Disordered eating behaviours and autistic traits-Are there any associations in nonclinical populations? A systematic review

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Disordered Eating Behaviors and Autistic Traits – are there any Associations in Non-Clinical Populations? A Systematic Review

Abstract

Objective: To critically review existing literature concerning the possible association between autistic-like behavior and problematic eating behaviors in non-clinical populations.

Method: We performed a systematic literature search in three large databases. Studies were included if they assessed any association between a broad range of autistic-like behaviors and problematic eating behaviors in non-clinical samples.

Results: Sixteen eligible studies were found covering 3595 participants in total, including 5 studies on children/adolescents (n=685). All studies were cross-sectional, and thus only concurrent associations could be evaluated. Several autistic-like behaviors were found to be associated with problematic eating behaviors, with the overall 'autism spectrum quotient', deficiencies in set-shifting, and theory of mind showing the strongest associations.

Conclusions: The existing literature indicates concurrent associations between specific autistic-like behaviors and problematic eating behaviors in non-clinical samples across ages. Large prospective longitudinal studies are needed for insight into the temporal order of these associations.

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Highlights:

- Associations between autistic-like behaviors and disordered eating exist in non-clinical populations

- Deficiencies in set-shifting and theory of mind show strong correlations to disordered eating

- The findings provide support to the endophenotype hypothesis of eating disorders

Keywords: problematic eating, autistic traits, theory of mind, central-coherence, set-shifting

Introduction

Eating disorders (ED) are complex and disabling mental conditions associated with high psychiatric

comorbidity and impaired social and socioeconomic functioning (Keski-Rahkonen & Mustelin,

2016). The etiology of ED is considered to be multifactorial, involving both genetic and

environmental factors (Culbert, Racine, & Klump, 2015). Knowledge about preceding

developmental phenotypes of ED and problematic eating is, however, still limited (Rikani et al.,

2013). Yet, results from recent population studies indicate that childhood symptoms of

neuropsychiatric disorders like obsessive-compulsive disorder (OCD) and attention-

deficit/hyperactivity disorder (ADHD) may precede disordered eating and ED in adolescence and

early adulthood (Micali et al., 2011; Sonneville et al., 2015). Also, a substantial comorbidity with

autism spectrum disorders (ASD) has been found in clinical samples of adults with ED (Westwood

& Tchanturia, 2017), however to a lesser extent in adolescents (Pooni, Ninteman, Bryant-Waugh,

Nicholls, & Mandy, 2012). And, it has been suggested that anorexia nervosa (AN) could represent

the expression of ASD in some patients (Westwood & Tchanturia, 2017). In the last decade, research

has also found that certain cognitive and behavioral patterns similar to those seen in ASD seem to be

prevalent in clinical samples of both adults and adolescents with ED (Baron-Cohen et al., 2013; Bora

& Kose, 2016; Rhind et al., 2014)**.** These patterns include: weak central coherence (defined as a

reduced ability to see 'the bigger picture' and a bias towards details), social withdrawal, difficulties

with set-shifting (indicating cognitive inflexibility), and deficiencies in social cognition including

impaired Theory of Mind (ToM) (Roberts, Tchanturia, Stahl, Southgate, & Treasure, 2007) (Lang,

Lopez, Stahl, Tchanturia, & Treasure, 2014; Tapajoz et al., 2013). Impaired ToM can be described as

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difficulties with understanding the mental state of others and their behaviors and has been found to be associated with both active and recovered ED in adults (Bora & Kose, 2016; Tapajoz et al., 2013), However, only few studies have investigated ToM in clinical samples of children and adolescents with ED, and with conflicting results. While two studies found no significant ToM impairments in adolescents with ED (Bentz et al., 2017; Laghi et al., 2015), another study reported impaired emotion recognition in adolescents with ED (Zonnevijlle-Bender, van Goozen, Cohen-Kettenis, van Elburg, & van Engeland, 2002). In the following, we use the term "autistic-like behaviors" to encompass all of these cognitive and behavioral patterns.

It remains unclear whether autistic-like behaviors in patients with ED are mainly a result of starvation or irregular eating patterns inherent in the ED itself, and thus a state; or if they are traits representing endophenotypes of ED (Idini, Marquez-Medina, Pifarre, Buj-Alvarez, & Castan-Campanera, 2012). If the latter is true, these behaviors should precede the development of the ED and would persist after recovery (Idini et al., 2012). On the other hand, if the autistic-like behaviors are mainly an effect of starvation, they should not be present before the ED develops, and should primarily emerge with restrictive ED.

The results from an old retrospective case-control study by Fairburn and colleagues (Fairburn, Cooper, Doll, & Welch, 1999) support the endophenotype hypothesis. This study found that adults with AN and bulimia nervosa (BN) often reported having experienced social difficulties, such as shyness and having no close friends, prior to developing the ED. However, retrospective studies are prone to recall-bias. Recent results from the Gothenburg cohort study by Gillberg and colleagues showed that adults with a previous history of AN had ToM impairments up to 18 years after recovery (Gillberg et al., 2010) This could support the endophenotype hypothesis, but the results could also

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reflect long-term changes of prolonged starvation, persisting even after recovery. In favor of the endophenotype hypothesis are the results from a recent large register-based study showing an increased prevalence of diagnosed ASD among relatives of individuals with ED (Koch et al., 2015). On the other hand, weaker associations are found in samples of children and adolescents with an ED, which speaks in favor of the state theory (Pooni et al., 2012).

In summary, the existing evidence from clinical studies on individuals with ED is limited and inconsistent, especially concerning childhood and adolescence, and is insufficient to determine the temporal relationship between autistic-like behaviors and later disordered eating or ED. However, the autism spectrum constitutes, as indicated, a collection of cognitive patterns lying on a spectrum from severely impaired functioning in several domains (ASD) to individuals in the normal population without intellectual impairment, but with one or a few autistic-like behaviors (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Similarly, ED can be perceived to be the extreme end of a similar spectrum with regard to different patterns of problematic eating behaviors (Aspen et al., 2014). Problematic eating behaviors and autistic-like behaviors are therefore likely to also include sub-clinical and 'prodromal' cases. Thus, an important next step in research is to examine the associations between these in non-clinical populations.

The aim of this review is to systematically assess studies examining the association between autistic-like behaviors and problematic eating behaviors in non-clinical samples. Further, we explore any such association in the sub-group of children and adolescents, which could provide indications of early endophenotypes and trait patterns, preceding and perhaps predisposing the individual to the

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development of an ED.

Methods

We followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman, & Group, 2009) and performed a systematic search through PubMed (including MEDLINE 1946 to December 2017), Embase (1974 to December 2017) and PsycInfo (1806 to December 2017) to identify relevant articles. The search terms are displayed in Table 1. All terms were searched as text words and as medical subject headings where possible. There were no language or age restrictions in the search. The reference lists of eligible papers were manually checked in order to identify further potentially eligible references that had not been identified in the above search.

Two of the authors, SSC and EMO, independently reviewed titles, abstracts, and full texts of the references identified, and assessed eligibility. Consensus decisions were made in case of discrepancy.

Inclusion and exclusion criteria

Studies were eligible if they examined an association between any autistic-like behavior (including set-shifting, central coherence, mentalization/ToM, empathy, psychological inflexibility and traits measured by the Autism Spectrum Quotient (AQ)) and problematic eating behaviors in non-clinical samples. Studies were excluded if the study sample included any individuals with diagnosed ED or ASD. Also, case studies, conference abstracts, dissertations and reviews were excluded.

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Data extraction

We extracted data using a standardized form, collecting information on: year of publication, study design, country, total sample size, number of cases and controls (if applicable), population characteristics, mean age, variables investigated, screening tools and key findings. To be able to distinguish children and adolescents from adults we defined adolescence as ending at age 17. Authors were contacted for any missing data.

Quality assessment

The included studies were assessed for methodological quality by the Newcastle-Ottawa Scale (NOS), which is a validated tool originally designed to assess case-control and cohort studies (Bae, 2016). However, as all eligible studies for this review were cross-sectional, we used a modified version previously presented by Herzog et al. (35). In this assessment points are given concerning selection (0-3), comparability (0-2), and 'outcome' measurements (0-5) and summed up to indicate high (8-10), medium (5-7), and low (0-4) quality.

Results

The initial search yielded a total of 311 studies, which were screened for eligibility based on the title or abstract. A total of 27 full-text articles were assessed for eligibility. Of these, 16 studies met the inclusion criteria and were included in the final assessment. Figure 1 depicts the flowchart of the selection process, while Table 2 gives an overview of the included studies.

The results of the quality assessment are displayed in Table 3. The overall quality of the studies, all of cross-sectional design, was medium to high, but all studies were suboptimal in specific areas: No studies reported having done a power calculation to justify sample sizes, and no studies were explicit about the response rates and the characteristics of non-responders. Thus, the representativeness of the samples and the credibility of especially 'non-significant' results are unknown.

Characteristics of included studies

In total, data from 3595 individuals were included in this review. A detailed overview of the characteristics and key findings of each study is shown in Table 3. Sample sizes ranged from 74 to 681, with most studies recruiting young adults and/or teenagers (mean age: 21.2 years). Five studies included females only, and one study had a male-only sample, resulting in a total of 70.4% female participants.

The included studies were all published within the last decade, between 2009 and 2016, and conducted in nine different developed countries. All studies had a cross-sectional design. In eight studies a dichotomized indicator of problematic eating (yes vs. no) was used and in most cases, based on pre-defined cut-offs on the total scores on eating behavior questionnaires. The remaining eight studies considered problematic eating behavior as a continuous variable, also based on screening tools. All studies had autistic-like behaviors as continuous variables.

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Screening tools

Autistic-like behaviors were assessed either by tests/tasks or by self-report questionnaires. Set-shifting, central coherence and ToM were all assessed via tasks, except in one study in which ToM was assessed by a self-report questionnaire (Innamorati et al., 2015). Empathy and psychological inflexibility were measured through self-report questionnaires. Five studies examined more than one type of autistic-like behavior (Bremser & Gallup, 2012; Carton & Smith, 2014b; Griffiths, Murray, & Touyz, 2013; Mansour et al., 2016a; Naor-Ziv & Glicksohn, 2016).

Eating behaviors were assessed by self-report questionnaires in most studies, but two studies used semi-structured interviews (Hartmann, Czaja, Rief, & Hilbert, 2010; Manasse et al., 2015). Ten studies used the Eating Attitudes Test-26 (EAT-26), a 26-item self-report questionnaire, designed to measure attitudes and behaviors associated with eating pathology (Garner, Olmsted, Bohr, & Garfinkel, 1982). Other self-report questionnaires were the Eating Disorder Examination Questionnaire (EDE-Q), used by 2 studies (Griffiths et al., 2013; Kelly, Bulik, & Mazzeo, 2013) , and the Eating Disorders Inventory 2 (EDI-2), used by 2 studies (Cuzzocrea, Costa, Larcan, & Toffle, 2015; Naor-Ziv & Glicksohn, 2016). The semi-structured interviews used to assess eating behavior was the Eating Disorder Examination (EDE) and the Child Eating Disorder Examination (CEDE), which have both been extensively validated for assessing eating disordered behaviors (Hartmann et al., 2010; Manasse et al., 2015). Two studies also examined specific types of problematic eating, namely binge eating and food addiction, using respectively the Binge Eating Scale (BES) and the Yale Food Addiction Scale (YFAS) (Cuzzocrea et al., 2015; Innamorati et al., 2015). Most studies did not distinguish between specific types of problematic eating behavior, and

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thus used problematic eating as one variable, covering all types of eating behavior. This limits our ability to analyze associations between specific problematic eating behaviors and autistic-like behaviors.

Associations between autistic-like behaviors and problematic eating behavior

Key findings of each study are summarized in Table 3. The rest of this section provides an overall description of the findings.

Autism spectrum quotient

Four studies assessed autistic 'traits' using the Autism Spectrum Quotient (AQ) (Carton & Smith, 2014b; Coombs, Brosnan, Bryant-Waugh, & Skevington, 2011; Mansour et al., 2016a; Raynal, Melioli, & Chabrol, 2016). The AQ is a 50-item self-report questionnaire assessing areas of social and cognitive abnormalities seen in ASD, and it includes the following subscales: 1) social skills, 2) attention to detail, 3) attention switching, 4) communication and 5) imagination (Baron-Cohen et al., 2001). One study used an abbreviated 10-item version of the AQ (AQ-10), which has a similar sensitivity and specificity as the full version (Raynal et al., 2016). Three studies found significant associations between high scores on the AQ and problematic eating behaviors (Carton & Smith, 2014a; Coombs et al., 2011; Mansour et al., 2016b), one of which was on children (11-14 years) (Coombs et al., 2011). All three studies reported significant correlations between particularly the EAT-26 subscales of 'Bulimia and Food Preoccupation' and 'Oral Control' and several of the AQ subscales; Bulimia and Food Preoccupation was associated to 'social skills', 'communication' and 'attention to detail', while Oral Control was associated to 'attention switching' and 'attention to

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detail'. The Bulimia and Food Preoccupation subscale assesses BN-like behaviors with the questions 'I have an impulse to vomit after meals' and 'I have gone on eating binges where I feel I might not be able to stop', and this subscale showed the strongest and most consistent associations across studies. The total EAT-26 score was also correlated to total AQ and to all AQ subscales, except 'Imagination'.

Set-shifting

Four studies examined the correlation between set-shifting and problematic eating behaviors (Griffiths et al., 2013; Kelly et al., 2013; Manasse et al., 2015; Naor-Ziv & Glicksohn, 2016). Set-shifting was measured by either the Wisconsin Card Sorting Test (WCST) or the Penn Conditional Exclusion Task (PCET) (Kurtz, Ragland, Moberg, & Gur, 2004; Lichtenstein, Erdodi, Rai, Mazur-Mosiewicz, & Flaro, 2016). Both tasks measure the ability to navigate between sudden changes in task criteria. Three of the studies included adults (Griffiths et al., 2013; Kelly et al., 2013; Manasse et al., 2015). One of these, a study on adult males, found significant associations between high pervasive errors on the WCST and high total scores on the EDE-Q, indicating an association between difficulties with set-shifting and problematic eating behavior (Griffiths et al., 2013). The two remaining studies investigated set-shifting in relation to binge-eating in obese subjects, but found no associations between set-shifting abilities in the binge eating group compared to controls (Kelly et al., 2013; Manasse et al., 2015). Although, one of the studies found that the total number of binge episodes per week was positively correlated to difficulties with set-shifting (Kelly et al., 2013). Only one study explored set-shifting and problematic eating in adolescents (Naor-Ziv & Glicksohn, 2016). In this study, the sample was divided into a high-risk-for-ED group, a medium-risk-for-ED

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group and a control group. Analysis of variance showed significant differences in the performances between the three groups. The high-risk-for-ED group performed worse on the WCST than the control group. The high-risk group was further sub-divided into a high-risk-for-AN and a high-risk-for-BN group. The total amount of errors on the WCST did not differ between these two sub-groups.; but the high-risk-for-AN group tended to perform worse on latter parts of the task, indicating more difficulties with learning from past experiences and mistakes (Naor-Ziv & Glicksohn, 2016).

Central Coherence

Three studies investigated associations between central-coherence and disordered eating (Carton & Smith, 2014b; Griffiths et al., 2013; Naor-Ziv & Glicksohn, 2016). The Matching Familiar Figures Test (MFFT) and the Embedded Figures Test (EFT) were used to measure central coherence. No associations were found between weak central coherence and problematic eating behaviors in neither adolescent nor adult samples (Carton & Smith, 2014b; Griffiths et al., 2013; Naor-Ziv & Glicksohn, 2016).

Theory of Mind

Two studies assessed ToM in relation to problematic eating behaviors in adults (Bremser & Gallup, 2012; Innamorati et al., 2015). In one study, difficulties with ToM, measured by the Mentalization Questionnaire, a 15-item previously validated self-report, were found to be associated with binge eating and food addiction (Innamorati et al., 2015). The second study examined ToM by the Reading the Mind in the Eyes test (RME), which is a computerized task, where participants are required to

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interpret a person's mental state based on pictures of different sets of eyes (Bremser & Gallup, 2012). No associations with problematic eating behaviors were found.

One study assessed ToM in adolescents both by the RME and the Faux Pas Recognition Task (FP) (Naor-Ziv & Glicksohn, 2016). As with the study on adults, no association was found between RME and disordered eating in adolescents. However, significant associations were found concerning Faux Pas. Testing FP requires participants to read a number of stories, some of which contain a social faux pas (a socially awkward or tactless act). The ability to recognize when a faux pas occurred was found to be significantly worse in the high-risk-for-ED group than in the control group. Furthermore, sub-group analysis showed that the high-risk-for-BN group performed significantly worse on the FP than the high-risk-for-AN group (Naor-Ziv & Glicksohn, 2016).

Empathy
Six studies explored a link between empathy and disordered eating (Bremser & Gallup, 2012; Costarelli, Antonopoulou, & Mavrovounioti, 2011; Costarelli, Demerzi, & Stamou, 2009; Cuzzocrea et al., 2015; Hartmann et al., 2010; Mansour et al., 2016a). A variety of different measures were used to assess empathy, all self-report questionnaires. The questionnaires assessed emotional empathy, through questions like 'I get upset, when I see someone being hurt' (Bryant, 1982) or 'I tend to get emotionally involved, with a friend's problems'(Baron-Cohen & Wheelwright, 2004). Some questionnaires also involved cognitive empathy; 'I can easily work out what another person might want to talk about' (Baron-Cohen & Wheelwright, 2004), but overall the questionnaires were comparable. Three studies investigated empathy and problematic eating behaviors in adults, with

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differing results (Bremser & Gallup, 2012; Costarelli et al., 2009; Mansour et al., 2016a). Thus, one study including nearly fifty percent males found that problematic eating (higher EAT-26 score) was associated with having more empathy (Bremser & Gallup, 2012); while another study including only females found that problematic eating was associated with lower levels of empathy (Costarelli et al., 2009). Finally, a third study including primarily females (less than twenty percent males) found no associations between empathy and EAT-26 scores (Mansour et al., 2016a). Three studies investigated empathy and problematic eating in adolescents, and none of these found any significant associations (Costarelli et al., 2011; Cuzzocrea et al., 2015; Hartmann et al., 2010).

Psychological Inflexibility

Two studies investigated psychological inflexibility in relation to problematic eating behavior in adults (Masuda, Muto, Tully, Morgan, & Hill, 2014; Moore, Masuda, Hill, & Goodnight, 2014), using the Acceptance and Action Questionnaire (AAQ-II) and the EAT-26. Psychological inflexibility is defined as an inappropriate regulation tendency that the individual uses to avoid unwanted thoughts and experiences (Masuda et al., 2014). One of the studies found no associations between psychological inflexibility and EAT-26 scores, while the other study found significant associations in their U.S. sample, but not in their Japanese sample (Masuda et al., 2014).

In all of the autistic-like behaviors investigated, an indication of a dose-response relationship was observed, as higher degrees of autistic-like difficulties seemed to be correlated with more severe disordered eating.

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Discussion

The present systematic review provides support to the assumption that associations between autistic-like behaviors and problematic eating do exist, also in non-clinical populations, especially concerning autistic traits measured on the AQ.

Autism spectrum quotient

One of the most replicable findings was the significant positive association between scores on the AQ and problematic eating behaviors, specifically the Bulimia and Food Preoccupation subscale of EAT-26; and AQ subscales were correlated to disordered eating in both adults and children. The fact that the AQ showed a more consistent association with disordered eating than the specific cognitive tasks suggests that autistic-like behaviors other than those in these specific cognitive domains are involved in problematic eating. The AQ assesses self-reported autistic symptoms, including difficulties in social contexts, for example: 'I find it hard to read between the lines, if someone is talking to me' (Baron-Cohen et al., 2001). This might indicate that difficulties with social functioning is more strongly related to problematic eating behaviors than specific cognitive deficits. This theory is challenged, however, as the AQ includes several items other than social experiences, which are also related to disordered eating in our analysis. In terms of problematic eating behaviors, the Bulimia and Food Preoccupation subscale of the EAT-26 appeared to be the most consistent correlation to several autistic-like behaviors, suggesting that autistic symptomatology may be of

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particular significance in relation to this type of eating behavior (Carton & Smith, 2014b; Mansour et al., 2016a). However, AN is much less prevalent in the general population than BN (Hoek & van Hoeken, 2003), and the lack of association with AN-like eating behaviors might be a matter of lack of power.

Set-shifting

Reduced cognitive flexibility as measured with set-shifting tasks may in theory lead to rigid thinking styles about food which might lead to or maintain disordered eating behaviors and ED. Difficulties with set-shifting were found in two studies; one on adults, where eating problems were defined using the total EDE-Q score including restrained eating patterns; and one on children, where the association was especially found with the high-risk-for-AN-group. In two other studies on binge eating in adults, no association with set-shifting was found (Kelly et al., 2013; Manasse et al., 2015). Reduced set-shifting ability has been documented in adult patients with AN (15, 16); and the findings of this review cautiously indicate that these impairments might in fact be preceding traits concerning eating behaviors with dietary restrain and AN. However, as all the studies were cross-sectional, no ordinal or causal direction can be discerned

Central Coherence

Weak central coherence has been found to be associated with AN in both adults and adolescents but no such association was found in our review, neither in adults (males and females) nor in children. This could indicate that central coherence might represent a state-effect rather than a trait of ED. Although, only three studies have investigated this, the fact that they measured central coherence by

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three different instruments indicate that the lack of association is inherent to the concept of central coherence rather than just instrument specific. However, the three studies used different measures of problematic eating, the EAT-26, EDE-Q and EDI-2 respectively, which limits the comparability between studies.

Theory of Mind and Empathy

The ToM ability to read emotions on the RME test showed no relationship to problematic eating in neither children nor adults. This stands in contrast to current evidence in adult patients with AN and BN, in which RME performances has been found to be impaired (Bora & Kose, 2016). This suggests that the reduced emotion recognition measured by RME captures a state effect. This hypothesis is corroborated by findings of normal RME performance in young persons with recent-onset AN (Bentz et al., 2017). On the other hand, two studies in this review using other measures of ToM in non-clinical children and adults (including the ability to recognize faux pas situations) reported significant associations with problematic eating behaviors. Measures of empathy showed no associations to problematic eating in children, and the results in adults were contradictory, with both positive and negative directions of associations reported(Bremser & Gallup, 2012; Costarelli et al., 2009) This is in concordance with findings in children and adults with ED where results are also inconsistent (Cardi et al., 2015).

Summarized, patterns of restrictive eating and BN-like eating were found in several studies to be associated with higher scores on the AQ. Measures of general problematic eating behaviors were associated with set-shifting problems, whereas binge eating in itself seemed to be unrelated to set-

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shifting difficulties. On the other hand, binge eating, food addiction and general measures of problematic eating behaviors were all found to be associated with poor performance on faux pas tasks, an aspect of ToM.

None of the studies have investigated sex-differences, but the diverging results concerning empathy suggest that gender differences may be involved.

Strengths and limitations

We used a rigorous systematic search strategy to identify all published articles on the topic in three large databases with no restrictions concerning language, year of publication, or age of participants. Also, no restrictions on types of measurement tools were applied, and search terms included a broad range of autistic-like behaviors in order to present a comprehensive analysis. Conference abstracts, case reports and dissertations however, were not included, with the risk of bypassing relevant literature. But, as good research behind conference abstracts are eventually turned into articles, and as dissertations are usually based on already published articles, we perceive this risk to be negligible. However, we did not search for unpublished literature, and consequently may be prone to publication bias. On the other hand, authors of the included studies were contacted for any missing data.

Concerning the current research on the association between autistic-like behaviors and problematic eating behaviors in non-clinical samples is limited by a shortage of published studies and small samples sizes. Additionally, heterogeneity across studies meant that the results could not be integrated into a meta-analysis. A number of methodological differences between studies were

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evident, including differences in: sample selection, autistic-like behaviors assessed, measurement

tools used to assess problematic eating, statistical analysis applied, and confounders adjusted for. As

a consequence of these variations in methodologies, the results from each study had to be evaluated

individually. All of the identified literature is cross-sectional, which precludes from determining a

temporal or causal relationship between the variables assessed. Our critical appraisal of each study

(table 2) revealed some methodological constraints within studies, even though the overall quality of

each study was medium to high. Another limitation is the inadequate analyses of non-participants

and potential selection bias, and it is possible that participants differed from the general population

concerning both eating patterns and autistic-like behaviors thus affecting the results in unpredictable

ways (Coombs et al., 2011). Furthermore, using subjective measures, such as self-reporting to

determine behaviors or traits implies a risk of information bias, for example due to respondents'

tendencies to answer in a way that seems more socially desirable or acceptable (Yu & Tse, 2012).

These methodological weaknesses limit the validity of study results and thereby the strengths of our

conclusions. However, all of the self-report measures used in our literature were well-validated

instruments and they showed good or average internal consistencies. With regard to the

representativeness of the review, it is important to note however, that all studies were from

developed countries

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Conclusion

This is the first systematic review exploring the association between autistic-like behaviors and problematic eating behaviors in non-clinical populations. Knowledge about whether autistic-like behaviors could precede and or even predispose an individual to engage in problematic eating behaviors, which could subsequently lead to an ED, is of outermost importance. The findings of this review suggest that some autistic-like behaviors, including specific ToM deficits and impaired set-shifting, are indeed present in non-clinical samples of both children and adults with problematic eating, thus indicating that such behaviors might represent traits of later pathological eating. However, the evidence is still sparse, and there is a need for large prospective longitudinal studies to determine the temporal relationship between autistic-like behaviors and problematic eating and possible gender differences.

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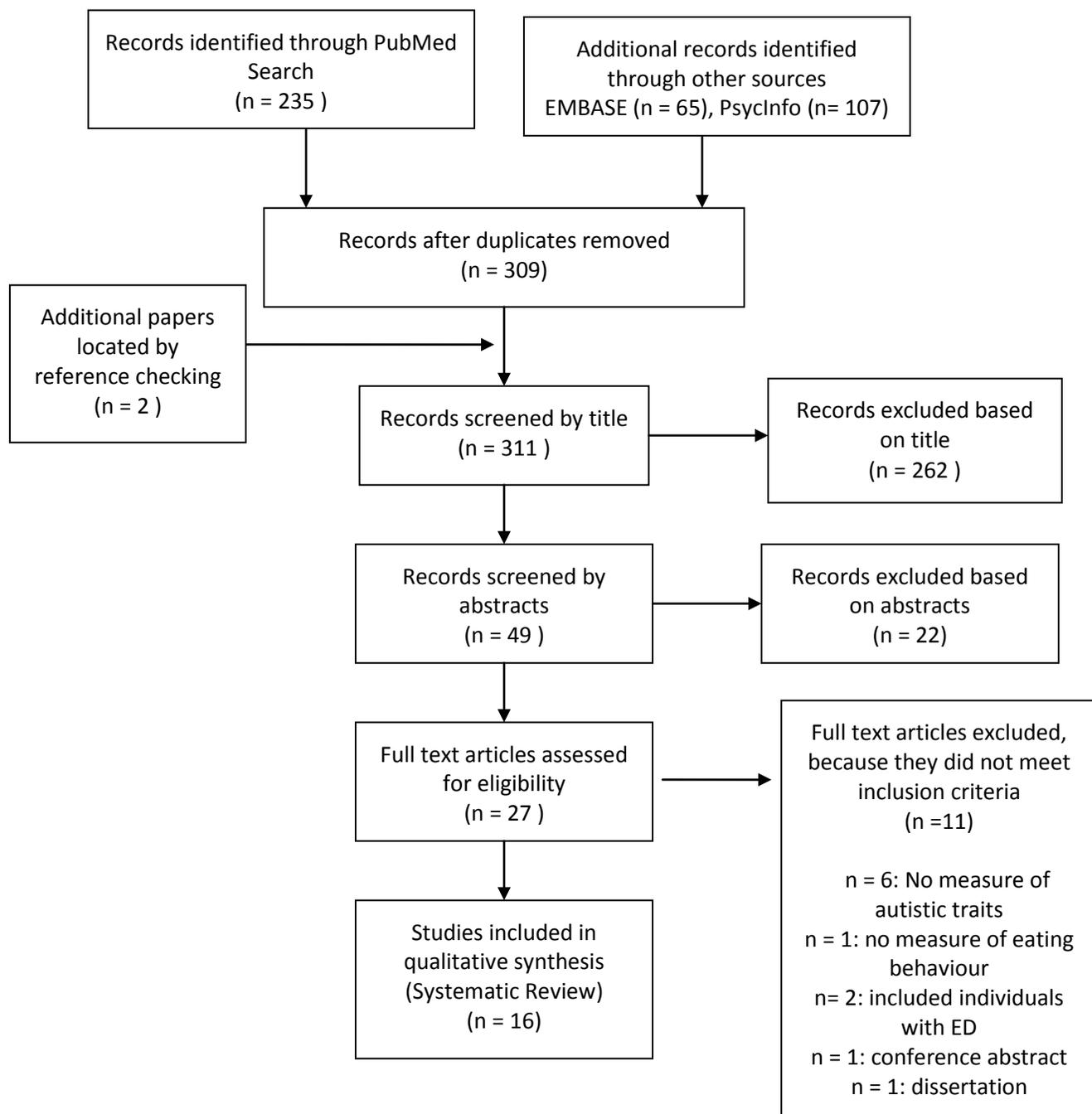
Table 1. Search Terms.

Search terms for problematic eating, combined by 'OR'		Search terms for autistic traits, combined by 'OR'
Problematic Eating Behaviour		Autistic Traits
Problematic Eating		Social Cognition
Disordered Eating		Psychological Inflexibility
Disinhibited Eating		Set-shifting
Maladaptive Eating	AND	Central Coherence
Abnormal Eating		Theory of Mind
Restrictive Eating		Mentalization
Disturbed Eating		Empathy
Dysregulated Eating		Autistic Symptomatology
Emotional Eating		Autism Spectrum Quotient
External Eating		
Binge Eating		

First author (year)	Selection			Comparability	Outcome			SUMMARY SCORE
	Representativeness of the sample. a) Truly representative of average in target population ★ b) somewhat representative ★ c) selected group of users d) no description of sampling strategy	Sample size. a) Justified and satisfactory ★ b) not justified	Non-respondents. a) respondent rate is satisfactory and non-respondents are compared to respondents ★ b) no comparability or unsatisfactory responce rate c) no response rate	Control for confounders. a) The study controls for the most important confounder (gender)★ or b) study controls for any additional confounder ★ c) not stated	Assessment of problematic eating. a) Validated screening tool ★ ★ b) non-validated screening tool, but tool is available or described ★ c) no desription of measurement tool	Assessment of autistic traits. a) validated measurement tool ★ ★ b) non-validated measurement tool, but tool is available/described ★ c) No description of measurement tool	Statistical test. a) statistical analysis is clearly described and appropriate and association is presented and p-value ★ b) statistical analysis is inappropriate, not described or incomplete	
Adult Samples								
Mansour (2016)	b) ★	b)	c)	★ ★	★ ★	★ ★	★	7/10 (medium)
Raynal (2016)	b) ★	b)	c)	c)	★ ★	★ ★	★	6/10 (medium)
Innamorati (2015)	a) ★	b)	c)	★ ★	★ ★	★ ★	★	8/10 (high)
Manasse (2015)	a) ★	b)	c)	b) ★	★ ★	★ ★	★	7/10 (medium)
Carton (2014)	b) ★	b)	c)	a)★	★ ★	★ ★	★	7/10 (medium)
Kelly (2014)	b) ★	b)	c)	b) ★	★ ★	★ ★	★	7/10 (medium)
Masuda (2014)	a) ★	b)	c)	★ ★	★ ★	★ ★	★	8/10 (high)
Moore (2014)	b) ★	b)	c)	b) ★	★ ★	★ ★	★	7/10 (medium)
Griffiths (2013)	b) ★	b)	c)	b) ★	★ ★	★ ★	★	7/10 (medium)
Bremser (2012)	b) ★	b)	c)	★ ★	★ ★	★ ★	★	8/10 (high)
Costarelli (2009)	b) ★	b)	c)	b) ★	★ ★	★ ★	★	7/10 (medium)
Children/Adolescent Samples								
Naor-Ziv (2016)	a) ★	b)	c)	b) ★	★ ★	★ ★	★	7/10 (medium)
Cuzzocrea (2015)	a) ★	b)	c)	b) ★	★ ★	★ ★	★	7/10 (medium)
Coombs (2011)	a) ★	b)	b)	a) ★	★ ★	★ ★	★	7/10 (medium)
Costarelli (2011)	a) ★	b)	b)	c)	★ ★	★ ★	★	6/10 (medium)
Hartmann (2010)	a) ★	b)	c)	b) ★	★ ★	★ ★	★	7/10 (medium)

Table 3. Study Characteristics and Key Findings

First Author	Publication year	Study Design	Country	Sample Size	Sample Characteristics	Sample divided into cases and controls?	Measure of Autistic Traits	Measure of Eating Pathology	Key findings
Adult samples									
Mansour	2016	Cross-sectional	Australia	416	University students. Age 17-48 years (mean age: 19,76), 82% females.	No	AQ and EQ-S (Empathy)	EAT-26	AQ: There was a significant positive correlation between total AQ score and total EAT-26 score (r=0.26, p<0.001). In multivariate analysis, total AQ predicted two EAT-26 subscales: Bulimia and Food Preoccupation (beta=0.18, p<0.0001) and Oral control (beta=0.14, p<0.01). Empathy: No significant relationship between empathy and disordered eating.
Raynal	2016	Cross-sectional	France	479	University students. Age 18-25 years (mean age: 21), 80% females.	Yes. Cases: disordered eating group (N=101), defined by EAT-26 score > 20. Controls: healthy eating group (N=378), defined by EAT-26 score < 20.	AQ	EAT-26	No significant differences in AQ scores between the disordered eating group and the control group.
Innamorati	2015	Cross-sectional	Italy	322	Community sample. >18 years (mean 35.30). 58% females.	No	MZQ (mentalization)	YFAS, BES	There was two significant correlations: between food addiction on the YFAS and mentalization (r=0.37, p<0.01), and between binge eating on the BES and mentalization (r=0.42, p<0.01).
Manasse	2015	cross-sectional	USA	52	Community sample. 18-70 years (mean age: 50.0). Females only. BMI > 30	Yes. Cases: sub-treshold binge eating disorder group (N=9). Weekly binge eating in the last 3 months. Controls: no binge eating in last 3 months (N=43).	PCET (set-shifting)	EDE	No difference in set-shifting performances between binge eating group and controls
Carton	2014	cross-sectional	UK	80	University students. Age 18-25 years (mean age: 20.43). 50% females. No history of ASD or ED.	No	AQ and EFT (central coherence)	EAT-26	AQ: There was a significant positive correlation between total EAT-26 and total AQ scores, controlled for gender (r=0.307, p<0.05). Total EAT-26 scores was significantly associated with AQ Attention Switching (r=X, p<X). By multivariate analysis, Bulimia and Food Preoccupation predicted AQ total (beta=0.364, p<0.05), AQ Social Skill (beta=0.38, p< 0.05) and AQ Communication (beta=0.46, p<0.005). EAT-26 Oral Control predicted AQ Attention Switching (beta=0.027, p<0.05) and AQ Attention to Detail (beta=0.328, p<0.005). Central coherence: No significant correlation.
Kelly	2014	Cross-sectional	USA	116	University students. Age 18-25 years. Females only. BMI >18,5.	Yes. Cases: sub-treshold binge eating disorder group (N=50), with weekly binge episodes in last 28 days. Controls: No previous history of binge eating in last 28 days (N=66).	WCST (set-shifting)	EDE-Q	No significant difference in set-shifting performance between binge-eating group and controls. However, within the binge-eating group, there was a significant correlation between total number of binge episodes and difficulties with set-shifting.
Masuda	2014	Cross-sectional	Japan and USA	681	Two samples: 1) University students from USA (N=200), 16-57 years (mean age: 21.23 years), 79% females, 2). University students from Japan. 18-46 years (mean age: 20.35) 50 % females.	No	AAQ-II (psychological inflexibility)	EAT-26	High psychological inflexibility was a positive predictor of disordered eating in the US sample, but not in the Japanese sample
Moore	2014	Cross-sectional	USA	421	University students. Females only. (mean age: 21.21)	No	AAQ-II (psychological inflexibility)	EAT-26	No significant correlation between disordered eating and psychological inflexibility.
Griffiths	2013	cross-sectional	Australia	91	University students. Age 18-45 years (mean age: 20.3). Males only. No history of OCD, ED	No	WCST (set-shifting) and MIFFT (central Coherence)	EDE-Q (muscular-oriented version)	Set-shifting difficulties were significantly correlated to muscular-oriented disordered eating (r=0.24, p<0.05). The correlation persisted when applying multivariate analysis and controlling for BMI (beta=0.24, p<0.05). Central coherence: No significant association between MIFFT performance and muscular-oriented-disordered eating.
Bremser	2012	Cross-sectional	USA	160	University students. Age 18-30 (mean age: 19.4). 54% females.	No	RME (Theory of Mind) and EQ (empathy)	EAT-26	Theory of Mind: No significant differences on RME and disordered eating. Empathy: Significant positive correlation between disordered eating and scores on EQ (r= 0.272, p<0.001).
Costarelli2	2009	Cross-sectional	Greece	92	University students. Mean age: 23.08 years. Females only. No history of ED or mental illness. No obese subjects.	Yes. Cases: Disordered eating group (N=21), defined as EAT-26 score > 20. Controls: Healthy eating group (N=71), defined as EAT-26 score < 20.	BarOn EQ-S (empathy)	EAT-26	The disordered eating group had significantly lower levels of empathy than the control group (Mann-Whitney test: p<0.01)
Children/adolescent samples									
Naor-Ziv	2016	Cross-sectional	Israel	150	High school students. Age 14-18 years (mean age: 15.9). Females only.	Yes. Cases: "high risk" for ED group (N=62), defined as score >14 on EDI-2 subscale of Drive for Thinness (DT). Controls: low-risk for ED group (N=59), defined as score < 2 on EDI-2 subscale of DT. Medium risk for ED group (N= 29), defined as EDI-2 score of 2-14	WCST (set-shifting), MIFFT (central coherence), GEFT (central coherence), FP (Theory of Mind) and RME (Theory of Mind)	EDI-2	Set-shifting: High-risk-for-ED group performed significantly worse on the WCST than controls (F= 21.6, p<0.001). Central Coherence: Very weak significant impairment in high-risk group compared to controls (F(=5.42, p<0.05) No significant difference between performances on GEFT. ToM: On FP; significant difference between high-risk and low-risk groups. High-risk did worse in global score (F= 8.53, p<0.005), total error and recognition score. There was no significant difference between performances on the RME.
Cuzzocrea	2015	Cross-sectional	Italy	81	High-school students, < 18 years (mean age: 17.1). 42% females.	Yes. Cases: Moderate binge eating group (N=28), defined as score 18-26 on BES. Controls: Non-binge eating group (N=53), defined as score = 0 (zero) on BES.	IVE (empathy)	EDI-2, BES	No significant difference in levels of empathy between the binge eating group and the control group.
Coombs	2011	Cross-sectional	UK	132	High School students. Age 11-14 years (mean age: 13.44). 54% females. No history of mental illness	No	AQ	EAT-26	Significant positive correlation between total EAT-26 and total AQ scores, controlled for gender. EAT 26 significant positive relation to attention to detail and communication subscale of AQ (Other AQ subscales, unsignifint). All EAT-26 subscales were positively correlated to total AQ. Attention to detail sole predictor of bulimia and oral control. Predictors for dieting: female gender, strong social skills and attention to detail, poor communication
Costarelli	2011	Cross-sectional	Greece	202	High school students. Mean age: 16.68 years. 46% females.	Yes. Cases: disordered eating group (N=37), defined as EAT-26 score > 20. Controls: Healthy eating group (N=60) defined as EAT-26 score < 20.	IECA (empathy)	EAT-26	No significant correlation between EAT-26 score and empathy.
Hartmann	2010	Cross-sectional	Germany	120	Community sample. Children, Age 8-13 years (mean age: 10.71). 57% females.	Yes. Cases: Loss of Control over eating group (N=60), defined as >1 overeating episode per week within last 3 months. Controls: No LOC group (N=60).	A IRBE (empathy)	CEDE	No significant correlation between eating pathology and empathy

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Figure 1. Flowchart of literature search strategy.

Table 1. Search Terms.

Search terms for problematic eating, combined by 'OR'		Search terms for autistic traits, combined by 'OR'
Problematic Eating Behaviour		Autistic Traits
Problematic Eating		Social Cognition
Disordered Eating		Psychological Inflexibility
Disinhibited Eating		Set-shifting
Maladaptive Eating	**AND**	Central Coherence
Abnormal Eating		Theory of Mind
Restrictive Eating		Mentalization
Disturbed Eating		Empathy
Dysregulated Eating		Autistic Symptomatology
Emotional Eating		Autism Spectrum Quotient
External Eating		
Binge Eating		

Table 2. Quality assessment of the 16 cross-sectional studies on autistic-like impairments and problematic eating behavior

First author (year)	Selection			Comparability	Outcome			SUMMARY SCORE
	Representativeness of the sample. a) Truly representative of average in target population ★ b) somewhat representative ★ c) selected group of users d) no description of sampling strategy	**Sample size.** a) Justified and satisfactory ★ b) not justified	**Non-respondents.** a) respondent rate is satisfactory and non-respondents are compared to respondents ★ b) no comparability or unsatisfactory responce rate c) no response rate	**Control for confounders.** a) The study controls for the most important confounder (gender)★ or b) study controls for any additional confounder ★ c) not stated	**Assessment of problematic eating.** a) Validated screening tool ★★ b) non-validated screening tool, but tool is available or described ★ c) no desription of measurement tool	**Assessment of autistic traits.** a) validated measurement tool ★★ b) non-validated measurement tool, but tool is available/described ★ c) No description of measurement tool	**Statistical test. a)** statistical analysis is clearly described and appropriate and association is presented incl p-value ★ b) statistical analysis is inappropriate, not described or incomplete	
Adult Samples								
Mansour (2016)	b) ★	b)	c)	★★	★★	★★	★	7/10 (medium)
Raynal (2016)	b) ★	b)	c)	c)	★★	★★	★	6/10(medium)
Innamorati (2015)	a) ★	b)	c)	★★	★★	★★	★	8/10 (high)
Manasse (2015)	a) ★	b)	c)	b) ★	★★	★★	★	7/10 (medium)
Carton (2014)	b) ★	b)	c)	a)★	★★	★★	★	7/10 (medium)
Kelly (2014)	b) ★	b)	c)	b) ★	★★	★★	★	7/10 (medium)
Masuda (2014)	a) ★	b)	c)	★★	★★	★★	★	8/10 (high)
Moore (2014)	b) ★	b)	c)	b) ★	★★	★★	★	7/10 (medium)
Griffiths (2013)	b) ★	b)	c)	b) ★	★★	★★	★	7/10 (medium)
Bremser (2012)	b) ★	b)	c)	★★	★★	★★	★	8/10 (high)
Costarelli (2009)	b) ★	b)	c)	b) ★	★★	★★	★	7/10 (medium)
Children/Adolescent Samples								
Naor-Ziv (2016)	a) ★	b)	c)	b) ★	★★	★★	★	7/10 (medium)
Cuzzocrea (2015)	a) ★	b)	c)	b) ★	★★	★★	★	7/10 (medium)
Coombs (2011)	a) ★	b)	b)	a) ★	★★	★★	★	7/10 (medium)
Costarelli (2011)	a) ★	b)	b)	c)	★★	★★	★	6/10 (medium)
Hartmann (2010)	a) ★	b)	c)	b) ★	★★	★★	★	7/10 (medium)

Table 3. Study Characteristics and Key Findings

First Author	Publication year	Study Design	Country	Sample Size	Sample Characteristics	Sample divided into cases and controls?	Measure of Autistic-Like Inpairments	Measure of Eating Pathology	Key findings
Adult samples									
Mansour	2016	Cross-sectional	Australia	416	University students, Age 17-48 years (mean age: 19,76), 82% females.	No	AQ and EQ-S (Empathy)	EAT-26	AQ: There was a significant positive correlation between total AQ score and total EAT-26 score (r=0.26, p<0.001). In multivariate analysis, total AQ predicted two EAT-26 subscales: Bulimia and Food Preoccupation (beta=0.18, p<0.0001) and Oral control (beta=0.14, p<0.01). Empathy: No significant relationship between empathy and disordered eating.
Raynal	2016	Cross-sectional	France	479	University students. Age 18-25 years (mean age: 21), 80% females.	Yes. Cases: disordered eating group (N=101), defined by EAT-26 score > 20. Controls: healthy eating group (N=378), defined by EAT-26 score < 20.	AQ	EAT-26	No significant differences in AQ scores between the disordered eating group and the control group.
Innamorati	2015	Cross-sectional	Italy	322	Community sample. >18 years (mean 35.30). 58% females.	No	MZQ (mentalization)	YFAS, BES	There was two significant correlations: between food addiction on the YFAS and mentalization (r=0.37, p<0.01), and between binge eating on the BES and mentalization (r=0.42, p<0.01).
Manasse	2015	cross-sectional	USA	52	Community sample. 18-70 years (mean age: 50.0). Females only. BMI > 30	Yes. Cases: sub-treshold binge eating disorder group (N=9). Weekly binge eating in the last 3 months. Controls: no binge eating in last 3 months (N=43).	PCET (set-shifting)	EDE	No difference in set-shifting performances between binge eating group and controls
Carton	2014	cross-sectional	UK	80	University students. Age 18-25 years (mean age: 20.43). 50% females. No history of ASD or ED.	No	AQ and EFT (central coherence)	EAT-26	AQ: There was a significant positive correlation between total EAT-26 and total AQ scores, controlled for gender (r=0.307, p<0.05). Total EAT-26 scores was significantly associated with AQ Attention Switching (r=X, p<X). By multivariate analysis, Bulimia and Food Preopccupation predicted AQ total (beta=0.364, p<0.05), AQ Social Skill (beta=0.38, p< 0.05) and AQ Communication (beta=0.46, p<0.005). EAT-26 Oral Control predicted AQ Attention Switching (beta=0.027, p<0.05) and AQ Attention to Detail (beta=0.328, p<0.005). Central coherence: No significant correlation.
Kelly	2014	Cross-sectional	USA	116	University students. Age 18-25 years. Females only. BMI >18,5.	Yes. Cases: sub-treshold binge eating disorder group (N=50), with weekly binge episodes in last 28 days. Controls: No previous history of binge eating in last 28 days (N=66).	WCST (set-shifting)	EDE-Q	No significant difference in set-shifting performance between binge-eating group and controls. However, within the binge-eating group, there was a significant correlation between total number of binge episodes and difficulties with set-shifting.
Masuda	2014	Cross-sectional	Japan and USA	681	Two samples: 1) University students from USA (N=200), 16-57 years (mean age: 21.23 years). 79% females, 2). University students from Japan. 18-46 years (mean age: 20.35) 50 % females.	No	AAQ-II (psychological inflexibility)	EAT-26	High psychological inflexibility was a positive predictor of disordered eating in the US sample, but not in the Japanese sample
Moore	2014	Cross-sectional	USA	421	University students. Females only. (mean age: 21.21)	No	AAQ-II (psychological inflexibility)	EAT-26	No significant correlation between disordered eating and psychological inflexibility .
Griffiths	2013	cross-sectional	Australia	91	University students. Age 18-45 years (mean age: 20,3). Males only. No history of OCD, ED	No	WCST (set-shifting) and MFFT (central Coherence)	EDE-Q (muscular-oriented version)	Set-shifting difficulties were significantly correlated to muscular-oriented disordered eating (r=0.24, p<0.05). The correlation persisted when applying multivariate analysis and controlling for BMI (beta= 0.24, p<0.05).Central coherence: No significant association between MFFT performance and muscular-oriented-disordered eating.

Bremser	2012	Cross-sectional	USA	160	University Students. Age 18-30 (mean age: 19.4). 54% females.	No	RME (Theory of Mind) and EQ (empathy)	EAT-26	Theory of Mind: No significant differences on RME performance and disordered eating. Empathy: Significant positive correlation between disordered eating and scores on EQ (r= 0.272, p<0.001).
Costarelli2	2009	Cross-sectional	Greece	92	University students. Mean age: 23.08 years. Females only. No history of ED or mental illness. No obese subjects.	Yes. Cases: Disordered eating group (N=21), defined as EAT-26 score > 20. Controls: Healthy eating group (N=71), defined as EAT-26 score < 20.	BarOn EQ-S (empathy)	EAT-26	The disordered eating group had significantly lower levels of empathy than the control group (Mann-Whitney test: p<0.01)

Children/adolescent samples

Naor-Ziv	2016	Cross-sectional	Israel	150	High school students. Age 14-18 years (mean age: 15.9). Females only.	Yes. Cases: 'high risk' for ED group (N=62), defined as score >14 on EDI-2 subscale of Drive for Thinness (DT). Controls: low-risk for ED group (N=59), defined as score < 2 on EDI-2 subscale of DT. Medium risk for ED group (N= 29), defined as EDI-2 score of 2-14	WCST (set-shifting), MFFT (central coherence), GEFT (central coherence), FP (Theory of Mind) and RME (Theory of Mind)	EDI-2	Set-shifting: High-risk-for-ED group performed significantly worse on the WCST than controls (F= 21.6, p<0,001). Central Coherence: Very weak sigificant. impairment in high-risk-group compared to controls (F(=5.42, p<0.05).No significant difference between performances on GEFT. ToM: On FP; significant difference between high-risk and low-risk groups. High-risk did worse in global score (F= 8.53, p<0,005),total error and recognition score. There was no significant difference between performances on the RME.
Cuzzocrea	2015	Cross-sectional	Italy	81	High-school students, < 18 years (mean age: 17.1). 42% females.	Yes. Cases: Moderate binge eating group (N=28), defined as score 18-26 on BES. Controls: Non-binge eating group (N=53), defined as score = 0 (zero) on BES.	IVE (empathy)	EDI-2, BES	No significant difference in levels of empathy between the binge eating group and the control group.
Coombs	2011	Cross-sectional	UK	132	High School students. Age 11-14 years (mean age: 13.44). 54% females. No history of mental illness	No	AQ	EAT-26	Significant positive correlation between total EAT-26 and total AQ scores, controlled for gender. EAT 26 significant positive relation to attention to detail and communication subscale of AQ (Other AQ subscales, unsignificant). All EAT-26 subscales were positively correlated to total AQ. Attention to detail sole predictor of bulimia and oral control. Predictors for dieting: female gender, strong social skills and attention to detail, poor communication
Costarelli	2011	Cross-sectional	Greece	202	High school students. Mean age: 16,68 years. 46% females.	Yes. Cases: disordered eating group (N=37), defined as EAT-26 score > 20. Controls: Healthy eating group (N=60) defined as EAT-26 score < 20.	IECA (empathy)	EAT-26	No significant correlation between EAT-26 score and empathy.
Hartmann	2010	Cross-sectional	Germany	120	Community sample. Children, Age 8-13 years (mean age: 10.71). 57% females.	Yes. Cases: Loss of Control over eating group (N=60), defined as >1 overeating episode per weeek within last 3 months. Controls: No LOC group (N=60).	AIRBE (empathy)	CEDE	No significant correlation between eating pathology and empathy

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