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# Estimations of Competence in Neurodevelopmental Conditions: A Review

Elizabeth A. Wanstall, Joshua Doidge, Jonathan Weiss, and Maggie E. Toplak

York University, LaMarsh Centre for Child and Youth Research,
Department of Psychology, Toronto, Canada

Abstract

Estimations of competence paradigms offer methods to help us measure how well we track our performance. Bridging across the clinical research and metacognitive research traditions, we identified the Positive Illusory Bias (PIB), metamemory and meta-reasoning paradigms for assessing estimation of competence in neurodevelopmental conditions. Overall, studies from PIB paradigms suggest that individuals with Attention-Deficit Hyperactivity Disorder, Autism, Intellectual Disability and Learning Disability tend to display a positive bias in their performance relative to other informants. In metamemory paradigms, individuals with these neurodevelopmental conditions tend to show more discrepancy between their subjective judgments and their memory performance relative to comparison controls, but these findings have been less consistent than for PIB. Meta-reasoning has been less well-studied across neurodevelopmental conditions. In order to advance our understanding of whether estimation of competence is a significant domain for understanding neurodevelopmental conditions, consideration must be given to conceptual models for each neurodevelopmental condition, methodological issues (paradigm selection and interpretation of self-report and subjective judgment) and developmental considerations.

*Keywords:* estimating competence, metacognition, monitoring accuracy, Positive Illusory Bias, Attention Deficit/Hyperactivity Disorder, Autism, Intellectual Disability, Learning Disability, neurodevelopmental conditions

## Introduction

The estimation of competence and monitoring accuracy have been most well-studied in the field of metacognition (Dunlosky & Metcalfe, 2009). Models that have emerged from this field have generally focused on the cognitive processes required to monitor our ongoing thought processes and control the allocation of mental resources (Ackerman & Thompson, 2017). To conceptualize metacognitive abilities,

✉ Maggie E. Toplak, 126 BSB, Department of Psychology, York University, 4700 Keele St., Toronto, Ontario, Canada M3J 1P3. E- mail: *mtoplak@yorku.ca*

it is helpful to think of two levels of cognitive processes. First, there are object-level processes that are needed to complete basic cognitive tasks, such as perceiving, remembering, and decision-making. Second, there are meta-level processes that help monitor the object-level processes to assess how they are functioning and determine the necessary allocation of mental resources to successfully complete these object-level processes (Nelson & Narens, 1990). The study of metacognition aims to better understand these meta-level processes, with metacognitive paradigms in the developmental literature suggesting that even typically developing (TD) children often overestimate their competence on tasks (Desoete & Roeyers, 2006; Schneider, Visé, Lockl, & Nelson, 2000). The estimation of competence and metacognitive paradigms have also been examined in clinical samples, including in neurodevelopmental conditions, such as Attention-Deficit/Hyperactivity Disorder (ADHD), autism, Intellectual Disability (ID), and Learning Disabilities (LD). It is of interest to determine whether estimates of competence in neurodevelopmental conditions differ from peers without neurodevelopmental challenges. The purpose of this review was to provide a summary of the paradigms and findings that assess estimations of competence in neurodevelopmental conditions, linking the clinical and cognitive literatures.

## Neurodevelopmental Conditions and Estimating Competence

The idea of examining the estimation of competence and metacognition in clinical conditions has been an emerging field of interest, especially in adult samples (Dimaggio & Lysaker, 2010). The impetus for consideration of metacognitive related difficulties in clinical samples is based on the idea that metacognitive paradigms may help explain some of the more persistent problems that are typically associated with clinical conditions. For example, if metacognitive awareness is related to difficulties in differentiating mental states, as has been suggested in autism and in schizophrenia, then paradigms that elucidate such awareness can help us to better understand these difficulties further. In the present paper, we chose to focus on neurodevelopmental disorders, which refer to a set of conditions that emerge early in the developmental period and have negative implications for cognitive, emotional, academic and social functioning [American Psychiatric Association (APA), 2013]. This broad umbrella term includes a number of diagnoses in the DSM-V, including ID, communication disorders, autism, ADHD, specific LD, and motor disorders (APA, 2013). Approximately 5% of the population is affected by neurodevelopmental conditions (Mitchell, 2015), but some estimates based on prevalence studies in the US have been reported to be as high as one in six children (Boyle et al., 2011). While at a broad level, there are compelling reasons to think that tracking or estimating performance may be problematic in clinical samples, our focus was based on a narrower view, that is, reviewing the studies that have provided measurable constructs for assessing these difficulties in neurodevelopmental conditions. While the terms metacognition and monitoring accuracy are well used in the cognitive literature, we chose to use the more generic term of "competence estimation" to reflect the breadth of paradigms that have been examined in the clinical literature to examine these types of constructs.

According to self-perception theory, it is proposed that children who tend to succeed in various domains are able to develop and maintain healthy and appropriate beliefs about their own competence. Conversely, children who tend to experience repeated failures in various domains are more likely to develop low beliefs regarding their own competence (Harter, 1981). As such, this model would suggest that individuals with neurodevelopmental conditions may develop low beliefs about their own competence in areas in which they may experience particular challenges (Owens & Hoza, 2003). However, this has not always been found to be the case in these populations. For example, studies have suggested that individuals with ADHD may actually overestimate their competence in various areas of functioning, including those in which they may experience particular challenges (Owens, Goldfine, Evangelista, Hoza, & Kaiser, 2007). It is in fact possible that there may be some unique and distinct characteristics related to competence estimation that specifically emerge in individuals with neurodevelopmental conditions. As such, garnering a more fulsome understanding of competence estimation across the cognitive and clinical literatures in these populations may shed light on some of their challenges, which could in turn provide important empirical and clinical information.

Attention-deficit/hyperactivity disorder (ADHD) is characterized by persistent symptoms of inattention and/or hyperactivity-impulsivity that impair functioning. Individuals with ADHD are described as experiencing deficits in self-regulation, which includes monitoring and adjusting one's behavior accordingly (Shiels & Hawk Jr., 2010). In terms of developmental functioning, self-perceptions have been identified as a critical domain of impairment in ADHD (Weyandt & Gudmundsdottir, 2015). The paradigm that has been most commonly used in the clinical research literature is the Positive Illusory Bias (PIB) to demonstrate that children with ADHD tend to display inflated self-esteem with respect to their own competence, which suggests key deficits related monitoring accuracy of behaviour and performance. However, in addition to the PIB paradigm, there has also been some research to examine metamemory and meta-reasoning paradigms in ADHD.

Autism is characterized by a persistent impairment in social communication and social interaction as well as restricted, repetitive patterns of behavior, interests and activities. Many individuals with autism have additional intellectual and/or language impairments. Individuals with autism have been reported to display deficits in theory of mind (i.e. the knowledge and understanding of others' mental states) and language development (Baron-Cohen, 2000; Boucher, 2003), which have been suggested to be correlated with metacognitive abilities from a young age (Fritz, Howie, & Kleitman, 2010). Difficulties in monitoring accuracy are not central to conceptualizations of autism deficits, however, there has been research to examine PIB and metamemory.

Intellectual Disability (ID) is characterized by significant deficits in general intellectual functioning resulting in impairment in adaptive behaviour compared to their peers. Generally, IQ scores below 70-75 qualify as significantly below age expectations, though test interpretation and other factors must be considered (APA, 2013). While monitoring accuracy difficulties do not seem to be central to conceptualizations of ID, there has been research to examine PIB and metamemory paradigms.

Learning disabilities (LD) are characterized by persistent difficulties in learning key academic skills, in domains such as reading accuracy/fluency, reading comprehension, writing, spelling, arithmetic, and mathematical reasoning. Specifically, the impairment in academic skills cannot be simply due to lack of opportunity, but a clear deficit in learning those academic skills (APA, 2013). Some studies have identified deficits in self-efficacy (i.e. one's belief in one's ability to succeed) in youth with specific LDs (Baird, Scott, Dearing, & Hamill, 2009), which may mediate the relationship between metacognition and performance (Coutinho, 2008). Monitoring accuracy, however, has not been central to defining the impairments observed in LD, but there have been studies examining PIB and metamemory in this special population.

Overall, difficulties in estimating competence have been implicated in ADHD, autism, ID and LDs. In order to survey the literature on studies that have assessed paradigms related to the estimation of competence, we purposely chose the use the term "estimation of competence" to reflect the diverse types of paradigms that have been used across these literatures in an effort to begin to compile these studies in one place, but also to begin to consider conceptual underpinnings that may underlie all of these paradigms, and to provide a reference point for further studies examining such paradigms. Based on our review of the literature, we identified PIB and metamemory paradigms as the most commonly studied paradigms to assess estimation of competence, with PIB most commonly studied in the clinical literature and metamemory paradigms rooted in cognitive and experimental literatures. To our knowledge, estimations in competence have not been examined in motor and communication neurodevelopmental disorders based on our review of the literature. To undertake this review, we broadly surveyed the literature across various search engines (e.g. PsycInfo, PubMed, Google Scholar). Our search terms included the neurodevelopmental conditions identified (i.e. ADHD, autism, ID, and LD) as well as relevant terms related to estimation of competence (i.e. competence estimation, performance calibration, positive illusory bias, metamemory, metareasoning, metacognition). Based on these searches, we selected articles that concretely tested paradigms related to estimation of competence, specifically in terms of positive illusory bias, metamemory and metareasoning. Throughout this process, we screened 435 articles and included 65 articles in our final literature review.

## Paradigms for Estimating Competence in Neurodevelopmental Disorders

From a broad perspective, the estimation of competence has been implicated as an important domain across neurodevelopmental conditions. Table 1 provides a summary of the empirical studies that provide measurable paradigms to assess the estimation of competence and that were included in this review. The PIB paradigm has been well-studied in the clinical literature, addressing competence estimation across all domains of functioning, including cognitive performance, academic performance and social functioning. In contrast, studies of metacognition are by definition more specifically focused on cognitive performance, referring specifically to individuals' knowledge, monitoring and control of cognitive activities (Dunlosky & Metcalfe, 2009). Within the field of metacognition, an emphasis has been placed on the study of metamemory (i.e. meta-level processes for learning and remembering), and in recent years a growing interest in meta-reasoning (i.e. meta-level processes for reasoning and problem-solving; Ackerman & Thompson, 2017).

### Positive Illusory Bias Paradigms

Many estimation of competence paradigms assess the extent to which individuals' estimates of their capabilities (i.e. metacognitive judgment) align with their actual performance (i.e. criterion task; Pieschl, 2009). However, estimations of competence can also be measured by comparing an individual's estimate of their capabilities with that of other raters. In children, this external rater is often a parent or a teacher (Bourchtein, Langberg, Owens, Evans, & Perera, 2017). When comparing self-evaluations to an external rater's evaluations on a given task or skill, individuals in the general population tend to overestimate their skills. This is often referred to as the "better-than-average" effect (Alicke & Govorum, 2005) or the optimism bias (Weinstein, 1980, 1982). In fact, having some positive bias about one's abilities is considered to be adaptive, as it is linked to sociability, happiness, and contentment among other positive outcomes (Taylor & Brown, 1988). The lack of positive self-perceptions has been associated with low self-esteem and depression (Hoza et al., 2004).

Many studies have examined the PIB in these special populations. PIB is defined as a phenomenon where individuals rate themselves as significantly more competent in a certain area compared to external raters (e.g. a parent or teacher rating) or more objective measures (e.g. test performance). Though some PIB studies do compare one's self-perceptions to an objective measure of their performance in a given domain, it is much more common in these studies to rely on an external rater. Generally, PIB is calculated using the discrepancy method, where the external rating (often a parent or teacher) or the objective measure selected is subtracted from the individual's self-rating of their own competency (Owens et al., 2007).

Table 1

*Estimation of Competence Paradigms and Findings in Neurodevelopmental Disorders*

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| **Positive Illusory Bias – ADHD Child and Adolescent Samples** | | | |
| Bourchtein, Langberg, Owens, Evans, & Perera (2017) | *N* = 326 adolescents with ADHD, age range 10.47-14.40 years | Self-report rating scale: Self-Perception Profile for Children (SPPC)<br>Parent rating: Parent version of SPPC<br>Academic Task: Grade Point Average (GPA) | 18.4% of the ADHD group revealed a global PIB, across the behavioral, scholastic, and social domains relative to parents. An additional 29% of the ADHD group displayed a PIB in the scholastic domain only. |
| Bourchtein et al. (2018) | *N* = 233 children with and without ADHD, age range 8-10 years | Self-report rating scale: Self-Perception Profile for Children (SPPC)<br>Parent rating: Parent version of SPPC<br>Social Skills Ratings: Peer and staff rating of Social Skills on children's group activity | The ADHD group did not display more of a PIB than the TD group. |
| Chan & Martinussen (2016) | *N* = 109 adolescents with and without ADHD, age range 14-17 years | Self-report rating scale: Conners Third Edition-Adolescent (Conners 3)<br>Parent rating: Conners Third Edition-Parent (Conners 3)<br>Academic Tasks: The Test of Memory and Learning (2nd ed) and The Woodcock-Johnson III Tests of Achievement *Calculations* subtest | ADHD group showed a larger PIB in their academic self-ratings than a TD group, but only when these ratings were compared with parent ratings. |
| Eisenberg & Schneider (2007) | *N* = 9062 children with and without ADHD, age range 8-9 years | Self-report rating scale: Math and reading skills (adapted from the Self-Description Questionnaire I)<br>Parent rating: math and reading skills.<br>Teacher rating: reading, language, and math skills<br>Academic Task:<br>Woodcock-McGrew-Werder Mini-Battery of Achievement | ADHD girls had more negative parents' and teachers' perceptions compared to TD samples. ADHD boys also had negative perceptions, but less pronounced than the TD boys. Self-perceptions are not significantly different by ADHD status, except boys had more negative self-perceptions related to math. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| Emeh, Mikami, & Teachman (2015) | $N$ = 78 children with and without ADHD, age range 6.8-9.8 years) | Self-report rating scale: Self-Perception Profile for Children (SPPC)<br>Parent: Parent version of SPPC<br>Teacher rating: Teacher version of SPPC | ADHD group had inflated PIB relative to parent and teacher ratings of their competence. This was not the case for the TD group. |
| Evangelista, Owens, Golden, & Pelhman (2008) | $N$ = 107 children with and without ADHD in grades 3, 4, 5 | Self-report rating scale: Self-Perception Profile for Children (SPPC)<br>Teacher Rating: Teacher version of SPPC<br>Academic Task: Wechsler Individual Achievement Test (Second Edition) – Abbreviated (WIAT-II-A) | Compared to the TD group, the ADHD group significantly overestimated their own competence relative to teachers' estimates in all domains. |
| Fefer et al. (2018) | $N$ = 24 children with ADHD, age range 9.75-13.75 years) | Self-report rating scale: Self-Perception Profile for Children (SPPC)<br>Parent Rating: Parent version of SPPC | ADHD group had more limited self-awareness, with mothers reporting overestimation of competence. |
| Fliers et al. (2010) | $N$ = 103 children with and without ADHD, Mean age = 10 years ($SD$ = 1.9 years) | Self-report rating scale: Self-Perception Profile for Children (SPPC)<br>Experimental Tasks: Movement Assessment Battery for Children (MABC) Competentiebelevingsschaal' for Children (CBSK) | Motor performance was significantly poorer in children with ADHD compared to their unaffected sibling group and TD group, but self-perceived motor performance did not differ between groups. |
| Gerdes, Hoza, & Pelham (2003) | $N$ = 197 children with and without ADHD (all boys), age range 7.33-12.75 years | Self-report rating scale: Parent–Child Relationship Questionnaire (PCRQ)<br>Parent Rating: Parent–Child Relationship Questionnaire (PCRQ) | ADHD boys did not differ from TD boys in their perceptions of their relationships with their parents. When the boys with ADHD were compared directly to those of their parents, ADHD boys' reported PIB relative to TD parent–child dyads. |
| Helseth, Bruce, & Waschbunsch (2016) | $N$ = 39 children with and without ADHD (all boys), age range 10-12 years | Experimental Tasks:<br>Boys completed four experimental tasks that measure physical abilities and then asked how successfully they performed the task. | The ADHD group were significantly more likely than TD group to overestimate their physical ability at difficult levels of the task. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| Hoza et al. (2010) | *N* = 797 children with and without ADHD, age range 8-13 years at timepoint 1.<br>Four timepoints over a 6-year span in this study. | Self-report rating scale: Self-Perception Profile for Children (SPPC) (for timepoint 1 and 2)<br>Self-Perception Profile for Adolescents (SPPA) (for timepoint 3 and 4), and for some participants<br>Teacher Rating:<br>Teacher version of SPPC (for timepoint 1 and 2)<br>Teacher version of SPPA (for timepoint 3 and 4) | Over 6-year time span, TD group exhibited less PIB than the ADHD group. |
| Hoza, Vaughn, Waschbusch, Murray-Close, & McCabe (2012) | *N* = 264 children with and without ADHD age range 7-12 years | Self-report rating scale: Self-Perception Profile (SPPC) (completed at 3 time points)<br>Teacher ratings: Teacher version of SPPC<br>Experimental Task: Matching game of teachers' ratings of competence of the child with and without a monetary incentive | Across conditions of the task, PIB by children with ADHD was never normalized in relation to TD children's self-perception rating. |
| Hoza, Waschbusch, Pelham, Molina, & Milich (2000) | *N* = 185 children with and without ADHD (all boys) age range 7.4-12.7 years | Self-report rating scale:<br>Questions on expectancy results about task based on different conditions, with confederate children.<br>Self-evaluation and attribution rating of performance.<br>Experimental Tasks: Social interaction task<br>Social Skills Ratings:<br>Observer coding of boy's social interactions.<br>Talk time in social interaction. | ADHD males rated their own performance more favorably than TD boys. |
| Jia, Jiang, & Mikami (2016) | *N* = 146 children with and without ADHD, age range 6.8-9.8 years | Self-report rating scale: Self-Perception Profile (SPPC) for those who completed grade 2, Perceived Competence and Social Acceptance for Young Children (PCS) for those in who have yet to complete grade 2<br>Teacher Ratings: Teacher version of SPPC | For the ADHD group, self-perceptions of competence in both social and behavioral domains were significantly more positive than that reported by their parents and teachers. In contrast, for the TD group, self-perceptions of competence in both domains were significantly |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| | | Social Skills: Peer Sociometric interviews with children | more negative than that reported by their parents and teachers. |
| Jiang & Johnston (2017) | *N* = 81 children with and without ADHD (all boys), age range 8-12 years | Self-report rating scale: Self-Perception Profile (SPPC)<br>Post-Task Self-Evaluations of Performance (PSP)<br>Parent rating: Parent version of SPPC<br>Experimental Task: Computerized social interaction tasks | Compared to the TD boys, the ADHD boys did not show PIB in their ratings of actual performance on the social tasks. But when difference scores were used that compared child and parent ratings, the ADHD boys showed a significant PIB compared to TD boys. |
| Langberg et al. (2011) | *N* = 57 children and adolescents, age range 10-14 years | Parent rating: Homework Problems Checklist (HPC)<br>Teacher rating: Children's Organization Skills Scales (COSS)<br>Academic Measure: School grades | Parents and teachers rated ADHD children and adolescents as demonstrating clinically significant problems in all areas, whereas the ADHD students rated themselves in the normal range. |
| Linnea, Hoza, Tomb, & Kaiser (2012) | *N* = 125 children with and without ADHD, age range 7-11 years | Self-report rating scale: Self-Perception Profile (SPPC)<br>Teacher rating: teacher version of SPPC<br>Experimental Task: Social interactions between the participant and a child confederate<br>Social Skills Ratings: Observer coding of social interactions | Only the ADHD children with PIB displayed less prosocial behavior and less effortful behavior. |
| McQuade, Mendoza Larsen, & Breaux (2017) | *N* = 120 children with and without ADHD, age range 8-12 years | Self-report rating scale: Self-Perception Profile (SPPC)<br>The self-esteem Implicit Association Test (IAT)<br>Teacher rating: Teacher version of SPPC | Differences among children with and without PIB did not depend on ADHD symptoms. |
| Mikami, Calhoun, & Abikoff (2010) | *N* = 43 children with ADHD, age range 6.9-11.9 years | Self-report rating scale: Self-Perception Profile (SPPC)<br>Camp Counselor ratings: Adult version of SPPC<br>Observed conduct problems at Summer treatment program behavioral intervention (STP) | PIB at the beginning of the summer predicted poorer response to intervention. Despite participating in an intensive intervention, there was high stability of ADHD children's biased self-perceptions regarding their performance. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| | | Social Skills Ratings: Peer preference nominations and friendship nominations | |
| Murray-Close et al. (2010) | *N* = 820 children with and without ADHD, age range 8-13 years | Self-report rating scale: Self-Perception Profile for Children (SPPC)<br>Parent Ratings: Diagnostic and Statistical Manual of Mental Disorders Fourth Edition (DSM-IV) Conduct Disorder Checklist<br>Teacher Rating: Teacher version of SPPC (for timepoint 1 and 2),<br>Teacher version of SPPA (for timepoint 3 and 4), Social Skills Rating System (SSRS) and Dishion Social Acceptance Scale (DSAS) | ADHD children were more likely than their TD peers to have PIB in both the social and behavioral domains. |
| Ohan & Johnston (2011) | *N* = 82 children with and without ADHD (all girls), age range 9-12 years | Self-reporting rating scale:<br>Matson Evaluation of Social Skills for Youngsters (MESSY)<br>Parent Ratings: Children's Impairment Rating Scale (CIRS)<br>Matson Evaluation of Social Skills for Youngsters (MESSY)<br>Children's Social Behavior Scale-Parent Form (CSBS-P)<br>Teacher Rating:<br>Children's Impairment Rating Scale (CIRS)<br>Matson Evaluation of Social Skills for Youngsters (MESSY)<br>Experimental Social Skills Task: "Girls Club!" computerized social interaction task<br>Social Skills Ratings:<br>Number of Friends and play-dates as estimated by mothers and teachers | Relative to scores from mothers, teachers, and the lab-task, girls with ADHD over-estimated their competence significantly more than TD girls. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| Owens & Hoza (2003) | *N* = 180, children with and without ADHD, age range 9-12 years | Self-report rating scale: Self-Perception Profile (SPPC)<br>Teacher ratings: Teacher version of SPPC<br>Academic Task: The Woodcock-Johnson III Tests of Achievement reading, and math subtests | ADHD Combined and Hyperactive/Impulsive subtypes had a PIB regarding scholastic competence more than ADHD Inattentive subtype when reading and math achievement scores were used. ADHD Combined and Hyperactive/Impulsive subtypes had higher PIB than TD group when math achievement and teacher ratings children's competence were used as criteria. ADHD children with predominantly inattentive symptoms generally did not differ from TD children with regard to PIB. |
| Rizzo, Steinhausen, & Drechsler (2010) | *N* = 54 children with and without ADHD, age range 8-10 years | Self-report rating scale: SelfReg questionnaire<br>Parent ratings: Behavior Rating Inventory of Executive Function (BRIEF)<br>Teacher ratings: Conners Teacher Rating Scale Revised (CTRS-R)<br>Behavior Rating Inventory of Executive Function (BRIEF) | Moderate tendency of ADHD children toward a PIB relative to TD group. |
| Steward, Tan, Delgaty, Gonzales, & Bunner (2017) | *N* = 57 children and adolescents with and without ADHD (all girls), age range 11-16 years | Self-report rating scale: Behavior Rating Inventory of Executive Functioning (BRIEF)<br>Parent rating scale: Behavior Rating Inventory of Executive Functioning (BRIEF) | The ADHD group had significantly higher PIB compared to TD children within the Inhibit, Shift, Monitor, Emotional Control, Working Memory, and Plan/Organization domains of the BRIEF. |
| Swanson, Owens, & Hinshaw (2012) | *N* = 228 children with and without ADHD (all girls), age range 6-12 years | Self-report ratings: Self-Perception Profile for Children (SPPC)<br>Academic Measure: Wechsler Individual Achievement Test (WIAT)<br>Teacher ratings:<br>Teacher Report Form (TRF)<br>Teacher Ratings of Peer Relations and Social Skill (TRPSK) | PIB among girls with ADHD in scholastic competence, social acceptance, and behavioral conduct, domains regardless of the external rater. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| | | <u>Social Skills Ratings</u>: peer preference nominations.<br><u>Parent rating</u>: Columbia Impairment Scale (CIS)<br>Maternal Ratings of Popularity | |
| Volz-Sidiropoulou, Boecker, & Gauggel (2016) | *N* = 183 children and adolescents, with and without ADHD, age range 6-15 years | <u>Self-report rating scale</u>: Competence Scale for Children and Adolescents (CCA)<br><u>Parent rating</u>: Child Behavioral Checklist (CBCL) | The ADHD group was significantly more likely than the TD group to show a PIB in daily activities relative to parent reports. |
| Whitley, Heath, & Finn (2008) | *N* = 54, with and without ADHD, age range 6-13 years | <u>Self-report rating scale</u>: Self-Perception Profile for Children (SPPC)<br>Children's Depression Inventory (CDI)<br><u>Teacher ratings</u>: Teacher version of SPPC<br>Teacher Report Form (TRF)<br>The Social Skills Rating Scale (SSRS) | Teachers rated the students in the ADHD group as performing significantly lower than the TD in scholastic, behavioral, and social areas. Difference scores for PIB was greater for the ADHD group than for the TD group. |
| Wiener et al. (2012) | *N* = 152, children with and without ADHD, age range 9-14 years | <u>Self-report rating scale:</u> Self-Perception Profile for Children (SPPC)<br>Attributions for ADHD questionnaire (AAQ)<br><u>Parent rating:</u> Conners' Parent Rating Scale-Revised: Long form (CPRS)<br><u>Teacher rating</u>: Conners' Teacher Rating Scale – Revised: Long form (CTRS) | Children with ADHD demonstrated a higher PIB than TD children. |
| **<u>Positive Illusory Bias – ADHD in Adult Samples</u>** | | | |
| Knouse, Bagwell, Barkley, & Murphy (2005) | *N* = 88 adults with and without ADHD, mean age = 31.93 | <u>Self-report rating</u>: Driving History Survey, Driving Behavior Survey (DBS), Estimates of Driving Ability<br><u>Experimental task</u>: Driving simulation | Despite poorer driving performance (e.g. more collisions, speeding tickets, etc.) adults with ADHD rated themselves as comparable to TD adults, demonstrating a PIB in driving. |
| Prevatt, Proctor, Best, Baker, Van Walker, & Taylor (2012) | *N* = 197 college students with and without ADHD, mean age = 21.59 | <u>Self-report ratings:</u> Work Performance Rating Scale (WPRS), Driving Behavior Survey (DBS) | Students with ADHD were significantly more likely to engage in PIB in their global rating of work performance and driving citations than the TD group. |

| *Study* | *Participants* | *Measures* | *Findings* |
| --- | --- | --- | --- |
| Weafer, Carmarillo, Fillmore, Milich, & Marczinski (2008) | $N$ = 38 drivers with and without ADHD, age range 19-30 years | Self-report ratings: Conners Adult ADHD Rating Scale (CAARS), ADD/H Adolescent Self-Report Scale, Barratt Impulsiveness Scale (BIS), Driving history and experience questionnaire (DHEQ), Personal Drinking Habits Questionnaire (PDHQ)<br>Experimental task: computerized driving simulation task | Compared to the TD group, drivers with ADHD overestimated their driving abilities and underestimated their degree of intoxication, indicating PIB. |
| **Positive Illusory Bias – Autism Spectrum Disorder in Child and Adolescent Samples** | | | |
| Johnson, Filliter, & Murphy (2009) | $N$ = 42 children and adolescents with and without ASD, age range 9.3-18.2 years old | Self- and parent-report ratings: Autism Spectrum Quotient (AQ), Empathy Quotient (EQ) and Systemizing Quotient (SQ) | In youth with ASD, youth reported fewer ASD symptoms and higher empathy than parents. No differences were found between youth and parents in controls. |
| Knott, Dunlop, & Mackay (2006). | $N$ = 19 children with ASD, age range 6.5-15 years old | Self- and parent-report ratings: Spence Social Skills Questionnaire, Social Competence with Peers Questionnaire | Parents rated the children with ASD's social skills and competence as significantly worse than the children did. |
| Koning & Magill-Evans (2001) | $N$ = 42 adolescent boys with and without ASD, age range 12-15 years | Standardized measures: Child and Adolescent Social Perception (CASP), Clinical Evaluation of Language Fundamentals Revised (CELF-R)<br>Self-, parent- and teacher-ratings: Social Skills Rating System (SSRS), Child Behavior Checklist (CBCL) | Adolescent boys with ASD rated their own social skills (as well as parent and teacher) as worse than the TD group, indicating no PIB. |
| Lerner, Calhoun, Mikami, & De Los Reyes (2012) | $N$ = 53 adolescents with ASD, mean age = 13.22 | Self-report ratings: Social Skills Rating System Student Form (SSRS-S), Hostile Attribution Questionnaire (HAQ), Children's Depression Inventory (CDI), Social Anxiety Scale – Adolescents (SAS-A) | Discrepancy identified between parent and adolescent with ASD's rating of social functioning, with adolescents rating themselves as comparable to their peers. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| | | Parent-report ratings: Social Skills Rating System Parent Form (SSRS-P), Parental Self Efficacy Scale (PSES) | |
| **Positive Illusory Bias – Intellectual Disability in Child and Adolescent Samples** | | | |
| Salaun, Reynes, & Berthouze-Aranda (2013) | *N* = 23 adolescents with ID (6-18 years old) | Intervention: Adapted Physical Activity Programme<br>Self-report ratings: Physical Self-Inventory (PSI-VSF-ID), EUROFIT Test Battery, Body Image Perception, Obesity awareness | The main predictor of adolescent's self-perceptions was their tendency to demonstrate a PIB before the intervention. |
| Zic & Igric (2001) | *N* = 40 children with and without ID (7-10.5 years old) | Standardized measures: Behavior Rating Profile: Student Rating Scale | Children with ID rated their confidence in their own abilities and success in relationships as equal to their peers. |
| **Positive Illusory Bias – Intellectual Disability in Adult Samples** | | | |
| Eden & Randle-Phillips (2017) | *N* = 88 young adults with ID, age range 16-25 years old | Self-report ratings: Stunkard figure rating scale (SFRS) | Females with ID underestimated their body size, demonstrating a PIB. Individuals with ID also had difficulty accurately associating a body weight category (e.g. overweight, healthy weight) accurately to their own bodies. |
| McVilly, Burton-Smith, & Davidson (2000) | *N* = 102 adults with ID, age range 18-82 years old | Self- and proxy-ratings: Comprehensive Quality of Life Scale For Adults (ComQol-A4), Mehrabian and Epstein Empathy Questionnaire (MEEQ) | Using a standardized approach to assessing QoL, results indicated a high degree of subject/proxy correspondence, suggesting no PIB. |
| **Positive Illusory Bias – Learning Disability in Child and Adolescent Samples** | | | |
| Alvarez & Adelman (1986) | *N* = 19 students with LD (9.6-15.2 years old) | Self-report ratings: Piers-Harris Self-Concept Scale<br>Experimental measures: self-efficacy measure (based on work by Bandura and Adams, 1977), measure of expectancy and aspiration of success, math task (20 math problems) | Across measures, participants with LD demonstrated "overstatements" (i.e. an overestimation) of their abilities, such as in their actual performance on the math task. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| Bear & Minke (1996) | *N* = 84 children with and without LD, Grade 3 | Self-report rating: Self-Perception Profile for Children (SPP-C), Self-evaluation interview | Children with LD were able to identify their specific deficits (e.g. forgetfulness, etc.), but perceived themselves as doing as academically well as their peers, indicating a PIB. |
| Heath, Roberts, & Toste (2013) | *N* = 58 adolescents with and without LD, 13.33-17.50 years | Standardized measures: Wechsler Abbreviated Scale of Intelligence (WASI), Wide Range Achievement Test (WRAT-3)<br>Parent-report rating: Conners' Parent Rating Scales (CPRS-R:L) | Adolescents with LD significantly overestimated their performance in math relative to their actual performance, but not in spelling. |
| Heath & Glen (2005) | *N* = 79 children with and without LD, 10.6-13.5 years | Standardized measures: Wechsler Intelligence Scale for Children (WISC-III Block Design and Vocabulary), Wide Range Achievement Test (WRAT-3), Woodcock Reading Mastery-Word Attack<br>Self-report rating: Prediction of performance on WRAT-3, Youth Self-Report (YSR) | Children with LD had a positive bias in their predicted performance on a spelling task, but after positive feedback their predictions became accurate. Children without LD had no original positive bias and no significant changes based on feedback. |
| Priel & Leshem (1990) | *N* = 80 children with and without LD, 6.5-7.5 years | Self-report rating: Pictorial Scale of Perceived Competence and Social Acceptance<br>Teacher-report rating: Teacher Rating Scale of Children's Competence and Acceptance<br>Experimental tasks: standardized tests assessing math, reading decoding, and reading comprehension, and sociometric status | Children with LD had a greater positive bias in cognitive competence than their peers. Their self-perceptions of peer acceptance were comparable to their peers, despite significantly lower sociometric and teacher ratings, suggesting PIB. |
| Stone & May (2002) | *N* = 101 adolescents with and without LD, Grades 9-12 | Self- parent- and teacher-report rating: Skills Rating Survey (SRS)<br>Self-report rating: Multidimensional Self-Concept Scale (MSCS)<br>Experimental task: vocabulary task with predictions (self, parent, and teacher predictions), computation task with predictions (self, parent and teacher predictions) | Students with LD overestimated their academic skills relative to their actual performance. These overestimations were less pronounced for students without LD. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| **Metamemory – ADHD in Child and Adolescent Samples** | | | |
| Antshel & Nastasi (2008) | *N* = 62 children with and without ADHD; mean age at T1 = 4.9 years old; mean age at T2 = 5.8 years old | Parent-report rating/interview: Behavior Assessment Scale for Children (BASC), Schedule for Affective Disorders and Schizophrenia for School-Age Children (K-SADS-PL)<br>Standardized measures: Wechsler Preschool and Primary Scale of Intelligence (WPPSI-R), Developmental Neuropsychological Assessment (NEPSY)<br>Metamemory task: question adapted from Kreutzer et al. (1975), picture-learning task (JOL) | At T1 (age 4), TD & ADHD children had similar metamemory abilities, but at T2 (a year later) controls made strong gains in metamemory while ADHD kids lagged behind. On the picture-learning task both two groups performed comparably on actual picture learning, but the ADHD was more optimistic in the number of pictures they could recall in order. This demonstrates inaccurate JOLs in this group. |
| Castel, Lee, Humphreys, & Moore (2011) | *N* = 116 children with and without ADHD, 6-9 years | Standardized measures: Wechsler Intelligence Scale for Children (WISC-IV), Wechsler Individual Achievement Test (WIAT-II)<br>Parent-report rating: Diagnostic Interview Schedule for Children (DISC-IV)<br>Metamemory task: selectivity task | There were no significant differences between controls and children with ADHD in terms of memory capacity, but children with ADHD were less selective than controls in terms of the value of items recalled (i.e. control of memory). |
| Voelker, Carter, Sprague, Gdowski, & Lachar (1989) | *N* = 24 children with and without ADHD, age range 6-12 years | Metamemory questionnaire: self-reflection on strategies used | No significant group differences between ADHD and non-ADHD boys on development of metamemory knowledge. |
| **Metamemory – ADHD in Adult Samples** | | | |
| Knouse, Anastopoulos, & Dunlosky (2012) | *N* = 68 adults with and without ADHD, mean age = 26.85 | Self-report rating: Computerized Diagnostic Interview Schedule for Children modified for adults (C-DISC-IV), ADHD Rating Scale (ADHD-RS)<br>Standardized measure: Wechsler Adult Intelligence Scale (WAIS) | Adults with ADHD were as accurate as adults without ADHD in terms of accuracy of JOL on a paired-associate recall task despite remembering fewer words. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| | | <u>Metamemory task</u>: JOL paradigm using paired-associate recall task | |
| Knouse, Paradise, & Dunlosky (2006) | $N = 56$ adults with and without ADHD, age range 18-60 years old | <u>Metamemory task</u>: JOL paradigm using paired-associate recall task<br><u>Self-report rating</u>: ADHD Rating Scale (ADHD-RS), Symptom Checklist-90-Revised (SCL-90-R)<br><u>Standardized measure</u>: Shipley Institute of Living Scale | No significant differences between the ADHD and non-ADHD groups in terms of accuracy of JOL. |
| **<u>Metamemory – Autism Spectrum Disorder in Child and Adolescent Samples</u>** | | | |
| Elmose & Happé (2014) | $N = 45$ children with and without ASD, age range 6.4-15.7 years | <u>Standardized tests</u>: Wechsler Intelligence Scale for Children (WISC-III)<br><u>Metamemory tasks</u>: performance judgements and certainty judgements | Overall, the metamemory results were comparable across ASD and TD groups. However, children with ASD were more accurate in judging their memory for non-social than social stimuli. |
| Farrant, Boucher, & Blades (1999) | $N = 144$ children with ASD, ID, and TD, mean age = 8.5 years | <u>Standardized tests</u>: Wechsler Intelligence Scale for Children (WISC)<br><u>Experimental tasks</u>: false belief test, memory span test, memory strategy task, prospective memory task<br><u>Metamemory tasks</u>: metamemory test 1 (knowledge of the effect of number of items on own memory), metamemory test 2 (knowledge of effect of age on others' memory) | Children with ASD and ID were not impaired on any of the metamemory tasks assessed. |
| Farrant, Blades, & Boucher (1999) | $N = 36$ children with ASD, ID, and TD, mean age = 10.4 years | <u>Experimental tasks</u>: picture span assessment test, recall readiness test | Children with ASD and ID had impaired recall readiness compared to TD group (i.e. would prematurely judge themselves as ready for recall). |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| Grainger, Williams, & Lind (2016a) | *N* = 63 children with and without ASD, mean age = 13.4 years | Standardized tests: Wechsler Abbreviated Scale of Intelligence (WASI)<br>Parent-report rating: Social Responsiveness Scale (SRS)<br>Metamemory task: JOC task (based on a video) | Children with ASD showed diminished accuracy in their judgments of confidence, indicating metacognitive monitoring impairments in ASD. |
| Grainger, Williams, & Lind (2016b) – Experiment 2 | *N* = 43 adolescents with and without ASD, mean age = 13.5 years | Metamemory tasks: JOL tasks (paired-word associates), and cue-alone JOL task (cued-recall task) | Across types of JOL tasks, adolescents with ASD demonstrated typical accuracy, suggesting no metamemory impairment. |
| Wojcik, Allen, Brown, & Souchay (2011) | *N* = 32 children with and without ASD, age range 7.05-16.06 years | Standardized tests: Wechsler Abbreviated Scale of Intelligence (WASI), Autism Spectrum Quotient (AQ), Autism Diagnostic Observation Schedule (ADOS)<br>Metamemory task: action memory task with JOC | The ASD group were significantly less accurate on the action memory task than controls, but there were no significant differences in the judgments of confidence on memory performance. |
| Wojcik, Moulin, & Souchay (2013) | *N* = 36 children with and without ASD, age range 9.04-17.03 years | Metamemory tasks: episodic FOK task and semantic FOK task | Children with ASD made significantly higher inaccurate FOK predictions compared to the control group but only for episodic materials and not the semantic task. |
| **Metamemory – Autism Spectrum Disorder in Adult Samples** | | | |
| Cherkaoui & Gilbert (2017) | *N* = 52 adults with and without ASD, 18-40 years old | Experimental tasks: intention offloading task, implicit confidence measure<br>Self-report rating scale: Metacognitions Questionnaire (MQ), Prospective and Retrospective Memory Questionnaire (PRMQ) | Performance of the ASD group was significantly poorer than the control group as well as metacognitive evaluations of memory. The ASD group failed to compensate for impaired performance in subsequent trials and would engage in fewer reminders. |
| Cooper, Plaisted-Grant, Baron-Cohen, & Simons (2016) | *N* = 48 adults with and without ASD, mean age = 30.92 | Standardized tests: Wechsler Abbreviated Intelligence Scale (WASI), Autism Spectrum Quotient (AQ) and Raven's matrices | Compared to the TD group, the ASD group had significantly worse metamemory for perceived-imagined info, but not for self-other information. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| | | Metmemory task: computer based reality monitoring task, involving word pairs with JOC | |
| Grainger, Williams, & Lind (2014) | *N* = 36 adults with and without ASD, mean age = 29.7 years | Standardized tests: Autism Spectrum Quotient (AQ), Autism Diagnostic Observation Schedule (ADOS), Wechsler Abbreviated Intelligence Scale (WASI)<br>Metamemory task: FOK task (word pairs)<br>Self-report rating: Metacognitions Questionnaire (MQ)<br>Experimental task: animations task | The ASD group made significantly less accurate FOK judgements compared to the control group. |
| Grainger, Williams, & Lind (2016b) – Experiment 1 | *N* = 36 adults with and without ASD, mean age = 29.7 years | Standardized tests: Autism Spectrum Quotient (AQ), Autism Diagnostic Observation Schedule (ADOS)<br>Metamemory task: 'cue-alone' JOL task | Adults with ASD demonstrated typical accuracy on a standard cue-alone JOL task compared to the TD group, suggesting no metamemory impairment. |
| **Metamemory – Intellectual Disability in Child and Adolescent Samples** | | | |
| Farrant, Blades, & Boucher (1999) | *N* = 144 children with ASD, ID, and without (mean age = 8.5 years) | Standardized tests: Wechsler Intelligence Scale for Children (WISC)<br>Experimental tasks: false belief test, memory span test, memory strategy task, propspective memory task<br>Metamemory tasks: metamemory test 1 (knowledge of the effect of number of items on own memory), metamemory test 2 (knowledge of effect of age on others' memory) | Children with ASD and ID were not impaired on any of the metamemory tasks assessed. |
| Lukose (1987) | *N* = 60 children with and without ID (mean age = 13.1 years) | Metamemory tasks: memory ability, story vs. list, study time, study plan | When metamemory tasks contained organizational features, the ID group performed comparably to their same age TD peers. However, when metamemory tasks had less structure, they performed worse than their same age TD peers, and performed comparably to TD children of the same mental age. |

| *Study* | *Participants* | *Measures* | *Findings* |
|---|---|---|---|
| **Metamemory – Learning Disorders in Child and Adolescent Samples** | | | |
| Geary, Klosterman, & Adrales (1990) | *N* = 72 children with and without LD, Grade 2 and Grade 4 | Metamemory tasks: Memory estimation, organized list, preparation object, study time for paired associates, study time for circular recall<br>Academic achievement: Stanford Research Associates (SRA) survey of basic skills | In Grade 4, children with LD performed significantly worse overall than TD children on the metamemory battery, and specifically had a worse performance on the Organized List and Study Time for Paired Associates tasks. |
| **Metareasoning – ADHD in Adult Samples** | | | |
| Mäntylä, Still, Gullberg, & Del Missier (2012) | *N* = 63 adults with ADHD and controls, age range 18-65 years | Meta-reasoning task: Under/overconfidence task from the Adult Decision-Making Competence Battery (A-DMC) | No significant differences were found between groups in knowledge calibration. |

**ADHD.** PIB has been studied extensively in ADHD (Weyandt & Gudmundsdottir, 2015). We identified several studies that examined PIB in ADHD samples, including 31 empirical studies that are summarized in Table 1, with 28 studies in childhood/adolescence and three studies in adults.

Many studies suggest that individuals with ADHD are more likely to overestimate their competence in various areas relative to parent or teacher ratings, when compared to peers without ADHD. PIB has emerged in a wide range of areas such as academic abilities, social abilities, behavioural symptoms, activities of daily living (e.g. daily cognitive requirements, graphomotor skills, executive tasks), and difficult physical activities for children with ADHD (Helseth, Bruce, & Waschbusch, 2016; Hoza et al., 2004; Volz-Sidiropoulou, Boecker, & Gauggel, 2016). Children with ADHD generally overestimate their abilities across multiple domains of functioning, such as behavioral, scholastic and social domains (Bourchtein et al., 2017). Although some positive self-perceptions seem to have an adaptive quality in the general population, PIB in individuals with ADHD has been associated with several negative outcomes. This includes poorer response to treatment, high rates of aggression, and less prosocial behaviour (Hoza et al., 2010; Hoza, Pelham Jr., Dobbs, Owens, & Pillow, 2002; Linnea, Hoza, Tomb, & Kaiser, 2012). Additionally, in children with ADHD, PIB has been shown to be a unique predictor of maladjustment in a new environment (Jia, Jiang, & Mikami, 2016). Of the 28 studies conducted in child and adolescent samples, 24 of these studies suggest that children and adolescents with ADHD tend to overestimate their performance relative to typically developing controls. Parallel findings were reported in the three studies conducted with adult ADHD samples.

Four principal theoretical explanations have been proposed to account for PIB in individuals with ADHD. First, the cognitive immaturity hypothesis suggests that children with ADHD are behaviorally and cognitively immature, and this extends to their overestimation of self-competence, which is analogous to the estimation that occurs in younger children. Second, the neuropsychological deficits hypothesis attributes anosognosia (i.e. a neurologically based lack of awareness of personal errors and self-perceptions which is linked to frontal lobe and executive dysfunction) as the cause for difficulties in monitoring at the core of PIB in children with ADHD. Third, the ignorance of incompetence hypothesis stipulates that children with ADHD may have overly inflated self-perceptions due to their inability to recognize their deficits because they lack skills in these areas. Fourth, the self-protective hypothesis suggests that children with ADHD overestimate their competence in many areas as a coping mechanism, so that they can present as confident to others and preserve their self-esteem (Owens et al., 2007). In fact, the self-protective hypothesis has been commonly used to explain PIB in ADHD samples (Emeh & Mikami, 2014), though the theoretical underpinnings of PIB in ADHD continue to warrant deeper investigation.

However, the literature on PIB in ADHD remains controversial. Some studies have failed to identify a PIB in individuals with ADHD (Hoza et al., 2002; Jiang & Johnston, 2017). Some have suggested that differences in responses are attributable to methodological concerns, such as the use of arbitrary cut-off points when using discrepancy scores (Bourchtein et al., 2017). It has also been argued that comorbidities in areas such as depression, aggression, and academic difficulties, which are common in ADHD, have not always been adequately controlled for when examining PIB (Owens et al., 2007). Despite some varied findings and difficulties within this literature, compelling evidence remains to suggest that individuals with ADHD have difficulty adequately calibrating their self-perceptions in various domains when compared to an external rater's perception.

**Autism**. Four studies were identified studying PIB in children or adolescents with autism. The PIB in autism has almost exclusively been focused in the domain of social function. Several studies identified a discrepancy between self-reports and others' reports of social functioning, at least when considering individuals with autism who do not have intellectual disability. Children with Autism tend to rate their social skills as better than do their teachers and parents, and this discrepancy is larger than what is found when examining children without Autism (Koning & Magill-Evans, 2001; Knott, Dunlop, & Mackay, 2006; Vickerstaff, Heriot, Wong, Lopes, & Dossetor, 2007). Johnson, Filliter, & Murphy (2009) found discrepancies between self and parent judgements of autistic traits and empathy, such that youth with autism reported fewer autistic traits and more empathetic qualities. In a study by Lerner, Calhoun, Mikami, & De Los Reyes (2012), discrepancies between the judgments of social skills between adolescents with autism and their parents were found to predict lower parental self-efficacy, fewer youth-reported hostile attributions to peers, and lower depression. Kanne, Abbacchi, and Constantino (2009) also detected informant discrepancies regarding psychiatric symptoms in children with autism, when compared to their parents' judgments, which were attributable to contextual factors rather than characteristics of the individual with autism. Overall, PIB of competence in youth with autism may provide important insights into youth social/emotional functioning and contextual factors.

**ID**. We only identified four studies that examined PIB in ID, with two in childhood/adolescence, and two in adulthood. Salaun, Reynes, and Berthouze-Aranda (2013) examined the contribution of PIB in the physical self-perceptions of adolescents with intellectual disabilities, and they found that the adolescents' inclination towards PIB was the main predictor of their physical self-perception and global self-esteem. Eden and Randle-Philips (2017) identified a similar trend in young adults with ID, such that they were more likely to underestimate their body size and hold positive beliefs about their bodies compared to their peers. Children with ID may also demonstrate a PIB in terms of their relationships with peers. While Zic and Igric (2001) found that children with ID did not rate their relationships to peers any lower than did their counterparts without ID, sociometric results from peers demonstrated that children with ID were actually not accepted as much by their classmates as were children without ID. When looking more broadly at quality of life, a study by McVilly, Burton-Smith, and Davidson (2000) revealed that adults with mild ID rated their quality of life comparably to the rating of their proxy (i.e. parent or sibling).

**LD**. Children's self-perception in their own academic abilities can act as a predictor of future academic outcomes (Stringer & Heath, 2008). We identified six studies investigating PIB in LD, all of which included children and adolescents. It has been reported that children with LD tend to overestimate their academic competencies, demonstrating a positive bias, which may be linked to the maintenance of positive academic self-concept (Alvarez & Adelman, 1986; Bear & Minke, 1996; Heath & Glen, 2005; Stone & May, 2002). This positive bias in academic competencies may protect against feelings of depression, such that depressed students with LD were more accurate in their self-perceptions, whereas non-depressed students with LD demonstrated a pervasive positive bias (Heath, 1995). Priel and Leshem (1990) also found that young children with LD had a positive bias in peer acceptance, with their self-perceptions of peer acceptance equaling those of their TD peers despite significantly lower ratings from teachers in the domain of social skills. Interestingly, when children with LD who had demonstrated a positive bias were given positive feedback on their performance of a spelling task, their subsequent predictions became more accurate, suggesting a self-protective hypothesis of PIB (Heath & Glen, 2005).

## Metamemory Paradigms

Metamemory is an aspect of metacognition that specifically addresses one's awareness of their own memory capabilities, which includes reflecting on one's memory skills and using this knowledge to subsequently regulate one's learning (Bebko, McMorris, Metcalfe, Ricciuti, & Goldstein, 2014; Flavell, 1979). From the time when an item to be remembered is first introduced and continues throughout the encoding and retrieval phases of memory (Nelson & Narens, 1990), various paradigms can be deconstructed and studied with regards to metamemory. Before or during learning of a given item, ease of learning (EOL, i.e. a judgment of how difficult something will be to learn) and judgment of learning (JOL, i.e. the likelihood of remembering an item at later recall) can be assessed. Before recall, judgment of comprehension (JOC, i.e. the perceived comprehensibility of the information) and prediction of performance (i.e. how well they will preform on a later recall task) can be assessed. During testing, feeling of knowing (FOK, i.e. judgment about probability of recognizing the answer to a question) and feeling of familiarity (FOF, i.e. how familiar a certain item appears) can be assessed. After testing, confidence (i.e. a retrospective judgment of the probability that a question was answered correctly) can also be assessed (Ackerman & Thompson, 2015).

In children without neurodevelopmental conditions, estimating one's memory abilities and subsequently monitoring one's memory capacities can be quite difficult at a young age. However, this ability develops substantially throughout childhood, and older children become quite proficient at these skills (Holland Joyner & Kurtz-Costes, 1998). In a developmental sample, Cavanaugh and Borkowski (1980) demonstrated that memory performance and metamemory are related abilities in children.

**ADHD**. Only five studies (three in childhood/adolescence, and two in adulthood) have examined metamemory in ADHD samples. Antshel and Nastasi (2008) followed the development of metamemory in preschoolers with ADHD. At age four, children with ADHD had metamemory skills that were comparable to those of children without ADHD. However, a year later, the comparison group children made considerable gains in this domain, whereas children with ADHD did not, suggesting a developmental lag. Given the pronounced executive function impairments in ADHD, it is also understandable that executive control processes that play an important role in metamemory function may be impaired (Cornoldi, Barbieri, Gaiani, & Zocchi, 1999). For example, Castel, Lee, Humphreys, and Moore (2011) identified that children with ADHD did not maximize their memory performance due to their lack of control of selective memory tools. Voelker, Carter, Sprague, Gdowski, and Lachar (1989) also found in a small sample of boys with ADHD that they did not lack metamemory knowledge (i.e. effective memory strategies), but had difficulty selecting appropriate strategies and applying this practically. Despite these preliminary studies examining metamemory strategies in children with ADHD, no studies have investigated metamemory paradigms (e.g. JOL, FOK, confidence, etc.) in this population. In adults with ADHD, some research has shown comparable performance to peers without ADHD in making metamemory judgments of learning and predictions of performance (Knouse, Anastopoulos, & Dunlosky, 2012; Knouse, Paradise, & Dunlosky, 2006).

**Autism**. Metamemory has been examined more extensively in children with autism, with mixed findings that suggest areas of both competency and difficulty. We identified a total of 11 studies examining metamemory in autism, with seven including children/adolescents and four including adults.

Farrant, Boucher, and Blades (1999) found that children with autism were not impaired on any metamemory tasks relative to matched peers without autism, but many qualitative differences emerged, particularly in terms of strategy selection. In particular, individuals with autism used compensatory memory strategies (e.g. rehearsing, setting reminders) less frequently than their peers (Bebko, Rhee, McMorris, & Ncube, 2015; Cherkaoui & Gilbert, 2017). Farrant, Blades, and Boucher (1999) also examined individual's recall readiness (i.e. judgment of when they had accurately encoded information and would be able to retrieve it successfully) and found that children with autism were more discrepant in their judgment of recall readiness than controls. Additionally, Grainger, Williams, and

Lind (2016a) found that children with autism were less accurate in their confidence judgments after a task (i.e. their own ratings of how likely they answered the question correctly was not as predictive of their actual performance, relative to controls), which may suggest impairments in metacognitive monitoring. When looking specifically at metamemory for face perception, Wilkinson, Best, Minshew, and Strauss (2010) found that children with autism had less accurate facial memory and confidence ratings (i.e. less reliable differentiation between their confidence ratings compared to children without autism), and a similar, though subtler, difficulty was found in adults with autism. In adults with autism, some studies have isolated areas of difficulty (e.g. reality monitoring and feeling-of-knowing), whereas others have found this population to be comparable to children without autism (e.g. judgment of learning; Cooper, Plaisted-Grant, Baron-Cohen, & Simons, 2016; Grainger, Williams, & Lind, 2014; Grainger, Williams, & Lind, 2016b).

However, there have also been several studies in children and adolescents with autism that indicated mixed findings regarding metamemory performance. For example, Wojcik, Waterman, Lestié, Moulin. and Souchay (2014) found that adolescents with autism made comparable judgments-of-learning to peers and could even regulate their study time according to these JOLs. In an action memory task, children with autism were as accurate as controls in judging the accuracy of their memory, which seems to suggest a lack of metamemory difficulties in this task (Wojcik, Allen, Brown, & Souchay, 2011). Some studies have also attempted to break down memory into different constructs to better understand this phenomenon. For example, Wojcik, Moulin, and Souchay (2013) investigated the feeling-of-knowing paradigm separately in episodic and semantic memory. Children with autism made inaccurate FOK predictions for episodic material, and not for semantic material. Additionally, Elmose and Happé (2014) examined how children with autism judge their own memory performance by looking at social and non-social stimuli. Although children with autism were accurate in predicting their memory performance overall, they were more accurate in their judgments for nonsocial than social material.

There is growing concern in the literature that language skills in autism may interfere with the study of metamemory in this population. In fact, Lockl and Schneider (2007) found that language abilities in young children were able to predict their future metamemory abilities. Additionally, Bebko et al. (2014) examined children's ability to spontaneously use rehearsal strategies and found that metamemory and language proficiency were both independent predictors of rehearsal strategy use. This is of particular significance in autism, as language difficulties are an important area of concern. As such, it appears as though examining metamemory while reducing linguistic requirements could prove useful to better understand these mechanisms in individuals with autism.

**ID**. Only two studies on metamemory in children/adolescents with ID were identified. Nonetheless, this is a worthwhile line of pursuit due to the fact that although intelligence and metacognitive skills are related, they may develop partly independently as well (Veenman, Wilhelm, & Beishuizen, 2004). The preliminary evidence suggests that metamemory may be less well developed in individuals with ID than peers without ID. Lukose (1987) identified that when task characteristics were manipulated to increase the metamemory demands (e.g. create a less organized task), adolescents with ID performed more poorly on memory tasks. Farrant et al. (1999) also found that children with ID had impaired recall readiness when compared to their typically developing peers. It appears as though individuals with ID may lack the metamemory knowledge necessary to apply these skills effectively. In fact, after a metamemory training program for children with ID, they had increased their metamemory knowledge and were able to apply these skills more effectively when prompted (Pérez & Garcia, 2002).

**LD**. In children and adults with LD, it has been shown that memory systems such as short-term memory and working memory are implicated in their academic performance (Swanson, 1994). Additionally, metacognitive abilities are crucial in skills such as reading and writing for children with LD (Wong, 1991). As such, metamemory may be of particular interest in this population (Gaultney, 1998; Harris, Graham, & Freeman, 1988). This review identified one study examining metamemory in children and adolescents with LD. Geary, Klosterman, and Adrales (1990) reported that Grade 4 children with LD performed significantly worse overall than TD children on a metamemory battery, and specifically had a worse performance on the Organized List and Study Time for Paired Associates tasks.

## Meta-Reasoning Paradigms

Meta-reasoning is an aspect of metacognition that specifically refers to the cognitive processes that monitor our progress on reasoning and problem-solving activities, and regulates the time and effort needed to accurately complete these tasks (Ackerman & Thompson, 2017). The field of research defined by meta-reasoning is about trying to understand the underlying metacognitive processes of more complicated tasks, such as reasoning and decision-making. Meta-level processes are relevant for the study of reasoning and decision-making, as these processes help to regulate goal setting, strategy selection, and monitoring one's progress on a given cognitive activity (Bjork, Dunlosky, & Kornell, 2013). Despite these clear implications of meta-level processes for reasoning, there is limited work that has been done in the field of meta-reasoning (Ackerman & Thompson, 2015), including both typically and atypically developing samples.

Many parallels can be drawn between the study of meta-reasoning and metamemory. As such, many of the paradigms developed in metamemory can serve as a basis for our understanding of meta-reasoning. Before or during a reasoning task, judgment of solvability (JOS; i.e. judge whether the task is solvable at all or that they have the requisite knowledge to solve the task) can be assessed. During a reasoning task, feeling of rightness (FOR; i.e. monitoring the production of a quick intuitive answer to analyze it more deeply and potentially produce a new answer), warmth ratings (i.e. how "warm" someone is getting as a measurement of how close they are to obtaining a solution), intermediate confidence ratings (i.e. judgment of how confident they are of their problem solving throughout the solving process), and dynamic predicting of knowing (dPOK; i.e. intermediate judgments of one's probability of knowing) can be assessed. After a reasoning task, final judgment of confidence (FJC; i.e. one's confidence in the final answer, after the reasoning of problem-solving is complete) can be assessed (Ackerman & Thompson, 2015).

Despite the field of meta-reasoning being in its infancy, there are indications that this topic may be of importance to individuals with a variety of other cognitive difficulties, such as individuals with neurodevelopmental disorders.

**ADHD**. It is well established that individuals with ADHD tend to score lower than typically developing individuals on executive function tasks (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). There have been relatively few studies that have examined meta-reasoning constructs in individuals with ADHD. Mäntylä, Still, Gullberg, and Del Missier (2012) examined decision-making and metacognitive constructs in adults with ADHD. Individuals with ADHD did not perform significantly worse on an over/underconfidence task of decision-making. Additionally, Basile, Toplak, and Andrade (in press) examined emotion recognition and resolution in children with ADHD. Despite no differences in overall accuracy on an emotion recognition task, children with ADHD were consistently more confident in their recognition of emotions compared to the TD group. Children with ADHD also showed lower resolution, indicating that TD children were better at discriminating correct from incorrect responses than children with ADHD. While resolution is a less direct measure of meta-reasoning (which is why we did not include this study in Table 1), these findings suggest differences between ADHD and controls in detecting correct and incorrect responses.

**Autism**. There is some evidence to suggest that individuals with autism may experience difficulties with reasoning abilities, such as syllogistic reasoning, counterfactual reasoning, and false belief understanding (Leevers & Harris, 2000; Peterson & Bowler, 2000). However, much of the emphasis has been placed on theory of mind reasoning, as social functioning is a core diagnostic feature of autism. Theory of mind refers to understanding how other's behaviours are motivated by their internal mental states (Sabbagh, 2004). Some studies have examined how metacognitive abilities contribute to mindreading reasoning. The "one-mechanism theory" proposes that mindreading and metacognition are intertwined abilities, so that impairment in one ability results in impairment in the other (Carruthers, 2009). However, Nichols and Stich (2003) propose that metacognition and mindreading are underpinned by different mechanisms, such that a "monitoring mechanism" is responsible for metacognition and a "mindreading mechanism" is responsible for mindreading. Grainger et al. (2014) identified mind-reading deficits in adults with autism that were accompanied by significantly less accurate feeling-of-knowing judgments on this mind-reading task than adults without autism.

We did not find any studies on meta-reasoning in ID and LD, which is perhaps not surprising given that this is a relatively new field of study.

## Characterizing the Estimation of Competence in Neurodevelopmental Disorders: Summary and Future Directions

There has been an emerging and growing literature on understanding the estimation of competence in individuals who experience impaired functioning across cognitive, academic and social domains, such as those with neurodevelopmental conditions. The estimation of competence has been identified as a critical domain for ADHD, but this domain has been less central for understanding other neurodevelopmental conditions, including autism, ID and LD. Given this, it is perhaps surprising that there is a literature examining paradigms related to the estimation of competence across all of these conditions, but it also suggests that there is some conceptual work to be done for understanding the relevance and basis across neurodevelopmental conditions. In our review, we found that PIB and metamemory paradigms have received empirical attention across the ADHD, autism, ID and LD special populations, but meta-reasoning (a relatively new domain of study) has only received attention in ADHD. Overall, there are more studies to suggest difficulties in these areas among these neurodevelopmental conditions than studies suggesting comparable performance to typically developing samples, but importantly not all studies consistently report such differences. We highlight the following considerations for advancing research in this area, specifically, consideration of conceptual questions, methodological issues and developmental considerations.

### Conceptual Questions

The opportunity to examine the estimation of competence across a number of neurodevelopmental conditions, as we have done in this paper, provides an important lens for determining whether this is an important domain for understanding each condition. For example, there is some suggestion in models of ADHD and based on findings with the PIB paradigm, that the estimation of competence may be a key difficulty for individuals with ADHD (Barkley, 2015), it also appears to be relevant for autism, LD and ID, despite not being a central diagnostic feature of these conditions. We did not find any literature examining monitoring accuracy in motor or language disorders. In the case of ADHD, poor monitoring is thought to be related to manifestation of self-regulation difficulties in these individuals, which may be mediated by co-occurring problems in internalizing speech (Weyandt & Gudmundsdottir, 2015). For example, Corkum, Humphries, Mullane, and Theriault (2008) reported that children with ADHD produced more task irrelevant speech while solving problem-solving tasks than typically developing controls. Then, during inhibition tasks, children with ADHD produced more task relevant speech, but their performance was lower than the typically developing group. Studies such as this one provide some insights into how cognitive monitoring may differ in ADHD relative to controls, for example, with respect to strategy selection and performance. Further work is needed to determine if monitoring accuracy may in fact be a defining feature for the difficulties observed in ADHD. However, even if monitoring difficulties may not be central in models for a given disorder, this does not mean that it is not relevant for study. Studies of clinical samples tend to focus on identifying impairments that may be diagnostic for a given disorder. The estimation of competence may not be defining of these disorders from a diagnostic perspective, but the relative awareness of one's successes and failures in tracking their performance in the environment may be useful for treatment and intervention planning, for example. Perhaps in the case of autism, LD and ID, monitoring difficulties may be correlated with executive function task performance difficulties that have been implicated in these disorders (Pennington, 2002). Many studies have called into question whether difficulties in performance calibration are specific to individuals with a given neurodevelopmental disability, or whether it is associated more generally to a shared underlying neurodevelopmental challenge (Bourchtein et al., 2017). For example, findings from Watabe, Owens, Serrano, & Evans (2018) and Jiang and Johnston (2017) suggest that the positive illusory bias demonstrated by children with ADHD is explained by their low competence in various areas and is not specifically due to their disorder. Miller and Geraci (2011) examined whether poor performers were unaware of their deficits by looking at confidence ratings. These students showed an overconfidence effect (i.e. estimated that they performed better than they did), but they also were less confident in these predictions compared to their typically performing peers, suggesting that poor performers may have some metacognitive insight. In autism, monitoring accuracy of the state of mind of others may be a defining feature of this disorder, related to theory of mind models. Conceptual models about how and why monitoring accuracy is relevant for each of these disorders will be important to explore in future studies (Dimaggio & Lysaker, 2010).

## Methodological Questions

It was perhaps bold of us to include PIB in the same paper as metamemory and meta-reasoning paradigms, as the conceptual basis for these different paradigms are entirely different. They originate from different literatures, involve entirely different methods and may even lead to different interpretations of the findings. The PIB paradigm has been studied in clinical research, and to a metacognitive researcher, the idea that self-monitoring measured relative to an informant report would be regarded as conceptually measuring something entirely different, where actual performance is the reference point for metacognitive judgment. However, the discrepancy between informants in the clinical literature and discrepancy between judgments and performance are generally interpreted as estimation in competence difficulties across these studies. One important consideration in clinical research studies is that there is a focus on identifying difficulties and impairments (APA, 2013), and that often becomes the starting point for identifying relevant paradigms to assess performance and behavior in these special populations. In the case of children with ADHD, parents and teachers are regarded important informants for identifying the impairments of children with ADHD, and the question then posed by PIB paradigms is whether children with ADHD also recognize the difficulties reported by their parents and teachers. Alternatively, metacognitive researchers reference point is how subjective judgments of performance are related to actual performance. It is important to note that both traditions offer important insights for understanding monitoring accuracy across these special populations, but that systematic study and careful consideration must be given to ensure that these paradigms are selected for appropriate reasons.

One other point that is important about methodology is the reliance on subjective judgment in both the PIB and metacognition literatures. In the ADHD literature, the PIB findings highlight the discrepancy between informants, which may contribute to the general clinical practice of a lack of reliance on self-report of symptoms and difficulties in ADHD, at least for children and youth under 17 years of age (APA, 2013). To move forward in this field, we must trust that self-report and subjective judgments are telling us something useful about monitoring accuracy in ADHD, not simply to justify the lack of validity of self-report or subjective judgment. Perhaps the integration of metacognitive theories and paradigms can help to advance work in the field of ADHD. It is unclear whether the reliability and validity of subjective judgment or self-report poses similar challenges in the other neurodevelopmental conditions, including autism, LD and ID.

## Developmental Considerations

The studies included in this review included all levels of development, from childhood to adults. Any conclusions based on these studies must take into account the cognitive development and the implications for monitoring accuracy. For example, there has been some convergence in the accuracy of metacognitive judgments in children suggesting significant improvement around 8 to 9 years of age (Koriat & Ackerman, 2010; Koriat & Shitzer-Reichert, 2002; Roebers & Howie, 2003; von der Linden & Roebers, 2006). Given the different paradigms and different periods of development, this further limits the potential conclusions we can draw about the estimation of competence across the neurodevelopmental conditions, but should be taken into account in future studies.

## Conclusions

Paradigms related to the estimation of competence and monitoring accuracy offer methods to help us measure how well we track our performance across different domains, including cognitive performance to social information processing. Bridging across the clinical research and metacognitive research traditions, we identified PIB, metamemory and meta-reasoning as the most commonly studied paradigms for assessing monitoring accuracy in neurodevelopmental conditions. Overall, studies from PIB paradigms suggest that individuals with ADHD, autism, LD and ID tend to display a positive bias in their performance relative to other informants. In metamemory paradigms, individuals with ADHD, autism, ID and LD tend to show more discrepancy between their subjective judgments and memory performance relative to comparison controls, but these findings have not always been consistently found. Meta-reasoning has been less well-studied, but preliminary studies suggest differences in ADHD and autism samples. In order to advance work in these areas, consideration must be given to conceptual models, methodological issues (paradigm selection and interpretation of self-report and subjective judgment) and developmental considerations. To our knowledge, a review of this literature on the estimation of competence in neurodevelopmental disorders has not been undertaken, and we hope that this paper provides a reference point for the research done to date and consideration of relevant issues to advance this work.

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