Interpersonal Cognitive Biases in Children and Young People with Neurodevelopmental Disorders: A Systematic Review

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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 5 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 demonstrate 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.

Keywords Neurodevelopmental disorders · Cognitive bias · Interpretation bias · Hostile attribution · Causal attribution · Systematic review

Introduction

Different neurodevelopmental disorders (NDD), which include intellectual disability (ID), autism spectrum disorder (ASD), attention-deficit/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, 15, 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, 18•, 19, 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

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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 when processing 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 (i) be 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, 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 to Verhoef et al. who also included studies that used bias measures containing a mixture of ambiguous and unambiguous social situations and that therefore included effect sizes based on composite scores [29•].

Publication Characteristics

The review included articles in English, Dutch, French, and German from 1980 onwards, 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 were 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 how the data in the original studies were presented, this could result in data being reported for a single ambiguous interpersonal vignette, for a subset of ambiguous interpersonal stimuli or for a subscale including the ambiguous stimuli.

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 were concerning 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 $K=0.936$ 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% or $K=0.895$ 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.

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

Fig. 1 Flow diagram for study selection, following the PRISMA statement

Table 1 Characteristics and outcomes of included studies ($n = 16$)

Study	Participants	Measure	Outcomes
<i>Intellectual disabilities (ID)</i>			
Gomez and Hazeldine (1996) [58]	$N = 39$ Male: 69% Age range: 5 years 4 months to 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 <i>Social Perception Task</i> : 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 <i>Interpretation Recognition Task (IREC-T)</i> : 2×8 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 <i>IREC-T</i> <i>Ambiguous Scenarios Task (AST)</i> : 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 with 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) [57]	$N = 117$ Male: $G1 = 47.5\%$; $G2 = 48.3\%$ Age range: 7.0–11.9 years G1 ($n = 59$): mild ID (<i>mean IQ</i> = 65.2, $SD = 6.1$) G2 ($n = 58$): no ID Setting: special education classrooms and general classrooms, the 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: $G1 < G2$

Table 1 (continued)

Study	Participants	Measure	Outcomes
Leffert et al. (2010) [34]	<p>$N=248$ 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, the USA</p>	<p>Bias: HAI <i>Social Perception Task</i>: 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</p>	<p>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</p>
van Nieuwenhuijzen et al. (2011) [59]	<p>$N=142$ 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</p>	<p>Bias: HAI <i>Social Problem-Solving Test for children with MID (SPT-MID)</i>: 9 peer vignettes: → 6 ambiguous, unclear intent → 2 clear, negative intent → 1 clear scenario, neutral intent Method: interview</p>	<p>HAI: → Higher HAI in $G1, G2$, and $G3$, compared with that in $G4$, $F(66, 360)=8.98, p=.000$ (Group differences in attributions ($G1, G2, G3>G4$) only for ambiguous scenarios)</p>
Autism spectrum disorder (ASD) Carothers and Taylor (2004) [52]	<p>$N=40$ 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, the USA</p>	<p>Bias: HAI 18 vignettes: → 6 ambiguous, unclear intent → 6 clear, neutral intent → 6 clear, negative intent Method: interview</p>	<p>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: $G1>G2$</p>

Table 1 (continued)

Study	Participants	Measure	Outcomes
Flood et al. (2011) [61]	<p>$N=50$ 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 Setting: specialist ASD schools, mainstream school ($G1: 50\%$ in each school type)</p>	<p>Bias: HAI and attributions of causality <i>SIP Interview (SIP)</i>: 4 ambiguous, unclear intent Method: Likert scale Attributional style: internal/external, global/specific, stable/unstable Method: multiple choice</p>	<p>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 with ASD mainstream school ($z=2.230$, $p=.026$) and $G2$ ($z=2.171$, $p=.03$) Attributional style: → $G1$: higher global attributions than in $G2$ ($z=3.074$, $p=.002$) 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 with $G1$</p>
Hollocks et al. (2016) [62]	<p>$N=83$ 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</p>	<p>Bias: threat interpretation <i>Ambiguous Situations Interview</i>: 12 ambiguous vignettes: → 6 social threats → 6 physical threats Method: multiple choice</p>	
<i>Specific learning disorder (SLD)</i> Bryan et al. (1998) [63]	<p>$N=96$ 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, the USA</p>	<p>Bias: HAI One ambiguous peer vignette Method: interview</p>	<p>HAI: → No group differences in HAI, $F(6, 65)=.629$, $p<.707$ → $C4$: lower HAI than $C1$ ($p<.007$) and $C2$ ($p<.009$)</p>

Table 1 (continued)

Study	Participants	Measure	Outcomes
<i>Attention-deficit/hyperactivity disorder (ADHD)</i>			
Andrade et al. (2012) [66]	<p>$N = 64$</p> <p>Male: $G1 = 76.9\%$, $G2 = 64.0\%$</p> <p>Age range: 6–12 years</p> <p>($G1$: $M = 9.4$, $SD = 1.6$; $G2$: $M = 9.2$, $SD = 1.9$)</p> <p>$G1$ ($n = 39$): ADHD</p> <p>$G2$ ($n = 25$): TD controls</p> <p>Setting: treatment program, Canada</p>	<p>Bias: HAI</p> <p>35 vignettes:</p> <p>→ 31 <i>ambiguous</i>, unclear intent with either unclear (10), positive (14), or negative (7) outcome</p> <p>→ 4 clear (2 positive intent and outcome and 2 negative intent and outcome)</p> <p>Method: interview</p>	<p>HAI:</p> <p>→ No group differences in HAI for any ambiguous scenarios</p> <p>Positive intent attribution:</p> <p>→ Higher positive intent attribution in $G1$ than $G2$ for ambiguous scenarios with negative outcome ($p = .020$) or positive outcome ($p = .003$)</p> <p>Positive outcome attribution:</p> <p>→ $G2 > G1$ for ambiguous scenarios with positive outcome ($p = .006$)</p> <p>Negative outcome attribution:</p> <p>→ $G1 = G2$ for all ambiguous scenarios</p> <p>Intent attribution accuracy: $G1 > G2$ for all clear scenarios</p> <p>Encoding of cues: $G1 < G2$ for all types of cues (controlled for conduct problems)</p> <p>Internal attributions:</p> <p>→ $G1$: higher attribution of child responsibility than in $G2$, $F(1,64) = 4.50$, $p = .038$</p> <p>External attributions</p> <p>→ $G1 = G2$ for other attribution dimensions</p>
Colalillo et al. (2014) [65]	<p>$N = 66$</p> <p>Male: 100% in all groups</p> <p>Age range: 7.7–12.2 years</p> <p>($G1$: $M = 9.85$, $SD = 1.19$; $G2$: $M = 9.68$, $SD = 1.09$)</p> <p>$G1$ ($n = 28$): ADHD</p> <p>$G2$ ($n = 38$): TD controls</p> <p>Setting: Canada</p>	<p>Bias: external and internal attributions</p> <p><i>Children's Attribution Measure (CAM)</i>:</p> <p>8 ambiguous parent-child vignettes:</p> <p>→ 4 unclear intent, negative outcome</p> <p>→ 4 unclear intent, positive outcome</p> <p>Attribution dimensions: child responsibility, task difficulty, or parent's effort or ability</p> <p>Method: Likert scale</p>	<p>Internal attributions:</p> <p>→ $G1$: higher attribution of child responsibility than in $G2$, $F(1,64) = 4.50$, $p = .038$</p> <p>External attributions</p> <p>→ $G1 = G2$ for other attribution dimensions</p>
Haas et al. (2015) [69]	<p>$N = 72$</p> <p>Male: $G1 = 82\%$, $G2 = 80\%$, $G3 = 59\%$</p> <p>Age range: 7.0–12.9 years ($G1$: $M = 9.7$, $SD = 1.8$; $G2$: $M = 9.9$, $SD = 1.6$; $G3$: $M = 9.7$, $SD = 1.6$)</p> <p>$G1$ ($n = 40$): CP/ADHD-only</p> <p>$G2$ ($n = 15$): CP/ADHD-CU</p> <p>$G3$ ($n = 17$): TD controls</p> <p>Setting: clinically referred for treatment, the USA</p>	<p>Bias: external and internal attributions</p> <p><i>The Peer Social Attribution Questionnaire (PSAQ)</i>:</p> <p>8 ambiguous vignettes:</p> <p>→ 4 unclear intent, positive outcome</p> <p>→ 4 unclear intent, negative outcome</p> <p>Attribution dimensions: (Other child nice, Other child's mood, Self nice, Ability, Effort, Self mood, Task difficulty, Luck, Behaviour problems)</p> <p>Method: Likert scale</p>	<p>External and internal attributions:</p> <p>→ 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</p> <p>→ For positive outcomes, $G1 = G2 = G3$</p>
King et al. (2009) [67]	<p>$N = 75$</p> <p>Male: $G1 = 75.0\%$, $G2 = 90.5\%$, $G3 = 64.7\%$</p> <p>Age range: 6–12 years ($G1$: $M = 9.82$, $SD = 2.02$; $G2$: 8.93, $SD = 2.04$; $G3$: 8.91, $SD = 1.93$)</p> <p>$G1$ ($n = 20$): ADHD (placebo)</p> <p>$G2$ ($n = 21$): ADHD (medicated)</p> <p>$G3$ ($n = 34$): TD controls</p> <p>Setting: summer treatment program, the USA and Canada</p>	<p>Bias: HAI</p> <p>8 ambiguous vignettes</p> <p>Method: interview</p>	<p>HAI:</p> <p>→ No group differences, $F(2,70) = .45$, $p = .641$</p>

Table 1 (continued)

Study	Participants	Measure	Outcomes
Mikami et al. (2008) [64]	<i>N</i> = 228 Male: <i>G</i> 1 = 0%, <i>G</i> 2 = 0% Age range: 11–18 years (<i>M</i> = 9.5 years at baseline) <i>G</i> 1 (<i>n</i> = 140): ADHD <i>G</i> 2 (<i>n</i> = 88): TD controls Setting: summer camp, the USA	Bias: HAI 5 ambiguous vignettes with unclear intent, Method: interview	HAI: → No group differences, Cohen's <i>d</i> = .07 → Significant associations between HAI and aggression in <i>G</i> 2, $\beta = .73$; <i>p</i> = .02, but not <i>G</i> 1, $\beta = -.15$; <i>p</i> = .13
Sibley et al. (2010) [68]	<i>N</i> = 45 Male: <i>G</i> 1 = 33.3%, <i>G</i> 2 = 66.7% Age: <i>G</i> 1, <i>M</i> = 12.36, <i>SD</i> = 1.04; <i>G</i> 2, <i>M</i> = 12.22, <i>SD</i> = .81 <i>G</i> 1 (<i>n</i> = 27): ADHD <i>G</i> 2 (<i>n</i> = 18): TD controls Setting: local middle schools, research centre, the USA	Bias: HAI 10 ambiguous vignettes with unclear intent, Method: interview	HAI: → No group differences, $F(1,42) = .05$, <i>n.s</i>

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

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.

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 nonresponders.

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).

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 [57]. Compared with controls, children with ID showed less hostile interpretations of potential insincerity, such as someone's ambiguously sincere apology [34]. 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 [58]. In a sample that was 71.6% male, higher HAI was found for children with ID, behaviour problems, or both, when compared with 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 3-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 control group, only the positive CBM-I group showed reduced social anxiety symptoms at follow-up.

Table 2 Quality appraisal of included studies

Study	Clear aims	Appropriate study design	Justified sample size	Clear and representative target population, sampling frame, and selection	Appropriate and previously piloted measures	Repeatable methods (including statistical methods)	Adequately described data	Sufficient information about response rate and nonresponders to draw conclusions about non-response bias	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
<i>ID</i>															
Gomez and Hazeldine (1996) [58]	+	+	-	±	+	+	+	-	+	+	+	-	-		
Houtkamp et al. (2017) [31]	+	+	±	±	-	+	+	-	+	+	+	+	+		
Klein et al. (2018) [60••]	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-
Leftert et al. (2000) [57]	+	+	±	±	+	+	-	-	+	+	-	-	-		
Leftert et al. (2010) [34]	+	+	±	±	-	+	+	-	+	+	+	-	-		
van Nieuwenhuijzen et al. (2011) [59]	+	+	±	+	+	+	+	-	-	+	+	-	-		
<i>ASD</i>															
Carothers and Taylor (2004) [52]	+	+	-	±	+	+	+	-	+	+	+	-	-		
Flood et al. (2011) [61]	+	+	+	±	+	+	+	-	+	+	+	-	-		
Hollocks et al. (2016) [62]	+	+	±	±	+	+	+	-	+	+	+	+	+		
<i>SLD</i>															
Bryan et al. (1998) [63]	+	+	±	+	-	+	+	-	+	+	+	-	-	+	+
<i>ADHD</i>															

Table 2 (continued)

Study	Clear aims	Appropriate study design	Justified sample size	Clear and representative target population, sampling frame, and selection	Appropriate and previously piloted measures	Repeatable methods (including statistical methods)	Adequately described data	Sufficient information about response rate <i>and</i> nonresponders to draw conclusions about non-response bias	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
Andrade et al. (2012) [66]	+	+	±	±	+	+	+	-	+	+	+	+	-		
Colalillo et al. (2014) [65]	+	+	±	-	-	+	+	-	+	+	+	-	+		
Haas et al. (2015) [69]	+	+	±	±	+	+	+	-	+	+	+	+	+		
King et al. (2009) [67]	+	+	±	±	+	+	+	-	+	+	+	-	+		
Mikami et al. (2008) [64]	+	+	±	-	+	+	+	±	+	+	-	-	-		
Sibley et al. (2010) [68]	+	+	±	±	+	+	+	-	+	+	+	-	+		

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

Interpretation Bias and Autism Spectrum Disorder

Three studies assessed cognitive bias in CYP with ASD and had predominantly male samples. Carothers and Taylor 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 learning disability, Flood et al. 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 with 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 [66–68]. 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 [69].

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 [34, 58] 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 [57], 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 et al. (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-I 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 with controls, CYP with ID and ASD were less accurate at interpreting scenarios with clearly accidental intent and at encoding neutral cues [34, 52, 58]. 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 with controls [51, 57–59]. 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 [57, 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].

Clinical Implications

For clinicians, the findings of this review indicate that interpretation biases represent a potential mechanism involved

in the occurrence of aggression or internalising problems in individuals with NDD.

Most evidence of this review relates to hostile intent attributions in CYP with ADHD or ID, and it was found that such attributions were not consistently higher in the NDD groups than in controls. Meanwhile, little is known about the association of HAI and aggression in CYP with ADHD. Consequently, one might consider ADHD and aggression as distinct dimensions of externalising problems [10, 77], each with their different intervention and support options. Furthermore, given that aggression is robustly linked to HAI in TD populations [29•] and that it can be reduced using interventions that target HAI [78•], assessing and modifying HAI in CYP with ADHD could help researchers and clinicians to understand and reduce these individuals' psychosocial problems that are likely exacerbated by their frequent comorbidity with aggression.

Finally, if future research replicates our tentative findings regarding 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, this would support the assessment and modification of such biases to alleviate mental health problems in this group.

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 [79•].

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Declarations

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