context is becoming increasingly inclusive towards pupils with NDD, disabilities or SEN, as required by the UN Convention on the Rights of People with Disabilities (United Nations General Assembly, 2006). Therefore, it would be exemplary if cognitive bias research, which is frequently and effectively conducted in a school context (Cristea et al., 2015), would strive to parallel such inclusiveness.

In order to address the gap in the literature regarding the use of an attribution measure that is inclusive and that assesses both characterological self-blaming and other-blaming

attributions, the current authors developed the Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP) as an accessible self-report questionnaire to assess attribution biases in CYP with and without NDD or SEN. Based on pupils' interpretations of ambiguous social vignettes, it assesses attribution of blame to other people's characters (COB) or one's own character (CSB), as well as a neutral form of attribution involving no blame (NB). To adjust for potential cognitive or reading deficits of participants, the VASAPP uses simplified language, short sentences and pictorial representations of the Likert-scale, and includes scenarios that are visualised by colourful cartoons. Two sets of the VASAPP were created so that the questionnaire may be used to evaluate the effectiveness of interventions that target attributions and to assess the generalisation of training effects to new vignettes in pre-post studies. Moreover, ensuring that the content of serial assessments in longitudinal research is not identical may reduce the risk of practice effects (Costa et al., 2012).

The aim of this paper was to validate the two VASAPP sets using a sample that was representative of the inclusive school environment, namely a sample of pupils with and without NDD or SEN attending inclusive secondary schools who completed the two VASAPP sets at different timepoints. This paper first assesses the reliability of the two VASAPP sets in terms of the internal consistency of the different types of attribution (COB, CSB and NB), as well as the alternate-form reliability and equivalence of the two sets. Next, the paper assesses the VASAPP's validity and demonstrates its content validity by relating the vignettes' content to previous literature. Furthermore, exploratory factor analysis is used to explore the construct validity of the three attribution subscales COB, CSB and NB.

The paper then continues to assess the convergent validity of the two VASAPP sets' attributions with aggression, as measured by the reactive-proactive aggression questionnaire (RPQ, Raine et al., 2006), which distinguishes between proactive aggression (driven by

perceived benefit) and reactive aggression (provoked by perceived threat; Walters, 2005). Regarding the evaluation of the VASAPP's convergent validity with the RPQ, it is further hypothesised that (i) other-blaming attributions (COB) would be significantly and positively correlated with reactive aggression, as opposed to proactive aggression, and (ii) that self-blaming attributions (CSB) would not be associated with aggression. These hypotheses are guided by evidence suggesting that HAI is more likely to be related to reactive aggression than to proactive aggression (Martinelli, Ackermann, Bernhard, Freitag, & Schwenck, 2018), that improving HAI via CBM-I specifically improved reactive aggression, not proactive aggression (van Bockstaele et al., 2020), and that self-blaming attributions appear to play a greater role in depression rather than in aggression (Perren et al., 2013; Quiggle et al., 1992).

Since this is, to the authors' knowledge, the first validation study to use a German translation of the RPQ (Raine et al., 2006), the paper additionally assesses the internal consistency and test-retest reliability of the RPQ-Deutsch.

Methods

Study population

The study recruited 267 pupils aged between 9 and 13 years (mean age = 11.28 years, SD = .72) from year groups 5 and 6 (43.6% female) of four inclusive secondary schools in the Northwest of Germany where pupils with and without NDD or SEN received inclusive education. Overall, 16 school classes participated, of which four did not include any pupils with NDD or SEN at the time of data collection.

The original form used to record gender included a female, male and a non-binary option. Participants, however, reported being confused by this third option and preferred the binary response options, which was subsequently implemented. In line with local data protection guidelines, participant ethnicity was not recorded as there was no theoretical rationale for its potential impact on the outcomes of interest. Hence, socio-demographic data

was limited to age, gender and NDD, SEN and refugee status. As countries may differ in their categorisation of SEN, the recorded NDD, SEN and DSM-5 disorders were converted into a single categorisation system according to the SEN and disability code of practice (Poulter & Timpson, 2015). Table 1 shows how the SEN of the German system and additional mental health diagnoses, which were both assessed via teacher reports, match onto Poulter and Timpson's (2015) categories 'cognition and learning', 'social, emotional and mental health difficulties', 'communication and interaction', and 'sensory and/or physical needs' categories.

ID, SLD, ADHD and ASD can all be considered NDD that may present with needs across all SEN areas, although the current classification only specifically acknowledges this for ASD (Poulter & Timpson, 2015). Where there was a direct overlap between German SEN categories (e.g. physical and motor disorders) and DSM-5 classifications (e.g. motor disorders), only the German SEN status was assessed (Hollenbach-Biele & Klemm, 2020). Whilst ethnicity was not assessed, as justified above, refugee status was assessed due to its relation with potential language problems and possible psychological trauma. Table 2 presents the type and number of participants with SEN or NDD at each assessment point. Nearly one sixth of pupils were reported by teachers to have SEN or NDD. The most frequently reported SEN in the current study's sample was 'cognition and learning', present in just over one tenth of pupils, while none of the participants had sensory and/or physical needs. Table 2 only presents the types of SEN, NDD or mental health problems that were actually reported to be present in the sample, while table 1 shows all the ones that were assessed.

Instrument characteristics

Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP)

Vignettes. The VASAPP consists of six ambiguous social scenarios, involving a protagonist who experiences undesirable social outcomes caused by other people, and aims to assess three types of blame attributions, namely blame relating to others, to the self, and to no

one. The scenarios are ambiguous because the information provided does not make it clear whether other people's behaviours are deliberate and mean or unintentional and harmless. Vignettes depicted as cartoons, such as the one displayed in Figure 1, were created by the first author using CrazyTalk® Animator 3 (Reallusion, Pipeline version 3.31.3514.1) software. The VASAPP example item in Figure 1 was adapted from Petermann, Natzke, Gerken and Walter (2006) who instead used a black-and-white pencil drawing. It depicts the protagonist in the red shirt sitting at their school desk, when a classmate appears to bump against their school supplies while walking past the desk, with the supplies falling to the floor.

For each vignette, participants are asked to imagine being the protagonist. The protagonist was designed to be androgynous. Five of the vignettes depicted other peers' behaviours that reflected either ambiguous physical harm, property damage, theft, social ridicule, or social rejection or exclusion (Kupersmidt et al., 2011; Troop-Gordon, Gordon, Vogel-Ciernia, Ewing Lee, & Visconti, 2018). In addition to the five peer-context vignettes, a sixth vignette concerned ambiguous behaviour of a teacher towards the protagonist (Samson & Wehby, 2019). Together, the six vignettes were designed to be representative of ambiguous events that pupils might experience and negatively interpret in a school context. To assess the questionnaire's content validity, the sources of the vignettes' categories and content are presented in the respective results section.

Scoring. For each vignette, participants were given three possible explanations for why the outcome happened and for which they had to rate their agreement ranging from 1 (*no, definitely not*) to 5 (*yes, definitely*). The three explanations reflected either characterological other-blame (COB), characterological self-blame (CSB) or no blame (NB). The order of these answer options was counterbalanced across vignettes. COB statements represented attribution of blame to an external, stable and global cause, namely to other people's general character (e.g. "This horrible guy always treats other people's stuff badly"). Similar to Graham and

Juvonen (1998), who previously measured external attributions using items like “these kinds of kids pick on everybody”, COB captures hostile features about other people that persist across time and situations. Graham and Jovonen (1998) distinguished external attributions from behavioural self-blame, representing attribution to internal, unstable and specific causes (e.g. “I should have been more careful”), and from CSB, representing attribution to internal, stable and global causes (e.g. “If I were a cooler kid, I wouldn't get picked on”). As the VASAPP focuses on attribution of blame to stable and global causes, it included CSB statements (e.g. “I deserve that this happens”) but not behavioural self-blame statements. The CSB items in the VASAPP thus differed from Perren et al.’s (2013) self-blame items that, unlike our self-blaming subscale, conveyed an element of specificity and controllability (e.g. “I must have done something to make it happen”).

Like Perren et al. (2013), this paper’s attribution measure also included items which conveyed that other people’s behaviour represented an unintended coincidence or accident, here referred to as no-blame (NB) statements (e.g. “They accidently bumped against the school supplies”). Including NB attributions enables the calculation of ‘difference scores’ for COB or CSB, namely by subtracting NB from COB or CSB scores. For instance, a participant who rates the COB item of a particular vignette as ‘5’ and the NB items as ‘1’, obtains a COB difference score of 4 (i.e. 5 - 1). Using difference scores of negative and benign items to calculate the overall attribution bias score is in line with previous interpretation bias studies (Kuckertz, Amir, Tobin, & Najmi, 2013; Yiend et al., 2019) and allowed the current study to control for neutral attributions and for possible extreme answering patterns (Orobio de Castro, Veerman, Koops, Bosch, & Monshouwer, 2002). This study aimed to validate both the raw scores of COB, CSB and NB, as well as the COB difference scores (COB - NB) and the CSB difference scores (CSB - NB), so that either scoring method could be used by future studies.

Accessibility. The questionnaire used simplified language and short sentences to adjust for potential deficits in verbal skills, in working memory and in other cognitive skills that may be present in CYP with NDD or SEN. To facilitate participants' understanding of the 5-point Likert scale, it was also presented as a visual analogue scale using glasses containing varying quantities of water (ranging from an empty to a full glass of water), which has similarly been done in adults with intellectual disability (Hartley & MacLean, 2005). Presenting some of the vignettes as colourful cartoon images was intended to reduce reading demands and to make the material more engaging. As effect sizes concerning the relationship between HAI and aggression were reported to be smaller when using pictures or videos, as opposed to written or narrated text (Orobio de Castro et al., 2002), the VASAPP used a mixture of stimulus presentation types: two of the six vignettes were presented as a cartoon and four in written text format that was read by participants. One of the four written items can be considered a 'cross-over', as it presented a picture of a group text message on WhatsApp®. This item and form of communication was expected to be particularly relevant and appealing to this age group (Grist, Croker, Denne, & Stallard, 2019).

Two VASAPP sets. Two sets (A and B) of the VASAPP were developed that were designed to be equivalent, with each set containing six vignettes and including the same overall vignette categories and presentation types. However, the type of presentation for a specific category partly differed between the two sets. For example, the category 'social rejection/exclusion' was presented as a cartoon image in set A and as a WhatsApp® group message in set B (for the original German VASAPP sets, see supplemental material 1).

VASAPP piloting. The two sets of the VASAPP were piloted in a sample of 185 university students (Mean age = 23.50, SD = 4.55; %female = 77.3) to gain a tentative insight into its psychometric quality. According to this piloting, the two VASAPP sets produced questionable internal consistency of the raw scores of COB (set A: $\alpha = .66$, set B: $\alpha = .60$) and

CSB (set A: α = .68, set B: α = .62), and unacceptable internal consistency of the raw scores of NB (set A: α = .44, set B: α = .52). Meanwhile, internal consistency was questionable in both sets for COB difference scores (set A: α = .62, set B: α = .61) and for CSB difference scores in set A (α = .68), and poor for CSB difference scores in set B (α = .58). Using the university student sample, paired-samples t-tests were used to test whether the overall attribution scores across the six vignettes, calculated by taking the mean, were equivalent between the two sets. No significant differences were found when comparing the two sets in terms of the COB difference score, $t(184) = .69$, $p = .49$, or the CSB difference score, $t(184) = .94$, $p = .35$. However, significant differences emerged when the two sets were compared based on the COB subscale, $t(184) = 3.68$, $p < .001$, CSB subscale, $t(184) = -10.88$, $p < .001$, and the NB subscale, $t(184) = 3.40$, $p < .001$. Therefore, VASAPP piloting only provided evidence for the equivalence of the two sets when considering the subscale difference scores (e.g. COB - NB).

Reactive-Proactive Aggression Questionnaire (RPQ, Raine et al., 2006)

The RPQ was chosen as a self-report measure of aggression to assess the convergent validity of the VASAPP, given the association between aggression and hostile attributions and the previous use of the RPQ in the international cognitive bias and HAI literature (Martinelli et al., 2018; van Bockstaele et al., 2020). The RPQ was translated into German (RPQ-Deutsch) by this paper's first author, with the back-translation having been checked for accuracy by the first author of the original study (Raine et al., 2006).

The RPQ and RPQ-Deutsch have an 11-item reactive aggression subscale and a 12-item proactive aggression subscale. Reactive aggression items represent angry responses to real or perceived provocation (e.g. "Reacted angrily when provoked by others"), while proactive aggression items represent premeditated and goal-directed acts (e.g. "Hurt others to win a game"; Card & Little, 2006; Raine et al., 2006). Items are self-rated on a three-point

Likert scale (*0 = never*, 1 = *sometimes, 2 = often*). For the RPQ-Deutsch the Likert scale was additionally visualised in line with the visual analogue scale of the VASAPP, namely using glasses with increasing amount of water. For the original RPQ, Raine et al. (2006) reported Cronbach's alpha values of .84 for the reactive and .86 for the proactive subscale. The validation of the Dutch RPQ showed acceptable test-retest stability during a 3-year follow-up in 324 juvenile offenders (Cima, Raine, Meesters, & Popma, 2013).

Procedure

This study was not preregistered. After the study was approved by the University's Ethics Committee, participants were recruited by contacting school staff of 21 inclusive secondary schools in the Northwest of Germany. Four schools agreed to take part, which resulted in a sample of sixteen classes from year groups 5 and 6. Informed oral consent was obtained from the participating children and written consent was obtained from their parents. Assessment took place during school hours in early 2020 with participants completing both the VASAPP and the RPQ-Deutsch at two time points (T0 and T1) with an interval of approximately three months depending on the time availability of each class. For the VASAPP, set A was used at T0 and set B was used at T1. Participants' T0 and T1 data were linked using self-generated pseudo-anonymised participant codes. Administration took approximately 90 minutes, as the total assessment procedure included additional measures on children's peer-victimisation experiences and school climate as part of a different project. At T0, teachers filled out a questionnaire that consisted of a list of SEN or NDD and that asked them to state which pupils of their class had which type of SEN or NDD, using participant numbers that were allocated to pupils as part of a peer nomination measure used for a different project. These participant numbers, which differed from the self-generated participant codes, allowed us to link SEN status to particular participants and thus to record the proportion of participants with SEN at T0 and T1.

Statistical Analyses

Items' raw scores (e.g. COB) and difference scores (e.g. COB - NB) were used in order to analyse the internal consistency of each subscale in each set and in order to analyse construct validity of the combined items. For all other analyses, namely those relating to alternate-form reliability, to equivalence testing, to the correlation between subscale scores and subscale difference scores and to convergent validity with aggression, each overall VASAPP subscale score was calculated as the mean attribution score (e.g. Mean COB) across the six vignettes of a set (Kupersmidt, Stelter, & Dodge, 2011; Samson & Wehby, 2019). This was done separately for each VASAPP set and separately for COB, CSB and NB and for the subscale difference score of COB (i.e. COB - NB) and the subscale difference score of CSB (i.e. CSB - NB). The overall score of a subscale was calculated as the arithmetic mean, as opposed to the sum, of a subscale's six items so that the overall attribution scores would be affected less in the case that participants did not complete all six vignettes in each set.

Construct validity was assessed with exploratory factor analysis. All other analyses should be considered confirmatory analyses.

Internal consistency

Cronbach's alpha coefficients were calculated for the VASAPP subscales' raw scores and the COB and CSB difference scores. This approach follows previous studies assessing the reliability of a questionnaire's separate subscales rather than overall items (Gardner, 1995). In addition, the RPQ total scale and its reactive and proactive subscales were assessed in terms of their internal consistency.

Alternate-form reliability and equivalence testing

Alternate-form reliability of set A and set B of the VASAPP was assessed using correlational analyses and the equivalence of both sets was evaluated using paired sample t-tests (Costa et al., 2012). In addition to classical paired- sample t-tests, a Bayesian paired-

sample t-tests was conducted in favour of the null hypothesis that the two sets do not differ. The Bayes factor, BF01, will therefore be reported to represent the 95% probability of finding the estimated mean in the observed data alongside the likelihood ratio (BF01) between the null hypothesis and the alternative hypothesis (Morey, Hoekstra, Rouder, Lee, & Wagenmakers, 2016). Evidence in favour of the null hypothesis is considered to be anecdotal for Bayes factor scores between 1 and 3, to be moderate for scores between 3 and 10, and to be strong for scores between 10 and 30 (Lee & Wagenmakers, 2014).

Correlation between subscale scores and subscale difference scores

Correlations between each subscale's overall subscale score and subscale difference score were calculated separately for each set to confirm that the two scoring methods are related.

Content, construct and convergent validity

Content validity was demonstrated by showing how the vignettes' content was based on previous literature. Exploratory factor analysis of the raw scores of the VASAPP subscales was conducted to assess construct validity, with the aim of identifying COB, CSB and NB as separate factors (Graham & Juvonen, 1998). Although some research recommends suppressing factor loadings below .3, factor loadings were not suppressed in this study, but those under .3 were considered to be low (Field, 2013). By using the visual analogue scale with glasses with increasing amounts of water, the scale is visualised as an interval scale with the differences in the amounts of water between adjacent values being equal, thereby making it appropriate for factor analysis (the amount of water representing the rating '4' was twice the amount of water for the rating '2'). Given the objective to develop an accessible measure for use with children with varying levels of cognitive functioning and SEN, the use of a Likert-scale with more than five points was not desirable.

The VASAPP's convergent validity with the RPQ was assessed using correlational analyses for both VASAPP sets. This study's data sets, analyses and materials are available from the corresponding author on request (for the VASAPP, see supplemental material 1).

Results

Participant characteristics

Of the 267 pupils who took part in the first assessment at T0, 222 took part in the second assessment at T1, with an attrition rate of 16.85%. Table 2 presents participant characteristics, including the number of pupils with SEN that were present at T0 and T1, based on the SEN of the German educational system and categorised in this paper according to Poulter and Timpson (2015). The most common form of SEN related to 'cognition and learning', which encompassed the SEN 'learning' of the German educational system (n = 12 at T0) and the NDD 'dyslexia' (n = 11 at T0). In addition, one pupil was reported to have refugee status.

Reliability and equivalence testing

Table 3 presents descriptive statistics of all subscale scores, which includes medians and interquartile ranges because the distribution of all subscale scores was found to be non-normal. Moreover, internal consistency of set A and set B of the VASAPP was calculated separately for the raw and difference scores of each subscale (Table 3). Spearman's rank-order correlation coefficients signify the alternate forms reliability of all subscale scores of both VASAPP sets and the correlations between overall subscale scores and overall subscale difference scores of each separate set. Frequentist and Bayesian non-parametric paired-sample tests report on the equivalence test of the two sets (Table 3).

In terms of internal consistency, the Cronbach's alpha coefficients of the three subscales ranged from .53 to .78 for set A of the VASAPP completed at T0 (n = 267) and

from .64 to .75 for set B completed at T1 (n = 218). Alpha coefficients were highest for COB and lowest for NB. When considering the subscale difference scores that were calculated by subtracting NB from COB or CSB, Cronbach's alpha was .71 (set A) and .73 (set B) for COB, and .54 (set A) and .63 (set B) for CSB.

When correlating the overall subscale scores and the overall subscale difference scores, Spearman's Rho was .87 (set A) and .78 (set B) for COB, and .67 (set A) and .58 (set B) for CSB. Spearman's correlations for the alternate-form reliability of the two VASAPP sets ranged from .40 to .51 for overall subscale scores and from .45 to .53 for overall subscale difference scores. Each vignette in set A was designed to have a corresponding vignette in set B of the same category (e.g. property damage). Results of the correlational analyses between the raw scores of these corresponding items can be found in supplemental material 2, according to which corresponding COB items and corresponding CSB items significantly correlated between set A and set B, but half of corresponding NB items did not correlate between the two sets.

Wilcoxon signed rank tests showed that only the median ranks of the overall COB scores were equivalent between set A and set B ($Z = -.76$, $p = .45$), as well as those of the CSB difference scores ($Z = -1.66$, $p = .10$). However, the Bayesian Wilcoxon Signed-Rank Tests produced a Bayes Factor of 1.77 for the COB scores and a Bayes Factor of 1.71 for the CSB difference scores, which represents only anecdotal and not strong evidence in favour of the null hypothesis of there being no differences between the two sets (Lee & Wagenmakers, 2014). For all other scores (COB difference scores, CSB and NB), frequentist statistics indicated significant differences between the two sets and Bayesian statistics merely provided anecdotal evidence for the two sets to be alike.

Table 4 presents the descriptive statistics, internal consistency and test-retest reliability of the reactive and proactive subscales of the RPQ-Deutsch, as well as its total scores, for T0

and T1. Due to non-normal distributions, medians, interquartile ranges and Spearman's Rho are presented. Internal consistency ranged from .71 to .86 at T0 and from .68 to .87 at T1. All test-retest scores significantly correlated, with Spearman's Rho of .56 for reactive aggression, .58 for proactive aggression and .63 for total aggression.

Content validity

The six categories of the vignettes (for each VASAPP set), as well as the content of each vignette, were adapted from previous literature. Vignette categories were partly matched to those of Kupersmidt et al. (2011) with the additional category 'social ridicule' being added to the VASAPP in accordance with other literature (Troop-Gordon et al., 2018). In addition to the five peer-context vignettes, a sixth vignette represented 'unfair treatment by a teacher', a category taken from Samson and Wehby (2019). Table 5 presents the corresponding category of each vignette in the order in which vignettes were presented to participants, as well as their form of presentation and the studies from which the content of each vignette were adapted.

Construct validity

Combining the COB, CSB and NB statements for each of the twelve vignettes (6 for each set) yielded 36 individual items. These items were combined and subjected to exploratory factor analysis, using principal axis factoring with oblique rotation, with the aim of identifying the three factors COB, CSB and NB. Table 6 shows the factor loadings of each item ordered by size and with factor loadings higher than .3 being presented in bold. The three factors COB, CSB and NB factors broadly emerged and together accounted for 28.17% of variance in participants' ratings. The first factor COB contained statements like "That stupid birthday girl thinks too much of herself", the second factor CSB included statements like "It is my own fault that others do not want me around" and the third factor NB included statements such as "The guy accidentally bumps against my stuff."

There were four unexpected factor loadings. For set A, two items did not load highly on any items, one of which was designed to represent CSB ("This always happens to me") and one of which was designed to represent NB ("The work of my classmate was simply better than mine"). For set B, the item "I did not get invited by accident", which was designed to represent NB, did not load on any of items. Moreover, the set B item "I am an easy victim" did not load on CSB as intended, but instead loaded on COB.

Convergent validity

The results of the convergent validity of the VASAPP with the RPQ-Deutsch are presented in Tables 7-8. For both sets of the VASAPP, the sum of the reactive aggression subscale significantly correlated with the overall COB score and the overall CSB score, as well as with the overall differences scores of COB and CSB. The same result pattern was found for the proactive aggression subscale and the total aggression scale (Table 8), with two exceptions: the sum of the RPQ-Deutsch proactive subscale at T1 did not significantly correlate with the difference score of COB (i.e. COB - NB) or with the difference score of CSB (i.e. CSB - NB) of set B (assessed at T1). Correlations between aggression and VASAPP scores were highest for COB items. NB did not correlate with the subscales of aggression or with total aggression.

Discussion

The aim of this paper was to validate the two VASAPP sets in inclusive secondary school pupils with and without NDD or SEN who completed the two sets at different time points. The reliability of the questionnaire was assessed by examining the equivalence of each subscale's overall attribution score between the two sets, as well as the internal consistency and alternate-form reliability of each subscales' attribution items. Examining the questionnaire's validity involved an assessment of its content validity and construct validity, in addition to its convergent validity with aggression, as measured by, to the authors'

knowledge, the first German translation of the reactive-proactive aggression questionnaire (RPQ, Raine et al., 2006) that was also assessed in terms of internal consistency and test-retest reliability.

Reliability of the two VASAPP sets

The internal consistency of the three subscales' raw scores ranged from poor to acceptable for set A of the VASAPP and from questionable to acceptable for set B, with coefficients being highest for COB and lowest for NB. When using the subscale difference scores, internal consistency was only acceptable for COB (i.e. COB - NB), but not for CSB, in both sets. Cronbach's alpha coefficients in the current study were similar to those in Perren et al. (2013) which were acceptable for hostile attributions and poor for self-blaming attributions.

Findings of COB's acceptable internal consistency is in line with the results of a meta-analysis of 111 studies assessing hostile attribution of intent and aggression, according to which average internal consistency of hostile attribution measures is generally acceptable (mean = .73), yet frequently not mentioned by reviewed studies (Verhoef et al., 2019). Correlations between set A and set B of the VASAPP were strong when correlating overall COB scores (i.e. mean COB) between the two sets, and when correlating overall COB difference scores (i.e. COB - NB) between the two sets. Moderate correlations were found between the two sets' CSB scores, between the two sets' CSB difference scores, and between the two sets' NB scores. Correlations between subscale scores and subscale difference scores in each separate set were strong for both COB and CSB. Although the overall COB score and the overall CSB difference scores of sets A and B were found to be equivalent, this was not found for any of the other subscales. Consequently, set A and set B cannot be reliably regarded as equivalent.

Validity of the two VASAPP sets

Content validity was demonstrated by showing how all items' content was based on previous literature. Combining COB, CSB and NB items of both sets and subjecting them to exploratory factor analysis rendered some support for the construct validity of the VASAPP, with the emergence of three factors COB, CSB and NB. However, two factor loadings in each set were not anticipated. For set A, the item "The work of my classmate was simply better than mine" did not load on NB, perhaps because it indirectly implied one's inferiority to others and thus did not clearly convey no-blame, but rather an element of self-blame. Moreover, the set A CSB item "This always happens to me" may not have loaded on any factors because it did not clarify where the focus of blame lies. For set B, the intended CSB item "I am an easy victim" may have loaded on COB because it may entail blaming others for exploiting one's weakness, while the item "I did not get invited by accident" may have been too vague to convey NB.

Evidence was found for the convergent validity of the VASAPP with aggression, as measured by the RPQ-Deutsch. Strongest and most consistent associations were found between aggression and the VASAPP subscale COB, as detailed below.

Specific hypotheses relating to RPQ-Deutsch

The internal consistency of the RPQ was good for reactive aggression at both time points, in line with Raine et al. (2006), but ranged from questionable to acceptable for proactive aggression, while Raine and colleagues reported good internal consistency for this subscale. In the present study, all test-retest scores significantly correlated, with moderately strong Spearman's Rho for reactive aggression, proactive aggression and total aggression, which was comparable to the test-retest reliability of the total and subscale scores of the Dutch RPQ previously validated in juvenile offenders (Cima et al., 2013).

It was hypothesised that other-blaming attributions (i.e. COB) would be significantly and positively correlated with reactive aggression, as opposed to proactive aggression. As predicted, a greater tendency to attribute hostile character (i.e. COB) was significantly associated with higher levels of aggression, both when using the overall COB score and when using the overall COB difference score (i.e. COB - NB). This association was stronger and more consistent with reactive aggression than with proactive aggression, as there was no significant positive correlation between proactive aggression and COB when using the COB difference score of set B. The meta-analysis by Verhoef et al. (2019) demonstrated a positive and modest association between aggression and HAI which was not stronger for reactive aggression than for a general construct of aggression that did not distinguish between reactive and proactive aggression. In contrast, when considering studies that differentiated between reactive aggression and proactive aggression, Martinelli et al. (2018) found evidence for a stronger relationship of HAI with reactive aggression, than with proactive aggression.

Since reactive aggression, relative to proactive aggression, has also been more strongly linked to symptoms of emotion dysregulation, ADHD, victimisation and internalising problems like depression (Card & Little, 2006), it is possible that such psychosocial maladjustment may be improved by targeting the processes causing reactive aggression. The finding of van Bockstaele et al.'s (2020) that CBM-I targeting hostile attributions specifically improved reactive aggression, but not proactive aggression, provided evidence for a potentially causal role of HAI in reactive aggression. If CBM targeting COB were to specifically improve reactive aggression, this would provide evidence for the suitability of COB as a target for treatments that aim to improve reactive aggression and associated psychosocial maladjustment.

With regards to correlations between aggression and the different VASAPP subscales, they were highest for COB, non-significant for NB, but significant for CSB, except for the

non-significant correlation between proactive aggression and the CSB difference score of set B. The finding that aggression was generally associated with self-blaming attributions (i.e. CSB) may be explained by previous findings which showed that aggression, anxiety, fear and depression were all linked to negative information processing biases that are pervasive, rather than specific, and thus for instance relate to both hostile intent attributions and to internal causal attributions (Reid et al., 2006).

Strengths and limitations

Since the VASAPP is based on self-report and on hypothetical vignettes, it may not accurately capture attributions that individuals actually make for ambiguous events with undesirable outcomes in real life. In addition, responses might be influenced by a social desirability effect which may cause individuals to endorse the socially desirable no-blame (NB) items, as opposed to the other-deprecating COB items. However, the addition of CSB items might make it less obvious which responses are socially desirable and the counterbalanced order of items was designed to reduce the risk of order effects.

While this paper validated the German translation of the self-report aggression measure RPQ and provided evidence for its convergent validity with the VASAPP, it would have been beneficial to additionally validate VASAPP with other aggression measures, including ones based on proxy-report or behavioural observations. Moreover, since the VASAPP also measured self-blaming attributions (CSB), which are known to be associated with depression (Anderson et al., 1994), future studies may improve upon the current study by also including a depression measure and assessing its association with CSB.

Since this study did not obtain data regarding nationality or ethnicity, it cannot comment on whether its sample is representative of the German school population, 12.4% of which, on average, are of foreign origin (Statistisches Bundesamt, 2020). However, since recruitment procedures were not specifically directed towards schools with specific student

characteristics other than inclusion, the sample and findings from this study are expected to be representative of pupils in other German inclusive secondary schools.

Recruiting from inclusive secondary schools that included both TD CYP and those with SEN produced a sample with an inclusion rate of pupils with SEN (16.10%) which was higher than can be expected in general German education (Hollenbach-Biele & Klemm, 2020). A much larger sample would be required to investigate whether the results are generalisable to CYP with specific SEN or NDD or with differing social economic status or sociocultural background. However, the accessibility of the VASAPP to CYP with and without specific NDD would make such larger studies feasible, as there were no reports of children having difficulties understanding or completing the questionnaire.

Theoretical and clinical implications

The current paper provides evidence for the validity and reliability of the VASAPP, but in particular for its COB subscale. Given that this subscale's factor loadings all emerged as expected, COB items would not have to be changed to ensure construct validity. Although the psychometric properties of the CSB subscale were less strong than that of the COB, reasons for keeping CSB in the questionnaire include the possibility that it provides a more complete picture of someone's interpretation of social ambiguity and that it might play a role in explaining both externalising and internalising problems in individuals with and without NDD (Colalillo et al., 2014; Reid et al., 2006; Sharma, Woolfson, & Hunter, 2014).

Given that NB was the weakest subscale, as indicated by poor internal consistency of NB items of set A and a lack of correlation between half of NB items in set A with corresponding NB items of set B (supplemental material 2), future studies may consider dropping this subscale. In contrast, a reason for its retention is that it allows the calculation of subscale difference scores (e.g. COB - NB) which is in line with previous research and which controls for neutral interpretations and extreme answer patterns (Orobio de Castro et al., 2002;

Yiend et al., 2019). Moreover, future CBM-I studies may want to use the NB scale to assess whether their intervention was successful at training non-hostile (e.g. no blame) interpretations. Such studies would however have to use the same VASAPP set before and after the intervention, since no evidence was found in the current study for the equivalence of the two VASAPP sets when considering the NB subscale. Taken together, the VASAPP gives researchers the option to assess the three different attribution styles with a single measure, which is more economical from a research perspective than administering three different measures, but still leaves researchers with the option to omit one of the subscales.

Given the lack of strong evidence for the equivalence of the two VASAPP sets and the comparatively stronger parametric properties of set B, the current authors recommend that future studies, which choose to use only one of the VASAPP sets, should use set B. In order to further improve the construct validity of set B, the two items with unexpected factor loadings, namely the CSB item "I am an easy victim" and the NB item "I did not get invited by accident", should be changed to something more clearly reflecting self-blame (e.g. "I am not cool enough") and no-blame (e.g. "She forgot to give me an invitation"), respectively.

The use of accessible attribution measures like the VASAPP by future studies, both in TD individuals and in those with different neurodevelopmental conditions, would facilitate meta-analytic comparisons of the groups' attribution biases. Such comparisons would provide insight into the processes causing increased rates of externalising and internalising problems in NDD and have implications for tailoring interventions to this group's needs.

Finally, the use of accessible attribution measures that can be completed by participants regardless of possible cognitive deficits would make cognitive bias research more inclusive and representative, in line with the inclusiveness towards individuals with NDD, SEN or disabilities that is increasingly recommended and pursued in schools and society.

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Figure 1

VASAPP example vignette depicting property damage, adapted from Petermann et al. (2006)

Table 16

Classification of German SEN and their corresponding DSM-5 disorders within the framework of the SEN and disability code of practice (Poulter & Timpson, 2015)

German SEN	DSM-5
Cognition and learning	
Mental development	Moderate, severe, or profound ID
Learning	Mild ID
	SLD
Social, emotional, and mental health difficulties	
Emotional and social development	ADHD; ASD; disruptive, impulse-control and conduct disorders; depressive disorders; anxiety disorders; trauma- and stressor-related disorders
Communication and interaction	
Speech	Communication disorders
Sensory and/or physical needs	
Physical or motor development	Motor disorders
Hearing	
Seeing	

Table 17

Participant characteristics

	T0	T1
n	267	222
%female	44.4	46.5
Mean Age (SD)	11.28 (.72)	11.68 (.71)
Age range	9.71 - 13.65	9.98 - 13.91
Pupils with SEN, NDD or mental health problems (%)	43 (16.10%)	23 (10.55%)
Cognition and learning	30	15
SEN Mental development	2	1
SEN Learning	12	5
Dyslexia	11	7
Dyscalculia	5	2
Social, emotional and mental health difficulties	9	6
SEN emotional and social development	4	2
ADHD	3	2
Disruptive, impulse-control and conduct disorders	1	1
Trauma- and stressor-related disorders	1	1
Communication and interaction	4	2
SEN speech	4	2

Table 18

Descriptives and results relating to the internal consistency, test-retest reliability and equivalence of the VASAPP subscales and VASAPP difference scores of sets A and B

	COB (A) n=267	COB (B) n=218	CSB (A) n=266	CSB (B) n=215	NB (A) n=267	NB (B) n=219	COB diff. score (A) n=261	COB diff. score (B) n= 211	CSB diff. score (A) n=261	CSB diff. score (B) n=211
Median (IQR)	2.67 (1.17)	2.83 (.83)	2.17 (1.00)	1.83 (.83)	3.00 (.67)	2.83 (1.00)	-.33 (1.17)	.00 (1.33)	-.67 (1.00)	-.83 (1.00)
Internal consistency	.78	.75	.67	.64	.53	.68	.71	.73	.54	.63
Correlations *	.87	.77	.67	.58	n.a.	n.a.				
Alternate forms reliability	.51(p= .00)		.45(p= .00)		.40 (p= .00)		.53 (p= .00)		.45 (p= .00)	
Equivalence **										
Wilcoxon Signed-Rank Test	Z= -.76 p= .45		Z= -4.98 p= .00		Z= -3.47 p= .00		Z= -2.80 p= .01		Z= -1.66 p= .10	
Bayesian Wilcoxon Signed-Rank Test	BF_{01}= 1.77		BF_{01}= 1.19		BF_{01}= 1.49		BF_{01}= 1.58		BF_{01}= 1.71	

* Correlations between subscale and subscale difference scores

** Equivalence of the two sets' median ranks

Table 19

Median scores, internal consistency, test-retest reliability of the RPQ

	Reactive aggression T0 (n=257)	Reactive aggression T1 (n=215)	Proactive aggression T0 (n=257)	Proactive aggression T1 (n=215)	Total aggression T0 (n=257)	Total aggression T1 (n=215)
Median (IQR)	4.00 (5.00)	4.00 (6.00)	1.00 (2.00)	1.00 (2.50)	6.00 (7.00)	6.00 (7.00)
Internal consistency	.85	.84	.71	.68	.86	.87
Test-retest reliability	r_s = .56 (p = .00)		r_s = .58 (p = .00)		r_s = .63 (p = .00)	

Table 20

Overview of VASAPP vignettes and their corresponding category, content, presentation type and original source

Set	Category	Title: summary	Presentation	Source
A	Unfair treatment by teacher	Group project: When presenting your group project with your classmate, he gets a better grade than you, even though you tried very hard.	Text	Samson and Wehby (2019)
	Social rejection/ exclusion	Greeting: When you raise a hand to say hello to a girl who is about to cross the street, she does not respond.	Cartoon image	Lester, Field, and Muris (2011)
	Social ridicule	Performance: When asking others in a group chat what they thought about your performance, they reply with "Haha" and a laughing emoji.	WhatsApp screenshot	Micco, Henin, and Hirshfeld-Becker (2014)
	Property damage	Notes: You place your homework notes on the ground while tying your shoe laces, when another boy steps on the notes and leaves a dirty footprint.	Cartoon image	Hudley and Graham (1993)
	Physical harm	Football: While playing goalie during a football game at school, a boy hits you hard on the head with a ball, which hurts badly.	Text	Conduct Problems Prevention Research Group (1995)
	Theft	Bicycle: Having parked your bicycle on the school playground, you cannot find it when you look for it after school.	Text	Miers, Blöte, Bögels, and Westenberg (2008)
B	Physical harm	Leg: While walking to your seat in the classroom, you fall over the foot of a classmate who stretches out his leg while chatting and laughing.	Text	Troop-Gordon et al. (2018)
	Property damage	School supplies: While a classmate walks past your desk, he bumps against your school supplies which fall to the ground.	Cartoon image	Petermann, Natzke, Gerken, and Walter (2006)
	Social rejection/ exclusion	Party: You get a text message asking you when you are going to a party which you did not hear about before.	WhatsApp screenshot	Leff et al. (2006)
	Theft	Phone: You drop your phone outside, when a girl quickly bends down to reach it.	Cartoon image	McGlothlin and Killen (2006)
	Social ridicule	Top: When a boy calls out that you have dirt on your newly bought outfit, his neighbour starts laughing.	Text	Troop-Gordon et al. (2018)
	Unfair treatment by teacher	Help: When working on a project with your friend, the teacher only replies to your friend's request for help.	Text	Samson and Wehby (2019)

Table 21

Factor loadings of the items ratings for both sets of the VASAPP questionnaire

Items	Set	Factor 1: COB	Factor 2: CSB	Factor 3: NB
That stupid birthday girl thinks too much of herself.	B	**.775**	-.191	.095
He is mean and wants others to laugh about me.	B	**.661**	-.071	.068
The classmate enjoys hurting others.	B	**,607**	-.113	-.054
The boy never pays attention to other people.	A	**.582**	.085	-.151
He always treats his favourite pupils better.	B	**.567**	.110	-.056
The unfair teacher prefers some of the pupils over others.	A	**.525**	.037	-.046
That mean guy does not care about me.	A	**.474**	.182	-.119
One of my classmates is a sneaky thief.	A	**.390**	.246	-.216
I am an easy victim.	B	**.376**	.216	.180
That horrible guy always treats other people's stuff badly.	B	**.374**	.142	-.332
The girl is shameless and sneaky.	B	**.354**	.167	-.171
That nasty girl deliberately ignores me.	A	**.345**	.197	-.265
They always gossip or laugh about others.	A	**.337**	.225	-.319
I did not get an invite by accident.	B	-.290	.235	.282
This always happens to me.	A	.267	.248	.159
It is my own fault that others do not want me around.	B	-.002	**.580**	-.170
I made a fool of myself again.	A	.109	**.548**	.017
I deserve that this happens.	B	-.095	**.544**	-.116
My clothing is embarrassing.	B	-.114	**.514**	.101
I always do something wrong.	A	.048	**.498**	.070
It is my fault that people do not notice me.	A	.135	**.435**	.000
I am bad at school.	A	.214	**.410**	-.051
I am sloppy with my stuff.	B	.071	**.352**	.194
I never manage to look after my things properly.	A	-.051	**.349**	.121
I do not understand anything anyway.	B	.224	**.309**	-.082
The guy accidentally bumps against my stuff.	B	-.176	.004	**.560**
He doesn't pay attention to his leg while he is talking.	B	-.141	.166	**.559**
He thinks that I had not noticed the dirt before.	B	.233	-.072	**.527**
Something funny happened during my performance.	A	.046	.150	**.481**
The boy in the blue jumper did not see my notes.	A	-.282	.088	**.450**
He knows we're friends and that she'll explain it to me.	B	-.004	-.021	**.399**
The girl is distracted and therefore does not notice me.	A	-.017	-.070	**.393**
She only wants to pick up the phone to give it to me.	B	-.032	-.107	**.364**
The boy just wanted to score a goal.	A	-.057	.064	**.350**
I made a mistake and looked in the wrong place.	A	-.038	.124	**.338**
The work of my classmate was simply better than mine.	A	-.091	.183	.224

Table 7

Convergent validity of the VASAPP set A with the RPQ (T0), indicated by Spearman's Rho

	COB (n=257)	CSB (n=257)	NB (n=257)	COB diff. (n =257)	CSB diff. (n =257)
Reactive aggression	.29 (p = .00)	.31 (p = .00)	.02 (p = .70)	.21 (p = .00)	.23 (p = .00)
Proactive aggression	.24 (p = .00)	.24 (p = .00)	-.02 (p = .73)	.20 (p = .00)	.22 (p = .00)
Total aggression	.31 (p = .00)	.32 (p= .00)	.02 (p =.79)	.23 (p = .00)	.25 (p = .00)

Table 8

Convergent validity of the VASAPP set B with the RPQ (T1), indicated by Spearman's Rho

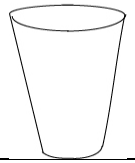
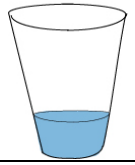
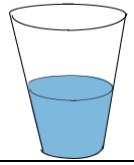
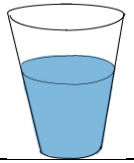
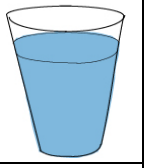
	COB (n=197)	CSB (n=197)	NB (n=197)	COB diff. (n=197)	CSB diff. (n= 197)
Reactive aggression	.37 (p = .00)	.33 (p = .00)	-.05 (p = .43)	.26 (p = .00)	.25 (p = .00)
Proactive aggression	.26 (p = .00)	.26 (p = .00)	.04 (p = .57)	.13 (p = .06)	.15 (p = .03)
Total aggression	.39 (p = .00)	.34 (p = .00)	-.03 (p = .67)	.26 (p = .00)	.24 (p = .00)

Supplemental material 1 (of Paper 4):
Vignette-based Assessment of Social Ambiguity Processing in Pupils (VASAPP)
VASAPP set A

A. Gruppenprojekt

Es wird dir nun die folgende Situation vorgelesen. Stell dir vor, dass sie dir passiert:

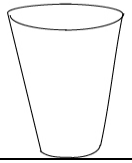
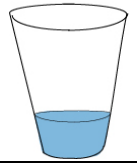
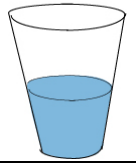
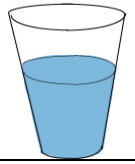
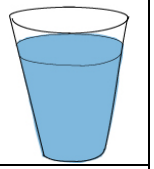
In der Schule stellst du mit deinem Sitznachbarn euer Gruppenprojekt vor. Du hast dir viel Mühe gegeben. Die Lehrerin gibt dir aber eine schlechtere Note als deinem Nachbarn.

Unten liest du mögliche Gedanken zu der Situation und bewertest, ob du ihnen zustimmst. Kreise dafür neben jeder Aussage eine Zahl ein. Rechts siehst du, was jede Zahl bedeutet. Wenn du zum Beispiel „auf jeden Fall“ zustimmst, dann mache bitte rechts einen Kreis um die 5. Die Gläser sollen beim Ausfüllen des Fragebogens helfen: Je voller das Glas ist, umso mehr stimmst du einer Aussage zu.	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil ich schlecht in der Schule bin.	1	2	3	4	5
b) Weil die ungerechte Lehrerin manche Schüler mehr mag.	1	2	3	4	5
c) Weil die Arbeit des Sitznachbarn insgesamt einfach besser war.	1	2	3	4	5

B. Gruß

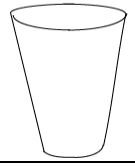
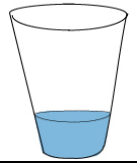
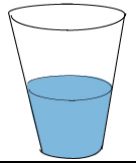
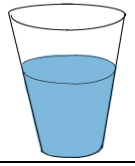
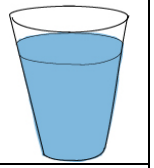
Schau dir rechts das Bild an und stell dir vor,

du bist die Person links im roten T-Shirt.

	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil das Mädchen abgelenkt ist und mich deshalb nicht bemerkt.	1	2	3	4	5
b) Weil es an mir liegt, dass andere Leute mich übersehen.	1	2	3	4	5
c) Weil das fiese Mädchen mich absichtlich ignoriert.	1	2	3	4	5

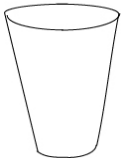
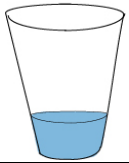
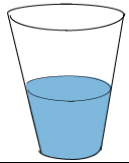
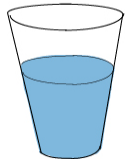
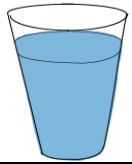
C. Auftritt

Stell dir vor, dass du übers Handy oder Internet mit einer Gruppe von Leuten das Gespräch führst, das rechts abgebildet ist.

	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil die beiden immer über andere lästern oder sie auslachen.	1	2	3	4	5
b) Weil bei meinem Auftritt etwas Lustiges passiert ist.	1	2	3	4	5
c) Weil ich mich mal wieder lächerlich gemacht habe.	1	2	3	4	5

D. Notizen

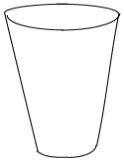
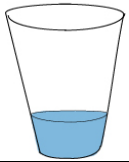
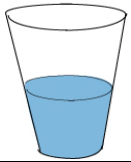
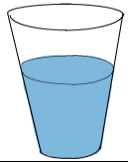
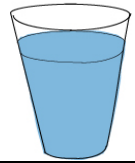
Schau dir rechts das Bild an und stell dir vor, du bist die Person rechts im roten T-Shirt.

	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil ich immer etwas falsch mache.	1	2	3	4	5
b) Weil der Junge im blauen Pulli meine Notizen nicht gesehen hat.	1	2	3	4	5
c) Weil der Junge nie auf andere Leute achtet.	1	2	3	4	5

E. Fußball

Es wird dir nun die folgende Situation vorgelesen. Stell dir vor, dass sie dir passiert.

Du spielst mit anderen Leuten in der Schule Fußball und stehst im Tor. Du drehst dich um und als nächstes trifft dich ein Junge mit dem Ball genau am Kopf. Der Ball trifft dich hart und es tut sehr weh.

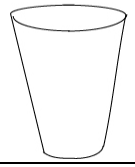
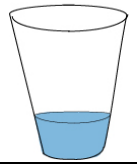
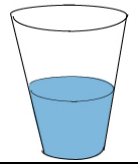
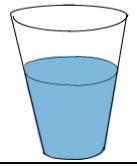
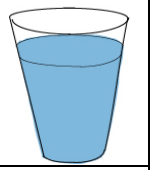
	1 = **nein, auf keinen Fall**	2 = **eher nein**	3 = **vielleicht ja, vielleicht nein**	4 = **eher ja**	5 = **ja, auf jeden Fall**
					
Warum passiert dir das? a) Weil ich dem gemeinen Typ egal bin.	1	2	3	4	5
b) Weil so etwas immer mir passiert.	1	2	3	4	5
c) Weil der Junge einfach nur ein Tor schießen wollte.	1	2	3	4	5

F. Fahrrad

Bitte lese die folgende Situation durch und stell dir vor, sie passiert dir:

Du hast dein Fahrrad vor dem Schulhof abgestellt.

Als du nach dem Unterricht das Fahrrad suchst, kannst du es nicht finden.

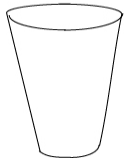
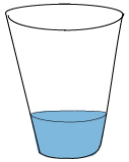
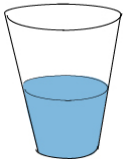
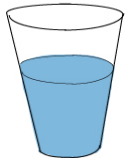
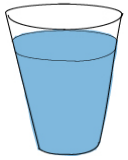
	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil ich mich vertan habe und an der falschen Stelle suche.	1	2	3	4	5
b) Weil ich immer schlecht auf meine Sachen aufpasse.	1	2	3	4	5
c) Weil einer meiner Mitschüler ein hinterhältiger Dieb ist.	1	2	3	4	5

VASAPP set B

A. Bein

Es wird dir nun eine Situation vorgelesen. Stell dir vor, dass sie dir passiert:

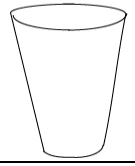
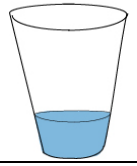
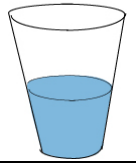
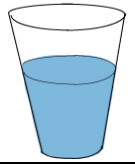
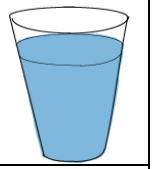
Du willst im Klassenraum zu deinem Platz gehen. Plötzlich stolperst du über den Fuß eines Mitschülers, der sich lachend unterhält und dabei gerade sein Bein ausstreckt.

Unten liest du mögliche Gedanken zu der Situation und bewertest, ob du ihnen zustimmst. Kreise dafür neben jeder Aussage eine Zahl ein. Rechts siehst du, was jede Zahl bedeutet. Wenn du zum Beispiel „auf jeden Fall“ zustimmst, dann mache bitte rechts einen Kreis um die 5. Die Gläser sollen beim Ausfüllen des Fragebogens helfen: Je voller das Glas ist, umso mehr stimmst du einer Aussage zu.	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil ich ein leichtes Opfer bin.	1	2	3	4	5
b) Weil der Mitschüler gerne anderen Leuten weh tut.	1	2	3	4	5
c) Weil er beim Reden nicht auf sein Bein achtet.	1	2	3	4	5

B. Schulsachen

Schau dir rechts das Bild an und stell dir vor,

du bist die Person rechts im roten T-Shirt.

	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil der Junge versehentlich gegen meine Sachen stößt.	1	2	3	4	5
b) Weil ich es verdient habe, dass das passiert.	1	2	3	4	5
c) Weil der gemeine Typ die Dinge von anderen schlecht behandelt.	1	2	3	4	5

C. Party

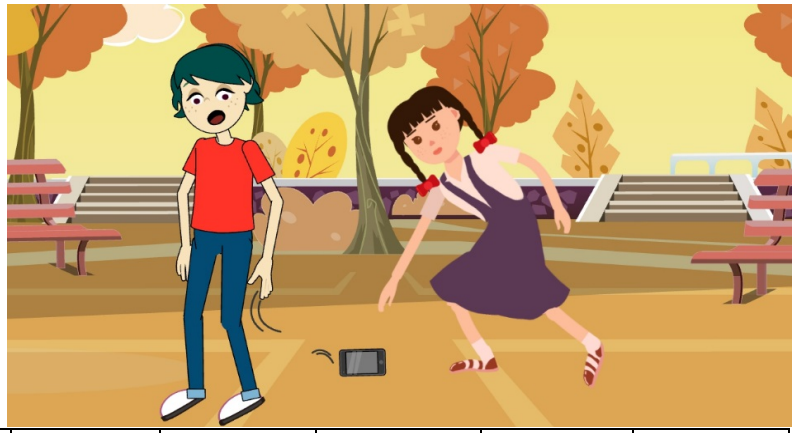
Stell dir vor, dass du übers Handy oder Internet das rechts abgebildete Gespräch über eine Geburtstagparty führst.

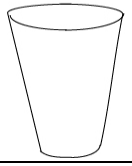
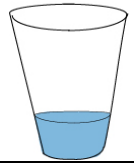
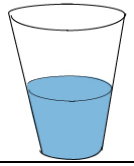
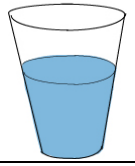
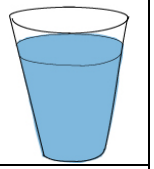
	1 = **nein, auf keinen Fall**	2 = **eher nein**	3 = **vielleicht ja, vielleicht nein**	4 = **eher ja**	5 = **ja, auf jeden Fall**
Warum passiert dir das? a) Weil das blöde Geburtstagskind sich für etwas Besseres hält.	1	2	3	4	5
b) Weil ich aus Versehen keine Einladung bekommen habe.	1	2	3	4	5
c) Weil ich selbst schuld bin, dass man mich nicht dabei haben will.	1	2	3	4	5

D. Handy

Schau dir rechts das Bild an und stell dir vor,

du bist die Person links im roten T-Shirt.

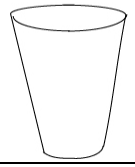
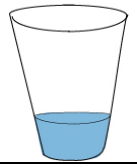
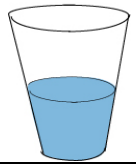
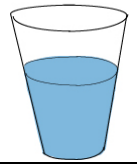
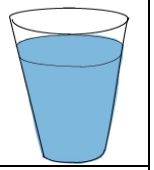


	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil ich schlampig mit meinen Dingen umgehe.	1	2	3	4	5
b) Weil sie nur das Handy aufheben will, um es mir zu geben.	1	2	3	4	5
c) Weil das Mädchen dreist und hinterlistig ist.	1	2	3	4	5

E. Oberteil

Es wird dir nun die folgende Situation vorgelesen. Stell dir vor, dass sie dir passiert:

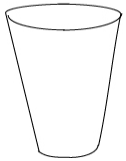
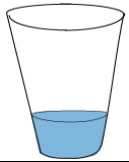
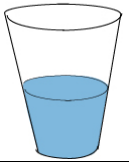
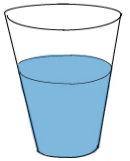
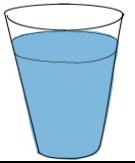
Du gehst einkaufen und kaufst dir ein neues Oberteil. Am folgenden Tag wirst du nach der Pause an die Tafel gerufen. Als du aufstehst, ruft dir ein Junge aus der Klasse zu, dass du Schmutz auf deinem Oberteil hast. Du hörst, wie seine Sitznachbarin lacht.

	1 = **nein, auf keinen Fall** 	2 = **eher nein** 	3 = **vielleicht ja, vielleicht nein** 	4 = **eher ja** 	5 = **ja, auf jeden Fall** 
Warum passiert dir das? a) Weil er gemein ist und will, dass andere über mich lachen.	1	2	3	4	5
b) Weil meine Kleidung peinlich ist.	1	2	3	4	5
c) Weil er denkt, dass ich den Schmutz vorher nicht bemerkt habe.	1	2	3	4	5

F. Hilfe

Bitte lese die folgende Situation durch und stell dir vor, sie passiert dir:

Du und deine Freundin sitzen in einem Fach immer zusammen und schreiben eine wichtige Hausarbeit. Ihr habt beide Probleme mit dem Thema und fragt den Lehrer um Hilfe. Er antwortet jedoch nur deiner Freundin.

	1 = **nein, auf keinen Fall**	2 = **eher nein**	3 = **vielleicht ja, vielleicht nein**	4 = **eher ja**	5 = **ja, auf jeden Fall**
					
Warum passiert dir das? a) Weil er weiß, dass wir befreundet sind und, dass sie es mir erklärt.	1	2	3	4	5
b) Weil ich sowieso nichts verstehe.	1	2	3	4	5
c) Weil er seine Lieblingsschüler immer besser behandelt.	1	2	3	4	5

Supplemental material 2:

Correlations between VASAPP set A items and corresponding set B items

Characterological Other-Blame (COB)

			Spearman's rho	p
Set A_VASAPP_A_COB	-	Set B_VASAPP_F_COB	.473***	< .001
Set A _VASAPP_B_COB	-	Set B _VASAPP_C_COB	.259***	< .001
Set A _VASAPP_C_COB	-	Set B _VASAPP_E_COB	.211**	.003
Set A _VASAPP_D_COB	-	Set B _VASAPP_B_COB	.300***	< .001
Set A _VASAPP_E_COB	-	Set B _VASAPP_A_COB	.263***	< .001
Set A _VASAPP_F_COB	-	Set B _VASAPP_D_COB	.171*	.018

Note. Items are labelled according to the name of the set, vignette and subscale e.g. Set A_VASAPP_COB represents the subscale COB of vignette A from VASAPP set A. This item significantly correlates with the COB item of the corresponding vignette of set B.

* p < .05, ** p < .01, *** p < .001

Characterological Self-Blame (CSB)

			Spearman's rho	p
Set A _VASAPP_A_CSB	-	Set B _VASAPP_F_CSB	.250***	< .001
Set A _VASAPP_B_CSB	-	Set B _VASAPP_C_CSB	.165*	.022
Set A _VASAPP_C_CSB	-	Set B _VASAPP_E_CSB	.243***	< .001
Set A _VASAPP_D_CSB	-	Set B _VASAPP_B_CSB	.279***	< .001
Set A _VASAPP_E_CSB	-	Set B _VASAPP_A_CSB	.164*	.024
Set A _VASAPP_F_CSB	-	Set B _VASAPP_D_CSB	.156*	.030

* p < .05, ** p < .01, *** p < .001

No Blame (NB)

			Spearman's rho	p
Set A _VASAPP_A_NB	-	Set B _VASAPP_F_NB	.067	.356
Set A _VASAPP_B_NB	-	Set B _VASAPP_C_NB	.083	.248
Set A _VASAPP_C_NB	-	Set B _VASAPP_E_NB	.273***	< .001
Set A _VASAPP_D_NB	-	Set B _VASAPP_B_NB	.222**	.002
Set A _VASAPP_E_NB	-	Set B _VASAPP_A_NB	.184**	.010
Set A _VASAPP_F_NB	-	Set B _VASAPP_D_NB	.092	.196

* p < .05, ** p < .01, *** p < .001

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