Journal of Psychiatric Research xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Psychiatric Research

journal homepage: www.elsevier.com/locate/jpsychires

Review article

An updated transdiagnostic review of social cognition and eating disorder psychopathology

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ARTICLE INFO

Keywords:
Social cognition
Eating disorders
Anorexia nervosa
Bulimia nervosa
Binge eating disorder

ABSTRACT

Existing data suggest that deficits in social cognitive functioning are transdiagnostic phenomena that are observed across various forms of psychopathology. The goal of the present review was to provide an updated systematic review of the literature on social cognitive functioning across eating disorders (EDs), including anorexia nervosa (AN), bulimia nervosa (BN), and binge eating disorder (BED). Studies that assessed six areas of social cognition were included: theory of mind, social perception, social knowledge, attributional bias, emotion perception, and emotion processing. A systematic search identified 71 studies, the majority of which examined adult women with AN. Research typically focused on alexithymia, theory of mind, empathy, social processing, emotion recognition, or emotion processing. Results suggested some deficits in social cognition in EDs. AN had the most studies with some evidence for deficiencies in social cognition but a fair amount of variability. Research on BN and BED was limited and inconsistent, though there appear to be some deficits in social cognition. Together, the limited coverage across EDs and heterogeneous methodology preclude firm conclusions regarding general or ED-specific deficits, as well as understanding the role of social cognition in ED etiology and maintenance. Therefore, several key questions and future directions are outlined for research moving forward.

Eating disorders (EDs) are among the most serious psychiatric illnesses (Keski-Rahkonen et al., 2018), and despite continuing advances that have improved the understanding of the pathophysiology of EDs, treatment outcomes remain far less than optimal (Linardon et al., 2017; Zipfel et al., 2015). Such evidence indicates a critical need for ongoing study to identify and target underlying mechanisms that contribute to the onset and maintenance of EDs. One such factor that has been the focus of increasing research in EDs is social cognition, which is defined as "the mental operations underlying social interaction, including the detection of dispositions and intentions of others" (Brothers, 2002). The current paper aims to review previous research on social cognition across EDs to update the literature.

Previous research has outlined facets of social cognition including (1) theory of mind (i.e., the ability to infer other's complex emotional states); (2) social perception (i.e., ability to understand social roles, rules, and contexts); (3) social knowledge (i.e., knowledge of the rules and expectations in various social situations) (4) attributional bias (i.e., one's inferences about positive and negative events to internal, external, or situational factors);; (5) emotion perception (i.e., ability to identify and name various emotions; also known as alexithymia); and (6) emotion processing (i.e., ability differentiate between various emotions and manage emotional reactions; Caglar-Nazali et al., 2014; Savla et al., 2013). In line with this framework, dysfunction in social-cognitive domains has been broadly implicated as a marker of developmental, neurological, and psychiatric disorders, as evidenced by results of a recent review of social cognition across 30 clinical conditions (Cotter et al., 2018). For example, social-cognition deficits play a central role in autism spectrum disorders (Baron-Cohen et al., 1985) and is among the core cognitive deficits found in schizophrenia (Savla et al., 2013). Likewise, researchers have proposed maintenance models of depression and anxiety that include factors such as deficits in social cognition and biases involved in recognizing and remembering emotions in others

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https://doi.org/10.1016/j.jpsychires.2020.11.019
Received 16 April 2020; Received in revised form 22 September 2020; Accepted 5 November 2020
Available online 9 November 2020

(Gilboa-Schechtman et al., 2002). Consistently, difficulties in social cognition have been shown to be important factors that are also salient in EDs (Caglar-Nazali et al., 2014).

1. Social cognition in eating disorders

In EDs there has been a long history of empirical and theoretical work elucidating the importance of social, cognitive, and emotional factors that are relevant to social cognition. For instance, inherent to some EDs is the importance patients place on the visual representation of the self to others (Fairburn et al., 2008). Based on this premise, it can be deduced that there are likely social factors embedded in the motivation behind engaging in ED behaviors; for instance, without perceived judgments or attributions from others, body weight and shape may be experienced as less important to the individual. Moreover, misinterpretation of social cues may contribute to overvaluation of shape and weight and therefore spur symptoms in some EDs (Fairburn et al., 2008). Additionally, interpersonal components are posited to be etiological and maintenance factors in major theoretical models of EDs (Pennesi and Wade, 2016). For example, in both the enhanced cognitive behavioral and interpersonal models of EDs, interpersonal problems and negative mood states serve as key maintenance factors, acting as precipitating agents of symptoms (Fairburn, 2008; Wilfley et al., 2002). Likewise, in dialectical behavioral therapy for EDs, a major component of treatment focuses directly on interpersonal skills training, including helping patients learn to communicate effectively and to navigate relationships in a healthy way (Safer et al., 2009). In addition to these interpersonal factors, individuals with EDs also have marked emotion dysregulation, which has prompted several theories to posit that deficits in emotion detection and regulation may be a driver of eating pathology (Harrison et al., 2009; Haynos and Fruzzetti, 2011).

It is therefore unsurprising that there is evidence suggesting that individuals with EDs, particularly anorexia nervosa (AN), have impaired social cognition (Caglar-Nazali et al., 2014). Deficits in socio-emotional functioning have been theorized to be both risk and maintaining factors in AN (Treasure et al., 2012). Specifically, the cognitive-interpersonal maintenance model of AN suggests that obsessive compulsive and anxious traits increase vulnerability for AN in part by contributing to problematic ways of relating to others, which in turn leads others to react negatively to individuals with AN, thereby perpetuating interpersonal dysfunction and symptom maintenance (Treasure and Schmidt, 2013). In line with this framework, empirical research thus far suggests that those with AN have difficulties in recognizing emotions in others, expressing their own emotions in a way others can detect, and understanding mental states of others (i.e., theory of mind) as well as perceiving and understanding oneself (i.e., alexithymia and interoception; for reviews see Oldershaw et al., 2011; Treasure and Schmidt, 2013). In addition, a more recent review indicated that individuals with AN exhibit lower cognitive and affective empathy compared to healthy controls (Kerr-Gaffney et al., 2019). Collectively, the results of research to date indicate overarching deficits in social cognitive functioning among those with AN. Conversely, studies of social cognition in bulimia nervosa (BN) and binge-eating disorder (BED) have been studied to a lesser extent.

Given the evidence within and outside of EDs, it stands to reason that social cognition is highly relevant not only to the nature of restrictive EDs such as AN, but also to non-restrictive EDs that may be highly linked to emotion dysregulation, such as BN and BED (Leehr et al., 2015). A previous systematic review and meta-analysis elucidated social cognition as a potential etiological and maintenance factor across several EDs (Caglar-Nazali et al., 2014). However several limitations were noted in the review, including a lack of data on some subdomains (i.e., reception of non-facial communication, production of non-facial communication, animacy, and action perception); primary use of self-report measures to assess social cognition; and most research examined AN compared to BN and BED. Given this review was conducted seven years ago, it is likely that the updated literature may have addressed some of the limitations.

Therefore, the purpose of the current review was to conduct an updated systematic review of the literature on social cognition across EDs, including comparisons between ED diagnostic groups and controls and comparisons across various EDs. The present review organizes the research by diagnostic group and includes studies that assessed six areas of social cognition, consistent with definitions of social cognition (Caglar-Nazali et al., 2014; Savla et al., 2013): theory of mind; social perception; social knowledge; attributional bias; emotion perception; and emotion processing.

2. Method

2.1. Article identification

The following methodology was informed by PRISMA guidelines for systematic reviews (Moher et al., 2015). Inclusion criteria stipulated that at least one ED diagnostic group and a control group were compared on at least one measure of social cognition and were published in 2013 or later. Studies that included multiple ED diagnostic groups as a single ED group, non-empirical studies, correlational studies, and non-English studies were excluded. To identify relevant articles, "social cognition", "theory of mind", "social perception", "attributional style", "emotion perception", and "emotion processing" were searched with each of the words "eating disorder", "anorex*", "bulimi*", or "binge eating disorder" in PsycInfo and Pubmed. The asterisk (*) indicates that the search engine should generate articles with that includes at least that portion of the term (i.e., the word can have any ending). Several preprint servers were also searched, but no additional studies were identified. The study identification and selection process is summarized by Fig. 1. This process resulted in 71 papers that were included in the current review.

2.2. Data extraction

Data from the included articles were then extracted using a checklist. This information included the ED diagnoses included in the sample, identification and characteristics of control groups, mean age, gender composition (% female), body mass index (BMI), diagnostic methodology, specific measures used to examine social cognitive functioning in the study, the methodology used to examine the studies' key variables, and key findings relevant to social cognition in EDs. Data extraction was reviewed by at least two coders (E.L., T.M., A.D.) who resolved any differences in findings through discussion.

2.3. Data synthesis

Data was synthesized through comparisons between each ED diagnosis and controls and comparisons between ED diagnoses on relevant social cognition variables. Within each section, findings were organized by domains of social cognition with an available research base: alexithymia, theory of mind, empathy, social processing, emotion recognition, and emotion processing.

2.4. Quality ratings

Authors (T.M., E.L., S.W., K.S.) created a quality score for each study using the Newcastle-Ottawa Quality Assessment Scale for Case Control Studies. The scale was used to assess selection (i.e., case definition, representativeness of cases, and case selection and definition; four points), comparability (i.e., match on age and gender; two points), and exposure (i.e., ascertainment of the exposure, same method for cases and controls, and similar non-response rate; three points). The highest quality score possible was nine. Coding was standardized through training; authors discussed any unsure ratings.

Table 1
Summary of included studies.

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
Abbate-Daga et al. (2015)	61 AN	59 controls	22.96 AN; 24.50 control	100.0	AN: 15.64; control: 20.69	SCID-I, DSM-IV	Alexithymia	TAS-20	- AN had higher alexithymia compared to the control group.
Zegarra-Valdivia et al. (2018)	15 AN	15 controls	15.67 AN; 16.27 control	100.0	–	DSM-IV criteria	Theory of mind	RME test	- AN have worse scores on gaze recognition but not sex recognition.
Aloi et al. (2017)	16 sub-threshold BED with obesity, 22 BED with obesity	20 controls (non-BED with obesity)	Non-BED with obesity: 50.6; Subthreshold BED with obesity: 42.5; BED with obesity: 43.8	62.1	Non-BED: 38.2; sub-threshold BED: 37.5; BED: 36.9	Binge Eating Scale, DSM-5 criteria, Binge Eating Disorder-Clinical Interview	Theory of mind; alexithymia; empathy	RME test; TAS; Empathy Quotient	- There were no differences in theory of mind or empathy between groups. - Individuals with BED and obesity had higher alexithymia compared to controls.
Ambwani et al. (2016)	41 OSFED (AN subtype) and AN	36 controls	N.S. (Range: 18–65)	100.0	–	SCID for DSM-IV	Social processing	Video-rating task in which participants received critical feedback from work supervisors; videos varied in amount of agency and communication; Circumplex Scales of Interpersonal Efficacy; Interpersonal Grid; Hypothetical Behavioral Responses	- Participants with AN perceived less warmth than controls. - " Individuals with AN chose more "cold behavioral responses than controls. - An interaction showed that those with AN who endorsed high confidence in ability to be cold selected more cold responses than nonclinical controls with roughly equivalent confidence in their ability to be cold.
Bang et al. (2016)	22 AN-rec	21 controls	AN-rec: 27.32; controls: 26	100	AN-rec: 20.39; controls: 21.85	SCID for DSM-IV	Emotion processing	While in the scanner, participants completed a task where they had to categorize affective faces while ignoring affective words; DERS	- AN-rec and controls did not differ in brain response to emotional conflict. - AN-rec had greater DERS scores than controls.
Beadle et al. (2013)	26 AN (20 were tested again after weight restoration)	16 controls	AN: 24.4; controls: 24.8	100	AN: 15.7 (20.2 when restored); controls: 25		Alexithymia; empathy	TAS-20; Interpersonal Reactivity Index	-AN before and after weight restoration had greater alexithymia than controls; alexithymia decreased after weight restoration.

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									- AN reported greater emotional empathy than controls, which did not differ by weight restoration. - There were no differences in cognitive empathy.
Bentz et al. (2017)	43 first-episode AN; 28 AN-rec	41 controls	First-episode AN: 16.1; AN-rec: 18.4; controls; 17.7	100.0	First-episode AN: 16.6; AN-rec: 21.3; controls: 22.0	ICD-10; Recovery defined with EDE global score and Morgan Russell Outcome Assessment Schedule; BMI	Social processing; theory of mind; emotion processing	ADOS; Socialization Domain of Vineland-II; RME-R; MiniPONS; Animated Triangles; Awareness of Social Inference Test Part 2: Social Interference-Minimal, Danish version, CANTAB Affective Go/No-go	- First-episode AN and AN-rec groups showed deficits in social processing, independent of BMI, anxiety, and mood - Parents rated participants with first-episode AN lower than AN-rec individuals on social processing. - AN-rec exhibited difficulties in specific areas of social perception including perceiving nonverbal body gestures and vocal prosody compared to controls and first-episode AN. - There were no differences in theory of mind or emotion processing.
Brockmeyer et al. (2013)	25 AN	25 controls	AN: 24.64; controls: 23.88	100.0	AN:15.19; controls: 21.48	SCID for DSM-IV criteria	Emotion processing	Emotions Interview during which participants wrote down their memories about a sad autobiographical event in detail	- AN retrieved more negative emotions and a similar amount of positive emotions compared to controls.
Brockmeyer et al. (2016)	25 AN	25 controls	AN: 23.72; controls: 24.56	100.0	AN:15.30; controls: 21.82	SCID-IV	Theory of mind	Movie for the Assessment of Social Cognition	- Participants with AN performed worse than controls in decoding emotional mental states - Inference of non-emotional mental states not significantly different between groups
Brockmeyer et al. (2019)	27 AN	26 controls	AN: 22.67; controls: 24.23	100.0	AN: 15.29; controls: 21.78	DSM-IV diagnosis using SCID	Emotion processing	Watched film-clips to elicit fear, sadness, amusement, and neutral emotional states while having eyeblink startle response measured	- AN showed blunted startle response to fear but not sadness compared to controls.

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
Cardi et al. (2017)	35 AN	30 controls	AN: 26.7; controls: 27.5	100.0	AN: 14.3; controls: 21.3	Tailored version of SCID-I	Social processing	Sentence completion task where participants generate completions to ambiguous social scenarios and to rate their best completion	- AN endorsed more negative interpretations and less neutral and positive interpretations than controls.
Crucianelli et al. (2016)	25 AN	30 controls	AN: 24; controls: 26	100.0	AN: 14.38; controls: 21.03	SCID-IV	Emotion processing	Presentation of visual stimuli involving expression of emotion; stroking of left forearm with make-up brush; pleasantness ratings	- Pleasure ratings of affective touch were reduced in AN. - AN group rated slow touch as significantly less pleasant, while ratings of fast touch were not significantly different - Accepting faces increased pleasantness ratings of touch, regardless of group
Dalmaso et al. (2015)	23 AN	23 controls	AN: 26.48; controls: 25.39	91.3	AN:16.2; controls: 20.94	SCID -IV	Social processing	Computer task during which participants viewed stimuli that cued directions with an arrow, point, or gaze	- Those with AN had deficits in their ability to respond to rapid and reflexive cues such as an eye or arrow. - They performed similarly to controls in their response to pointing gesture cues.
Dapelo et al. (2015)	35 AN	42 controls	AN: 27.84; controls: 26.98	100.0	AN: 15.33; controls: 22.53	DSM-IV criteria with SCID-I	Alexithymia; emotion recognition	TAS-20, Facial emotion recognition task	- AN had greater alexithymia than controls. - AN were less accurate at identifying disgust than controls. - No difference between groups with respect to other emotions. - AN were more likely than controls to interpret non-angry faces as anger.
Dapelo et al. (2016)	20 AN 20 BN	20 controls	AN: 28.85 BN: 26.85 controls: 26.4	100.0	AN: 15.59 BN: 22.15 controls: 22.47	SCID-I DSM-5 EDE-Q	Emotion processing; alexithymia	TAS-20; Recordings of ace while participants viewed neutral and humorous clips	- AN had shorter duration and intensity of Duchenne smiles than BN and control groups; BN and controls did not differ.

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									- AN and BN had shorter duration of non-Duchenne smiles than controls; AN and BN did not differ in duration. - AN had shorter intensity of non-Duchenne smiles than BN and control groups; BN and controls did not differ. - AN and BN groups had higher alexithymia compared to controls; there were no differences between AN and BN.
Dapelo et al. (2016)a,b	36 AN; 25 BN	42 controls	AN: 27.5 BN: 26.32 controls: 26.98	100.0	AN: 15.34 BN: 21.74 controls: 22.53	Meet DSM-5 criteria and SCID-I.	Emotion recognition; emotion processing	Posed expression task where participants were given an emotion and asked to generate a facial expression for the given emotion. Imitated expression task where participants were asked to imitate facial expressions of emotions.	- There were no differences in posed expression recognizability. - Participants with AN and BN had more difficulty accurately posing and imitating facial expressions compared to controls; there were no differences between AN and BN.
Dapelo et al. (2017)	26 BN; 35 AN	42 controls	AN:27.54; BN: 26.42; controls: 26.98	100.0	AN: 15.33; BN: 21.74; controls: 22.53	SCID-IV and a frequency of binge eating and purging to adjust for DSM-5	Emotion recognition	Emotion recognition task using faces portraying blended emotions and a video task involving body motion	- Individuals with AN and BN showed a tendency to interpret non-angry faces as angry as well as deficits in recognizing disgust in less-ambiguous expressions compared to controls. - There were no differences between AN and BN. - There were no differences between the three groups on the body motion task.
Davidovic et al. (2018)	25 AN	25 controls	AN: 20.3; controls: 21.2	100	AN: 16.3; controls: 21.1	Meet DSM-IV criteria with SCID-1	Emotion processing	Neuroimaging while have their skin stroked (affective) or indented; pleasantness ratings	- AN perceived stroking as less pleasant.

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									-AN showed less activation in the caudate, bilateral frontal pole, bilateral precuneus, and right temporal pole compared to controls.
Dell'Osso et al. (2018)	47 AN-R; 24 AN-BP; 34 BN; 34 BED	160 controls	AN-R: 29.3; AN-BP: 27.8; BN: 32.1; BED; 40.5; Controls: 26.5	AN-R: 97.8%; AN-BP: 100%; BN: 97.1% BED; 82.4%	AN-R: 16.8; AN-BP: 16.6; BN: 22.9; BED; 38.6	SCID-5	Social processing; empathy	Adult Autism Subthreshold Spectrum	- All ED groups were poorer than controls on all domains. - No differences between ED groups.
Dinkler et al. (2019)	26 AN-rec	31 controls	AN-rec: 44.2; controls: 44.2	100	AN-rec: 23.5; controls: 24.8	MINI and SCID-IV	Emotion recognition	Facial emotion recognition task	-AN-rec did not differ from controls in emotion recognition accuracy and visual scanning behavior during.
Fonville et al. (2014)	31 AN	35 controls	AN: 23; control: 25	100	AN: 15.9; controls: 21.9	DSM-IV diagnosis	Emotion recognition	Neuroimaging while completing an implicit facial emotion processing task	- AN has slower reaction times compared to controls for all faces. - AN showed greater BOLD response in the fusiform gyrus to all facial expressions compared to contrls, which increased with the happiness of the expression.
Gramaglia et al. (2016)	39 AN	48 controls	AN: 30.59; controls: 33.19	–	AN: 16.3 controls: 21.82	DSM-IV criteria using SCID-I	Alexithymia; emotion recognition; empathy; social processing	Interpersonal Reactivity Index (IRI); TAS-20; Facial Emotion Identification Test; The Awareness of Social Inference Test (TASIT)	- AN had higher alexithymia than controls - No differences between AN and control group in total empathy, but AN had higher personal distress subscale scores. - AN was worse at identifying fear and better at identifying disgust than the controls. - No significant differences in social processing.
Hamatani et al. (2016)	18 AN	18 controls	AN: 35.4; controls: 32.8	100.0	AN: 14.78; controls: 20.92	DSM-5 criteria	Theory of mind; emotion recognition	SCSQ	- AN group had significantly lower scores in theory of mind, metacognition,

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									and total social cognition deficits. - There were no significant differences in hostility bias.
Harrison et al. (2016)	102 BED with overvaluation; 72 BED without overvaluation; 25 BED patients	40 controls with obesity; 40 controls with normal weight	BED with overvaluation: 44.71; BED without overvaluation: 41.25; BED patients: 43.46; controls with obesity: 48.63; controls with normal weight: 36.30	100.0	BED with overvaluation: 34.92; BED without overvaluation: 31.42; BED patients:37.55; controls with obesity: 39.27; controls with normal weight: 21.58	EDE-Q for low and high overvaluation groups; structured interview for BED patients	Emotion processing	DERS	- BED with overvaluation had higher scores than BED without overvaluation and both control groups; they had similar scores as the BED patients. - BED without overvaluation had significantly higher scores than controls with normal weight and higher, but not significantly, scores than controls without obesity.
Harrison et al. (2019)	25 AN; 25 AN-rec	25 controls	AN: 27.85; AN-rec: 26.00; controls: 27.00	100.0	AN: 16.72; AN-rec: 22.27; controls: 22.9	Eating Disorder Examination for AN and SCID-5 for AN-rec	Social processing	Eye tracking of static black and white images; eye tracking of moving stimuli in a video; eye tracking in a real life social interaction	- AN had reduced eye contact in the real life interaction vs the static photo than controls. - AN-rec had greater eye contact in the real life interaction vs the static photo than AN but lower than controls.
Hildebrandt et al. (2016)	32 AN	20 controls	AN: 16.68; controls: 17.91	100	AN: 17.75; controls: 21.54	DSM-IV criteria	Emotion recognition	Emotional go/no-go with happy, disgusted, and neutral stimuli	- AN responded to more non target faces with more error for disgust and happy faces.
Horndasch et al. (2018)	15 adolescent AN; 16 adult AN	18 adolescent controls; 16 adult controls	Adolescent AN: 16.41; adult AN: 26.71; adolescent controls: 15.95; adult controls: 26.88	100.0	AN: 16.68; controls: 17.91	Adolescent AN: 2.88 (BMI percentile); adult AN: 16.20; adolescent controls: 48.99 (BMI percentile); adult controls: 21.40	Emotion processing	Participants viewed negative, positive and neutral valenced pictures from the International Affective Picture Set	- There were no differences in subjective ratings of picture valence between AN and controls. - Adult AN showed both higher and lower activation in the cerebellum in response to all valanced picture compared to controls.

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									-Adult AN showed lower activation in the inferior frontal gyrus (IFG) and striatum when processing negative valenced stimuli than controls and lower in the IFG than controls with neutral pictures. - Adult AN showed higher activation in the precuneus when viewing positive images than controls. - Adolescent AN showed lower activation in the cerebellum in response to all valenced images compared to controls. -Adolescent AN showed lower activation in the ACC, the striatum, frontal and temporal areas for negative images compared to controls; results were similar for positive images but also AN showed lower activation in precuneus and hippocampus. -Adolescent AN showed more activation in the medial prefrontal gyrus than controls when viewing neutral and positive images. - Adolescent AN showed greater activation in the cerebellum for negative images than adult AN whereas adult AN showed greater activation in the cerebellum for neutral and positive images. - Adult AN had greater activation in the

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									superior parietal lobe, frontal lobe, and caudate compared to adolescents AN when viewing positive images.
Isobe et al. (2018)	24 AN	22 controls	AN: 35.8; controls: 34.59	100	AN: 14.3; controls: 21.8	DSM-IV using SCID	Social processing	Ultimatum Game, which is a behavioral task where a person has to split a sum of money between two players.	- AN offered more to money to the other person compared to HC controls - AN had a higher minimum acceptable amount of money to accept the offer compared to controls. -AN emphasized more fairness and less emphasis on monetary reward compared to controls.
Jappe (2015)	19 AN-R	19 controls	22.63	100	AN: 16.98; controls: 22.30	DSM-5 criteria using modified SCID-I	Emotion recognition; alexithymia	Emotional faces task in the scanner; TAS	-AN had lower activation in the pregenual anterior cingulate and ventral prefrontal cortex when viewing fearful versus happy faces. - AN has higher alexithymia compared to controls.
Jermakow and Brzezicka (2016)	11 AN	10 Asperger Syndrome; 33 female controls; 27 male controls	AN: 26.80; Asperger Syndrome: 28.30; female controls: 21.33; male controls: 27	AN: 100		ICD-10 criteria	Empathy; social processing; theory of Mind	Empathy Quotient; Autism Quotient; Interpersonal Reactivity Index; RME test	- AN had higher empathy (measured by Empathy Quotient) than male controls and Asperger Syndrome but did not differ from female controls. - AN had lower scores on the Personal Distress component of empathy than male and female controls. - AN had more communication difficulties than female controls but did not differ from male controls or Asperger's syndrome. - AN had higher Theory of Mind than Asperger Syndrome

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									but did not differ from controls.
Kerr-Gaffney et al. (2020)	51 AN, 51 AN-rec	51 controls	AN: 27.6; AN-rec: 26.3; controls: 24.4	AN: 92.2; AN-rec: 98.0; controls: 93.5	AN: 15.7; AN-rec: 21.2; controls: 21.7	SCID-5; AN-rec: BMI within 19–27 for past year	Empathy	MET; MiniPONS; ADOS-2	- Groups did not differ in cognitive empathy - AN group had lower positive affective empathy compared to controls but did not differ from AN-rec in empathy.
Kim et al. (2018)	31 BN	33 controls	BN: 23.9; controls: 22.5	100.0	BN: 20.79; controls: 20.85	DSM-5 criteria using SCID	Emotion processing	STAXI; DERS	- BN had higher anger expression and emotion regulation difficulties than controls; there were no differences in anger control.
Kolar et al. (2017)	20 AN	20 controls	AN:16.0; HC: 15.9	100.0	AN: 16.5 control: N.S.	DSM-5 criteria assessed with Eating Disorder Examination	Alexithymia	Ecological momentary assessment asking how well participants could name the emotion they are currently feeling	- AN reported higher alexithymia than controls.
Kucharska et al. (2016)	25 AN	25 controls	AN: 27.1; controls: 24.5	100.0	AN: 17.6; controls: 23.4	ICD-10 and the DSM-IV	Emotion recognition; theory of mind	FERT, Short RMTF, RME test	- There were no significant differences among groups on emotion recognition or theory of mind.
Laghi et al. (2015)	40 AN-R	40 controls	AN: 14.93; controls: 14.88	100.0	AN: 15.76; controls: 21.85	DSM-IV-TR criteria with KSADS-PL	Theory of mind	RME test	- There were no differences between AN and HC in RME total scores; similar abilities in both groups to decode negative, positive, and neutral emotions -AN showed lower performance in identifying "not believing" compared to controls. - AN was better able to discriminate affective emotions than controls.
Lang et al. (2015)	97 AN (61 adults, 36 adolescents)	96 controls	AN: 22.4; controls: 23.72	100.0	AN: 15.44; controls: 22.34	DSM-5 diagnosis using an adjusted ED module of the SCID	Emotion recognition from body movement	Point-light walkers task	- Individuals with AN performed more poorly on a task of recognizing sadness - Adolescents with AN performed worse overall on emotion recognition tasks
Lang et al. (2016)	66 AN	75 controls		100.0					

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
			AN: 20.06; controls: 19.85		AN: 15.43; controls: 21.21		Emotional processing	FACES measure while watching positive and negative film clips	- During the positive clip, AN experienced more emotional incongruence. - There were no differences in emotional expression during the negative clip.
Leppanen et al. (2017)	100 AN; 33 BN; 38 AN-rec	126 controls	–	–	AN: 15.00; BN: 20.00; AN-rec: 19.90; controls: 21.45	DSM-5 criteria with SCID	Emotion processing	Presented with two videos and filmed for facial reactions	- People with AN showed less positive facial expressions when showed a funny clip in relation to HC and AN-rec. - BN participants trended on showing more positive facial affect than the AN group and did not differ from controls or AN-rec. - No significant differences for the sad clip.
Leppanen et al. (2017a)	20 AN	20 controls	AN: 28.6; controls: 25.75	100.0	AN: 15.87; controls: 21.15	DSM-IV diagnosis with SCID	Emotional processing	Viewing happy, neutral, and fearful faces in the scanner	- AN responded more slowly to all trials and were less accurate at identifying fearful faces than controls. -AN showed less activation in the ventrolateral PFC and amygdala in the fearful vs. neutral contrast - AN showed greater activation in the right posterior insula in the happy vs. neutral contrast.
Leppanen et al. (2017b)	21 AN	26 controls	AN: 25; controls: 25.50	100	AN: 15.84; controls: 19.9	SCID for DSM-5	Emotional processing	Viewing positively-valenced, negatively-valenced, and neutral infant faces in the scanner	- There was no differences in accuracy in the task but AN responded slower than controls. AN had greater activation in the bilateral amygdala and the right dorsolateral PFC in the positive > neutral contrast while the HC showed reduced activation.

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									-AN had greater activation in the left posterior insula in the negative > neutral contrast. while the HC showed reduced activation.
Lule et al. (2014)	15 AN	15 controls	AN: 16.2; controls: 16.5	100.0	AN: 17.07; controls: 21.06	DSM-IV	Alexithymia; empathy; emotion recognition;	Saarbrucker Personlichkeitsfragebogen; TAS-26; Facially Expressed Emotion Labeling (FEEL) test;	- AN has higher alexithymia than controls. - AN recognized happiness better than controls. - AN trended on less ability to recognize disgust than controls. - All facial expressions were recognized faster by AN. - No differences in self-reported empathy.
Manuel and Wade (2013)	24 AN	24 controls	AN: 23.17; controls: 23.25	100.0	AN: 18.04; controls 22.84	Met diagnostic criteria according to clinical interview	Social attentional and anger threat biases; emotion processing	Computerized Stroop task with pictures of angry facial expressions and neutral facial expressions; DERS	- AN had lower bias for anger threat compared to controls; there were no differences with social attentional bias. - AN had higher emotion regulation difficulties than controls.
McAdams and Krawczyk (2014)	18 AN-rec	18 controls	AN-rec: 26.1; controls: 24.5	100	AN-rec: 19.8; controls: 23.2	SCID for DSM-IV	Social processing	Neuroimaging while completing social appraisal tasks using three different perspectives: Self, Friend and Reflected.	- AN-rec had lower ratings for social self and social reflected conditions than controls. -There were differences in activation for self-knowledge and perspective-taking in the precuneus, dorsal anterior cingulate, and the left middle frontal gyrus.
McAdams et al. (2015)	23 recent history AN, 19 AN-rec	21 controls	AN: 26.3; AN-rec: 29.6; controls: 27	100.0	AN: 18.00; AN-rec: 22.8; controls: 22.8	SCID for DSM-IV	Social processing	Neuroimaging task involving the Trust Game, a task involving exchange based on investing money with another person managing a stock market; IPSAQ	- Controls showing significantly higher rates of reciprocity as compared to the other groups - The AN-rec group showed reduced responsivity to

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Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									malevolence in the trust game as compared to the control group. -AN and AN-rec had lower activation in the benevolence task in the precuneus and right angular gyrus compared to controls. - AN had less activation in the malevolence condition in the left fusiform compared to controls; AN-rec did no differ from controls.
Morris et al. (2014)	28 AN; 25 AN-rec	54 controls	AN: 26.3; AN-rec: 29.5; controls: 29.4	100.0	AN: 15.5; AN-rec: 20.1; controls: 23.1	DSM-IV using SCID	Emotion recognition; Empathy; social processing	Socio-Emotional Questionnaire (SEQ)	- AN reported lower levels of empathy than AN-rec and controls. - There were no differences in emotion recognition or social processing.
Nalbant et al. (2019)	32 AN	32 controls	AN: 15.2; controls: 15.2	100.0	AN: 16.6	DSM-5 criteria	Emotion processing; alexithymia; theory of mind; empathy	DERS; RME Test; TAS-20; Child and Adolescent KA-SI Empathetic Tendency Scale	- No significant difference between AN and controls in theory of mind. - AN had higher alexithymia, higher emotion regulation difficulties, and lower empathy compared to controls.
Nandrino et al. (2017)	23 AN-R	23 controls	AN-R: 19.64; controls: 20.65	100.0	AN-R: 15.2; controls: 21.05	DSM-5 criteria; at least 6 months of illness, with BMI between 13 and 18	Empathy; social processing	Basic Empathy Scale; video with a stop-distance paradigm involving assessing periopersonal action-space and interpersonal social-space – the task involved stopping an approaching stimulus at a distance appropriate for them or another person to interact with it.	- When an object was approaching, the groups did not differ in their choice of interpersonal space, but they AN-R increased their distance when the stimulus was a male or female individual - When deciding from a third-person perspective, both individual-object and individual-individual spaces were significantly larger for those with

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Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									AN-R compared to controls. - There were no significant differences in empathy.
Phillipou et al. (2015)	26 AN	27 controls	AN: 22.81; controls: 22.46	100.0	AN: 16.63; controls: 22.60	The Mini International Neuropsychiatric Interview with exception of amenorrhea criterion to match the DSM-5	Emotion processing	The Mayer-Salovey-Caruso Emotional Intelligence Test: Managing Emotions	- No significant difference found on emotion processing.
Pollack (2018)	31 AN (adolescents)	Normative samples for tasks	14.41	100.0	20.42	Diagnosis of AN, confirmed with electronic medical record	Emotion recognition	Diagnostic Analysis of Nonverbal Accuracy 2	- Adolescents with AN performed significantly worse compared to a norm group on a task of emotion identification from posture
Redondo and Herrero-Fernández (2018)	38 AN	433 controls	AN: 21.9; controls: 20.0	AN: 100.0; controls: 80.8	N.S.	DSM-IV criteria	Theory of mind	RME test	- Women with AN scored lower on RMET than control women but did not differ from healthy men
Renwick et al. (2013)	77 AN (51 AN-R and 26 AN-BP); 57 BN	50 controls	AN: 26.4; BN: 27.6; controls: 24.1	100.0	AN: 16.5; BN: 25.2; controls: 23	DSM-IV criteria	Social processing	Interpersonal Perception Task (consists of 15 video clips with complex social situations; participants assess the relationships of characters in the videos)	- There were no differences between groups on total scores as well as on subscale scores on the Interpersonal Perception Task - One finding for the intimacy subscale approached significance, with a post-hoc test indicating that AN-R participants performed more poorly than healthy controls on a task involving detecting levels of intimacy between others.
Rhind et al. (2014)	16 AN-R	17 controls	AN: 14.75; controls: 14.41	100	AN: 17.03; controls: 19.97	DSM-IV criteria	Emotion processing	Facial affect measured using Facial Expression Coding System. Participants were shown emotional film clips and had their faces recorded.	- AN showed less positive facial affect during positive and negative film clips compared to controls, and AN showed less negative facial affect

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									during negative clips compared to controls.
Robinson et al. (2015)	43 BED	23 controls	BED: 46.95 controls: 41.3	79.5	BED: 32.82 controls: 23.8	DSM-5 criteria using Eating Disorder Examination	Emotion processing	Emotion Regulation Questionnaire (ERQ); Difficulties in Emotion Regulation Scale (DERS); Emotion Conflict Task (ECT)	- BED had greater DERS scores than control but there were no differences on the ERQ or ECT.
Rommel et al. (2013)	25 AN-R; 19 AN-purging	37 controls	AN-R: 20; AN-purging: 21; controls: 20	100.0	AN-R:15; AN-purging: 18; controls: 20	DSM-IV criteria	Alexithymia; emotion processing	Level of Emotional Awareness Scale; TAS-20	- AN groups did not differ from controls in awareness of their own emotions. - AN-R only differed from controls in awareness of others' emotions. - AN groups had higher alexithymia than controls.
Rothschild-Yakar et al. (2019)	41 AN; 20 depression	53 controls	AN: 17.58; Depression: 15.85; controls: 17.63	100.0	N.S	DSM-5 criteria with SCID-I	Alexithymia; theory of mind; mentalizing; emotion processing	RME test; TAS-20; Reflexive Function scale; Differentiation of Self Inventory	- Lower mentalizing, lower emotion processing, and higher alexithymia in the AN and depression groups compared to controls. - There were no differences in theory of mind between groups.
Sacchetti et al. (2019)	53 BN	87 controls	BN: 30.6; controls: 29.14	BN: 94.3; controls: 87.4	BN: 23.55; controls: 21.63	DSM-5 criteria with EDE-Q	Theory of mind; mentalizing	Reflective Function Questionnaire (RFQ); RME test	- BN had lower mentalizing and theory of mind compared to controls.
Sedgewick et al. (2019)	20 AN	20 controls	AN: 19.41; AN with features of autism: 18.62; controls: 19.16	100	AN: 18.04; AN with features of autism: 18.59; controls: 21.54	DSM-5 criteria	Theory of mind	Frith-Happe Triangle Animations	- There were no differences.
Seidel et al. (2018)	36 AN	36 controls	AN: 16.63; controls: 16.90	100.0	AN: 14.65; controls: 20.72	DSM-5 criteria	Emotion processing	Emotion Regulation Questionnaire; An emotion regulation paradigm was used in the scanner; participants either passively viewed negative, positive and neutral images or actively downregulate any emotions arising in response to the negative and positive images.	- AN reported less use of reappraisal than controls but similar levels of suppression. - There were no group differences in arousal rating between AN and controls. - AN had increased activity in the right amygdala and right and left dorsolateral prefrontal cortex in response to passively viewing negative pictures as compared to

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Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									passively viewing neutral ones compared to controls. - AN had a decrease in activity in the left amygdala during distancing as compared to watching than controls; AN had increased activity in the right dorsolateral prefrontal cortex while distancing compared to watching than controls. - There were no differences during explicit emotion regulation.
Sfarlea et al. (2018)	26 AN	37 controls; 26 major depression	AN: 15.2; major depression: 14.8; controls: 15.2	100.0	AN: 15.4; major depression: 21.3; control: 20.1	ICD-10 criteria with Kinder-DIPS	Emotion recognition	Emotion discrimination task (indicate which emotion a face expressed), and two control tasks	- Adolescents with AN were more accurate at identifying afraid expressions than controls and more accurate at recognizing happy, sad, and afraid than the major depression group
Sfarlea et al. (2016)	20 AN	24 controls	AN: 15.7; controls: 15.2	100.0	AN: 15.3; controls: 20.1	ICD-10 criteria with Kinder-DIPS	Emotion recognition	ERPs and behavior were measured during a passive viewing task and three tasks of processing of emotional faces.	- AN did not differ from controls in performance on the emotion recognition task. - AN had a less pronounced early posterior negativity in response to all facial expressions compared to controls.
Sweitzer et al. (2018)	20 AN-rec	24 controls	AN: 22.50; controls: 24.50	100	AN:20.95; controls: 22.48	Prior DSM-5 diagnosis	Emotion processing	Neuroimaging while viewing smiling faces	- There were no differences in brain activity when viewing smiling faces.
Tamiya et al. (2018)	22 AN-R, 18 AN-BP	69 controls	AN-R: 27.59; AN-BP: 30.61; controls: 34.36	100.0	AN-R: 14.27; AN-BP: 16.79	Clinical interview	Emotion processing	Mayer-Salovey-caruso Emotional Intelligence Test's Managing Emotions component	- The AN-R and AN-BP groups exhibited significantly worse emotion processing compared to controls.
Tapajoz P. de Sampaio et al. (2015)	29 AN; 28 BN	28 controls		100.0	AN: 18.1; BN: 24.4; controls: 21.6	DSM-IV criteria	Social processing		- Individuals with AN reported higher

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Table 1 (*continued*)

Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
			AN: 25.2; BN: 24.7; controls: 25.8					Self-Assessment Manikin and 30 images from the International Affective Picture System	arousal and lower control for only social images with neutral valence - Individuals with BN reported higher arousal and lower control when viewing images with pleasant, unpleasant, and neutral valence of social content
Tapajoz et al. (2013)	22 AN, 19 BN	24 controls	AN: 24.3; BN: 25.3; controls: 25.2	100.0	AN: 18.1; BN: 25.2; controls: 21.5	DSM-IV criteria	Theory of mind	RME test; Faux Pas Test	- Individuals with AN performed worse than BN and controls on the affective theory of mind task, particularly in identifying emotion in male eyes - Individuals with BN did not perform significantly differently from controls
Tapajoz P. de Sampaio et al. (2013)	24 AN, 24 BN	24 controls	AN: 24.5; BN: 24.4; controls: 25.2	100.0	AN: 18.1; BN: 25.0; controls: 21.5	DSM-IV criteria	Theory of mind	RME test; Faux Pas Test	- AN performed worse on RME and Faux Pas tasks compared to controls and worse on RME compared to BN. - There were not differences between BN and controls.
Tarrega et al. (2014)	22 BN; 22 BN-rec	19 controls	BN: 28.9; BN-rec: 27.2; controls: 29.4	100	BN: 23.7; BN-rec: 24.9	DSM-IV criteria by SCID-I	Emotion processing	Facial recognition software recorded facial expression while playing a video game; State-Trait Anger Expression Inventory 2	- BN expressed more joy while playing the game than BN-rec and controls; there were no differences between BN-rec and controls. - BN expressed less anger while playing the game than BN-rec and controls; BN-rec expressed less anger than controls. - BN reported more Expression-In (i.e., experiencing anger but not expressing out) than controls; there were no

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Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									differences for Expression-Out.
Torres et al. (2015)	52 AN-R; 28-AN-BP	80 controls	AN: 19.21; controls: 19.20	100.0	AN: 15.27; controls: 21.08	DSM-IV criteria using the Interview for the Diagnosis of Eating Disorders-IV	Alexithymia	TAS-20;	- Both AN groups had higher alexithymia scores than controls - There were no differences in alexithymia between AN subtypes.
Turan et al. (2019)	32 BED and obesity	32 non-BED with obesity; 64 controls	BED: 15.00; Obesity, non-BED: 14.81; controls: 15.43	BED: 57.6%; Obesity, non-BED: 54.4%; controls: 51.56%	BED: 34.58; Obesity, non-BED: 32.72; controls: 20.00	DSM-5 diagnosis using K-SADS-PL	Theory of Mind; emotion recognition; empathy; emotional awareness	RME test; Faux Paus Test; Unexpected Outcomes Test; Faces test; DERS-emotional Awareness	- The control group had better theory of mind, emotion recognition, and empathy; there were no differences between BED and non-BED, obesity groups. - BED had poorer emotional awareness than the other two groups.
Via et al. (2015)	20 AN-R	20 controls	AN: 28.4; controls: 28.15	100.0	AN: 16.94; controls: 20.99	SCID-IV	Social processing	A social judgment task was used; participants were presented with people's faces with neutral expressions and asked if they would like to meet them or not; during the fMRI they were shown the faces again but given feedback on whether the other person wanted to meet them or not as well.	- There were no differences in performance on the task or perception of rejection or acceptance. - AN had lower activation of the dorsomedial prefrontal cortex during social acceptance compared to controls. - AN had higher activation of the left secondary visual cortex during social rejection compared to controls.
Wyssen et al. (2019)	61 AN; 58 BN	130 controls; 59 mixed mental disorders	AN: 22.87; BN: 23.16; controls: 21.53; mixed mental disorders: 25.29	100.0	AN: 17.05; BN: 22.64; controls: 22.01; mixed mental disorders: 24.32	DSM-IV criteria with the Diagnostisches Interview für psychische Störungen	Emotion recognition; emotion processing	QUEST threshold seeking algorithm - shown facial expressions and asked to indicate the corresponding emotion; DERS	- Mixed mental disorders and BN groups needed higher signal strength to identify disgust compared to controls and AN; there were no differences between AN and controls. - Response bias to emotion expression did not differ between any groups.

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Article	ED Diagnoses included	Control group	Mean age (years)	Gender composition (% female)	Mean BMI (kg/m^2)	Diagnostic Methodology	Specific Variables Examined	Measures/Methodology of key variables	Key Findings
									- Mixed, AN, and BN groups had more emotion regulation difficulties than controls; there were no differences between mixed, AN, and BN.
Xu et al. (2017)	24 AN-rec (adolescents)	18 controls	AN-rec: 16.4; controls: 16.1	100.0	AN-rec: 19.5; controls: 21.2	Either the SCID for DSM-IV or the Kiddie Schedule for Affective and Mood Disorders	Social processing	fMRI task involving the Social Identity-V2 task	- The AN-rec group showed significantly slower reaction time in the social tasks than controls. - There were no differences in neural activation between AN-rec and controls.

Note. ED = eating disorder; AN = anorexia nervosa; AN-R = AN restricting subtype; AN-BP = AN binge/purge subtype; AN-rec = AN recovered; BN = bulimia nervosa; BED = binge eating disorder; EDNOS = Eating disorder not otherwise specified; OSFED=Other specified feeding or eating disorder; BMI = body mass index; DSM = Diagnostic and Statistical Manual for Mental Disorders; SCID=Structured Clinical Interview for DSM Disorders; SCID-IV=SCID for DSM-IV; RME test = Reading the Mind in the Eye test; TAS-20 = Toronto Alexithymia Scale; EDE = Eating Disorder Examination; CANTAB= Cambridge Neuropsychological Test Automated Battery; ADOS = Autism Diagnostic Observation Schedule; AQ = Autism-spectrum quotient; OSS= Oslo Social Support Scale; SF-36 = Short Form Health Survey-36; SCSQ= Social Cognition Screening Questionnaire; RMF test = Reading the Mind in the Films test; ICD-10 = International Classification of Diseases-10; FERT = facial expression recognition test; RMTF = recognition memory test for faces; IPSAQ= Internal, Personal, and Situational Attribution Questionnaire; fMRI = functional magnetic resonance imagin; MET = Multifaceted Empathy Test; MiniPONS = Mini Profile of Noverbal Sensitivity.

3. Results

3.1. Study characteristics

Table 1 provides information on the studies' samples, method, and results. Mean sample size across studies were AN: 32.12 ± 18.66; AN-recovered: 26.91 ± 9.67; BN: 34.00 ± 14.07; and BED: 53.50 ± 27.88. The vast majority of the studies included only female participants, particularly studies examining AN and BN. There were 13 studies on alexithymia, 16 on theory of mind, 10 on empathy, 17 on social processing, 18 on emotion recognition, and 27 on emotion processing. The mean quality score rating was 6.76 ($SD = 1.35$; Range: 4–9), indicating medium-to-high methodological quality of articles (see Supplementary Table 1 for quality ratings).

3.2. An

There were 65 studies that compared AN or recovered AN to controls across a range of social cognition variables.

3.2.1. Alexithymia

All 12 studies that compared alexithymia between AN and controls found higher alexithymia in AN with no evidence for differences by subtype (Torres et al., 2015). While almost all studies used a single questionnaire measure, Kolar et al. (2017) used ecological momentary assessment reports of momentary alexithymia, which showed higher alexithymia in AN compared to controls. Further, Beadle et al. (2013) found those with AN showed elevated alexithymia (compared to controls) both before and after weight restoration, though alexithymia significantly decreased after weight restoration in AN.

3.2.2. Theory of mind

There were 13 studies comparing theory of mind between AN and controls, with mixed results across studies; the Reading the Mind in the Eyes test was most often used to assess theory of mind. Six studies found evidence for theory of mind deficits in AN compared to controls, while seven found no differences. Adrian Zegarra-Valdivia et al. (2018) reported worse scores on gaze recognition in AN, and Brockmeyer et al. (2016) reported deficits in AN in emotional, but not cognitive aspects of theory of mind. Consistently, in a separate study, individuals with AN exhibited theory of mind deficits, particularly with regard to negative emotion and identifying emotion in male eyes (Tapajoz et al., 2013). Also, individuals with AN showed higher theory of mind compared to an Asperger's Syndrome comparison group, but no differences compared to controls (Jermakow and Brzezicka, 2016).

3.2.3. Empathy

There were nine studies that examined empathy in AN, primarily with self-report questionnaires; results were highly variable with regard to differences in empathy between AN and controls. Three studies found lower empathy scores in AN compared to controls (Dell'Osso et al., 2018; Morris et al., 2014; Nalbant et al., 2019) while two studies found no differences (Lule et al., 2014; Nandrino et al., 2017). In addition, Kerr-Gaffney et al. (2020) found lower positive affective empathy in AN, but no differences in cognitive empathy or other aspects of affective empathy. Alternatively, Beadle et al. (2013) reported higher emotional empathy in AN. Further, one study found higher personal distress empathy in AN (i.e., experiencing distress and discomfort in response to extreme distress in others scores; Gramaglia et al., 2016), while a separate study found lower personal distress empathy in AN (Jermakow and Brzezicka, 2016).

Some research suggests lower empathy in current AN compared to recovered AN (Morris et al., 2014). However, other studies have found no differences in empathy between current AN and individuals recovered from AN or who have been weight restored (Beadle et al., 2013; Kerr-Gaffney et al., 2020). Furthermore, one study found that

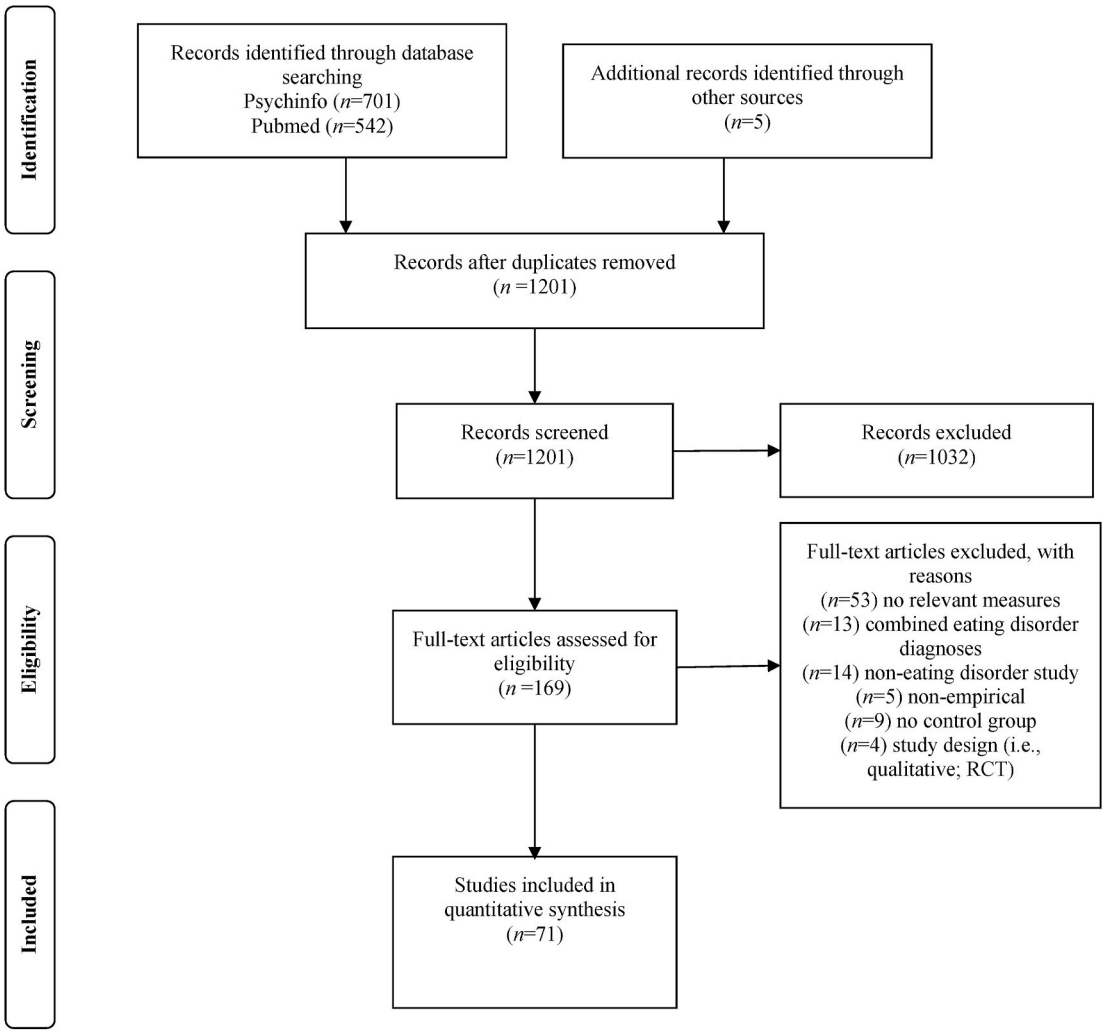

Fig. 1. PRISMA diagram of study selection process.

individuals with AN had higher empathy than male controls and individuals with Asperger's Syndrome, but did not differ from female controls (Jermakow and Brzezicka, 2016).

3.2.4. Social processing

Eighteen studies examined differences in social processing between AN and controls; of which, most employed tasks to assess social processing. Findings consistently showed deficits in social processing in AN. Eleven studies found some evidence for deficits in social processing in AN compared to controls, assessed with a variety of measures. Two studies also compared individuals recovered from AN and controls, and found some evidence for social processing deficits. However, five studies found no differences between AN and controls. One study only found elevated communication difficulties in women with AN compared to female controls with AN, but no differences between AN and male controls or individuals with Asperger's syndrome (Jermakow and Brzezicka, 2016).

Four studies compared brain activation differences between AN and controls during social processing tasks. McAdams et al. (2015) reported that individuals with AN and recovered from AN had lower neural activation in a benevolence task in the precuneus and right angular gyrus compared to controls; individuals with AN also had lower neural activation during a malevolence task in the left fusiform compared to controls. Via et al. (2015) found that individuals with AN had lower activation of the dorsomedial prefrontal cortex during social acceptance and higher activation of the left secondary visual cortex during social rejection compared to controls. Further, McAdams & Krawczyk (2014) found differences in activation in the precuneus, dorsal anterior cingulate, and the left middle frontal gyrus between individuals recovered from AN and controls during self-reflection and perspective-taking tasks. Xu et al. (2017) also found no differences in brain activation during social identity tasks in individuals recovered from AN and controls.

3.2.5. Emotion recognition

Twenty-one studies examined differences in emotion recognition between AN and controls. Thirteen studies showed deficits in emotion recognition in AN compared to controls using an array of task-based measures, with results suggesting some deficits in recognizing disgust, fear, sadness, anger, and happiness. While these findings were variable across studies, individuals with AN most consistently showed deficits in recognizing disgust. Further, emotional expression was shown to be altered in AN when viewing positive affective stimuli. A minority of studies showed better emotion recognition by AN, and one study also showed better emotion recognition in adolescents with AN compared to adolescents with major depression (Starfea et al., 2018).

Four studies compared brain activation differences between AN and controls during emotion recognition tasks. One study showed individuals with AN had lower activation in the pregenual anterior cingulate and ventral prefrontal cortex when viewing fearful versus happy faces (Jappe, 2015). When viewing faces in the scanner, a second study found that individuals with AN showed less activation in the ventrolateral prefrontal cortex and amygdala in the fearful vs. neutral

contrast and greater activation in the right posterior insula in the happy vs. neutral contrast (Leppanen et al., 2017a). Next, Leppanen et al. (2017b) reported that individuals with AN had greater activation in the bilateral amygdala and the right dorsolateral prefrontal cortex in the positive vs. neutral contrast, and greater activation in the left posterior insula in the negative vs. neutral contrast. Finally, individuals with AN showed greater activation in the fusiform gyrus in response to all facial expressions, which increased with the happiness of the expression (Fonville et al., 2014).

3.2.6. Emotion processing

Fifteen studies examined differences in emotion processing using tasks between AN and controls, with eleven studies finding evidence for alterations in emotion processing in AN compared to controls. This includes alterations in retrieval of emotions, startle response, pleasure ratings to affective touch, and emotional expression. Six studies examined differences in emotion processing with self-report instruments, with all studies finding evidence of poorer emotion processing in AN compared to controls.

Four studies used fMRI to measure differences in emotion processing. Davidovic et al. (2018) found that individuals with AN showed less activation in the caudate, bilateral frontal pole, bilateral precuneus, and right temporal pole when experiencing affective touch compared to controls. Seidel and colleagues (2018) found that individuals with AN had increased activity in the right amygdala and right and left dorsolateral prefrontal cortex in response to passively viewing negative pictures as compared to passively viewing neutral pictures compared to controls. Also, individuals with AN showed decreased activity in the left amygdala and increased activity in the right dorsolateral prefrontal cortex during distancing as compared to watching than controls. In another study, Horndasch and colleagues (2018) found that adolescents with AN showed reduced processing in several brain regions compared to controls; however, while differences in activation were found in adults with AN compared to controls, findings were less clear. Finally, Sweitzer and colleagues (2018) reported no differences in brain activity when viewing smiling faces.

3.3. BN

There were 13 articles identified that compared social cognition in individuals with BN and controls, with self-report and task measures being used. Only one study examined alexithymia and found higher self-reported alexithymia in BN compared to controls (Dapelo et al., 2016a, b). Of the three studies that investigated theory of mind, one found lower theory of mind in BN (Sachetti et al., 2019), and two found no differences (Tapajoz et al., 2013; Tapajoz P. de Sampaio et al., 2013). Only one study examined empathy, with results showing less empathy in BN compared to controls (Dell'Osso et al., 2018). Three studies assessed social processing in BN: one study found no differences on an interpersonal perception task (Renwick et al., 2013); one study found lower self-reported verbal and nonverbal communication skills in BN (Dell'Osso et al., 2018); and one study found higher arousal and lower control when viewing images with pleasant, unpleasant, and neutral valence of social content among those with BN (Tapajoz P. de Sampaio et al., 2015). Three studies examined emotion recognition and BN, with two finding some differences and one finding null results (Dapelo et al., 2016a,b). In one study, individuals with BN showed a tendency to interpret non-angry faces as angry as well as deficits in recognizing disgust in less-ambiguous expressions, but no differences on a body motion task (Dapelo et al., 2017). In the other study, individuals with BN required more information to identify disgust compared to controls (Wyssen et al., 2019).

Four studies investigated differences in emotion processing between BN and controls using task-based measures. Three found evidence for differences while one found no differences. Dapelo, Boadas, et al. (2016) a found that individuals with BN had more difficulty accurately posing and imitating facial expressions compared to controls. Also, Dapelo, Hart, and colleagues (2016)b found that those with BN had shorter duration of non-Duchenne smiles than controls, but they did differ on duration or intensity of Duchenne smile or intensity of non-Duchenne smile. Finally, Tarrega and colleagues (2014) reported that individuals with BN expressed more joy and less anger than individuals recovered from BN and controls; there were no differences between individuals recovered from BN and controls on joy, but individuals recovered from BN expressed less anger than controls. Three studies investigated differences in emotion processing between BN and controls using self-report measures. All studies showed evidence for emotion processing deficits in BN including emotion regulation difficulties (Kim et al., 2018; Tarrega et al., 2014; Wyssen et al., 2019).

3.4. BED

Only five studies were identified that studied social cognition in BED. One study found greater self-reported alexithymia in individuals with BED and obesity compared to controls with only obesity (Aloi et al., 2017). Of two studies that examined theory of mind, one evidenced lower theory of mind in BED compared to controls (Turan et al., 2019), while the other found no differences (Aloi et al., 2017). Two studies found evidence for lower empathy in BED versus controls (Dell'Osso et al., 2018; Turan et al., 2019), while a third study found no differences (Aloi et al., 2017). Only one study examined social processing in BED, with results showing lower self-reported verbal and nonverbal communication skills in BED compared to controls (Dell'Osso et al., 2018). Also, only one study examined emotion recognition in BED and found lower emotion recognition compared to controls (Turan et al., 2019). All three studies that examined emotion processing found greater emotion regulation difficulties, assessed with self-report, in BED compared to controls. However, Robinson and colleagues (2015) found no differences when using a task-based measure. Further, Harrison and colleagues (2016) showed that individuals with BED who endorsed overvaluation of shape and weight had more self-reported emotion regulation deficits compared to those with BED without overvaluation of shape and weight.

3.5. ED comparisons

Nine studies compared one or more ED diagnostic groups on social cognition. No differences were found in alexithymia between AN and BN (Dapelo et al., 2015) or empathy between AN, BN, and BED (Dell'Osso et al., 2018). There were no differences between AN, BN, and BED on social processing (Dell'Osso et al., 2018) or in a separate comparison of AN and BN (Renwick et al., 2013). Two studies found deficits in theory of mind in AN compared to BN (Tapajoz et al., 2013; Tapajoz P. de Sampaio et al., 2013). Also, two studies reported no differences in emotion recognition between AN and BN (Dapelo et al., 2016a,b; Dapelo et al., 2017), while a third study showed that individuals with BN required more information to identify disgust compared to AN (Wyssen et al., 2019). Using task-based measures of emotion processing, two studies found some differences between AN and BN, while a third reported no differences. Dapelo and colleagues (2015) showed that individuals with AN had shorter intensity and duration on Duchenne smile and shorter intensity of non-Duchenne smiles than BN. Similarly, Leppanen and colleagues (2017) reported that individuals with BN tended to display more positive facial affect than AN individuals.

4. Discussion

The current review summarized the literature on social cognition across AN, BN, and BED in the years following the 2014 review by Caglar-Nazali and colleagues on social cognition in EDs. Quality of articles included in the review were medium-to-high, which suggests that studies were generally methodologically-sound. In line with the prior

review, social cognition has been studied more in AN than other EDs, with evidence pointing to deficits in social cognition in AN as well as relationships between social cognitive processes and neural activation. The limited research on BN and BED also suggests some problems in social cognition, but there remains a dearth of data across domains in these disorders. Most consistently, EDs were characterized by elevated alexithymia and poorer emotion processing. Review of other social cognitive domains provided some evidence for deficits in EDs, but findings were largely mixed. Further, deficits were more consistently found in studies using self-report measures opposed to behavioral tasks, which showed more variability in results. Importantly, this review showed that many limitations identified by the previous review by Caglar-Nazali and colleagues (2014) still exist–including little data on reception and production of non-facial communication, animacy, and action perception. While AN research has begun to move beyond self-report measures, such as tasks and fMRI, the majority of BN and BED research remains limited to self-reports.

It is particularly noteworthy that this review revealed there was not comprehensive investigation of social cognition across the spectrum of EDs, and therefore findings must be interpreted in light of this limitation. It is possible that the trend for research to focus on AN rather than BN and BED could be an artifact of a bias against publishing null findings. Even among the findings that do exist in EDs, there is notable inconsistency. Further, many studies that compared EDs found no differences in social cognition between ED diagnoses, though some studies suggest poorer processing of positive affect in AN compared to BN. These inconsistencies imply that there are likely social cognitive abnormalities in at least some patients with EDs, but it is difficult to make firm conclusions regarding the nature of differences between EDs and controls or across different EDs. Moreover, social cognition deficits may depend upon levels of psychopathology, such as severity of ED symptoms or co-occurring symptoms, rather than simply ED diagnostic group.

Notably, there appears to be a trend among many of the studies on social cognition and EDs, in that few base their research premise on a previously developed theoretical framework of social cognition. Instead, they often study one component of social cognition (e.g., theory of mind) without placing the findings within a larger theory, such as the theory of social cognition proposed by Ochsner and Gross (2008). Nevertheless, many of the studies' variables of interest tap into issues closely tied with constructs that are part of previous theories. For example, one of the four categories of Ochsner's and Gross' theory of social cognition focuses on recognizing and responding to social-affective stimuli, which has been examined in ED research. A number of studies on AN suggest there is an apparent attentional bias toward negative emotions (e.g., anger and disgust) and against positive emotions in the context of facial cues (e.g., Caglar-Nazali et al., 2014). Individuals with AN also have difficulties with accurately identifying or noticing emotions through affective touch and body movement, suggesting that the deficit spans across various forms of communication (Crucianelli et al., 2016; Lang et al., 2015). Initial findings indicate that individuals with BN may also exhibit these difficulties in noticing negative emotions (Dapelo et al., 2017). Overall, this category of social cognitive research is likely deficient in both AN and BN, but the direct connection to theories of social cognition was significantly developed in these studies. In order to strengthen the theoretical relevance and therefore impact of studies on social cognition in EDs, it may be important to scaffold research off of a broader evidence-based theoretical framework of social cognition.

4.1. Limitations and future directions

There were a number of notable limitations in the current review as well as in the studies collected. Consistent with previous reviews, the limited coverage across EDs and inconsistent findings and measurement makes it challenging to extract firm conclusions. This leads to uncertainty as to what degree the findings from the current review are accurate representations of social cognition across all individuals with EDs. Therefore, a primary goal of future research on social cognition should center on gaining greater research coverage across EDs, particularly for BN and BED. Many of the studies from the current review included limited sample sizes, and multiple studies in the current review may have used the same sample of participants, leading to questions about the generalizability of the current results. Therefore, future research should aim to include large sample sizes that compare diagnostic categories and subgroups on specific areas of social cognition. This approach could help identify distinct profiles of social cognitive deficits that might exist among certain ED subgroups.

Similarly, the studies predominantly consisted of cross-sectional assessments of social cognition, thereby limiting conclusions regarding the role of social cognition in etiology, maintenance, and course of EDs. Future studies should consider longitudinal methodologies that can give stronger evidence for causal links among variables and impact of social cognition across the course EDs. Additionally, intensive longitudinal studies (i.e., ecological momentary assessment [EMA]) could be useful to elucidate the role of social cognitive deficits in micro-temporal mechanisms that serve to maintain eating psychopathology.

In line with the problem in having mostly cross-sectional studies, the identified articles mostly failed to consider more complex forms of social cognition, such as navigating complex social interactions, initiating conversation, or social-emotional expression. These nuanced social skills are likely more difficult to target in research but may be pertinent to the study of social cognition across EDs. For example, given the initial evidence that individuals with BN may have heightened emotional responses to particular affective cues (Tapajoz et al., 2015), their verbal and behavioral responses to social situations may have a distinct pattern that could contribute to their clinical impairment. Understanding how the possible deficits in emotion recognition and theory of mind impact dynamic interaction with another person may be a window into the various psychopathologies. This idea is consistent with the model created by Treasure and colleagues suggesting that social-emotional functioning is central to eating pathology, particularly in the context of AN (Harrison et al., 2012).

One method that may be especially useful for examining these questions about complex social interaction as well as through a longitudinal lens is the use of EMA. EMA is a naturalistic means of studying behavior and psychological states by asking participants to report information via a palm pilot or cell phone throughout their day or after particular events (Haedt-Matt and Keel, 2011). The benefit of this approach is that individuals are able to report their mood or behaviors in the moment and in their natural environment, rather than days or weeks later. This approach has been used to study eating pathology, including in examining affective states before and after a binge eating episode (Smyth et al., 2001), as well as in studying dyadic interpersonal interactions (Smyth and Heron, 2014). The methodology allows researchers to ask people in a relationship to rate their naturalistic interactions with another person in the moment, and it provides the ability to study how multiple people in a situation react to and respond to the other (Janicki et al., 2006). Using these approaches or others to examine interpersonal effectiveness, particularly at times of heightened emotion arousal such as at times of conflict, may provide answers into how social cognition interplays with behavior and thereby eating pathology.

Ascertaining whether deficits in social cognition exist as an endophenotype that predicts the onset of symptoms or whether they are a scar of the illness may also provide useful information to the field. Specifically, gathering data on social skills in large longitudinal studies may give insight into the role of social cognition in the etiology of eating disordered behavior. The current study identified three studies that suggested the existence of social cognition deficits not only among individuals currently meeting criteria for AN but also among those recovered from AN, providing initial evidence for trait-level problems in social domains among those with a history of AN (Bentz et al., 2017;

McAdams et al., 2015; Xu et al., 2017). Thus, much remains to be learned regarding the role of social cognition in the onset, maintenance, and course of eating disorder pathology.

While many of the studies took into account important covariates, such as comorbidities like anxiety or depression (e.g., Bentz et al., 2017), others did not. This is particularly important in light of prior work suggesting transdiagnostic social cognitive deficits (Cotter et al., 2018). Therefore, future research should carefully discriminate to what degree deficits in social cognition are attributable to comorbidities or are core drivers of eating pathology. This approach could disentangle how particular types of deficits in social cognition impact the behavioral manifestation of a psychopathology (e.g., whether the individual engages in binge eating or social avoidance). More studies could also examine moderators of deficits in social cognition. For example, given the inconsistency in findings, studies on BN could examine whether a history of AN, indicating a restrictive path to the individual's current bulimia, might relate to particular deficits in social cognition.

5. Conclusions and implications

The current review consolidated literature on social cognition across AN, BN, and BED, which suggested possible deficits of social cognition in AN, as well as some potential deficits among subgroups of BN. The current review brings to light the fact that there continues to be a lack of coverage of research on social cognition across eating pathologies and the findings that do exist are inconsistent. It is concerning that the results from the current study offer more questions than answers. The scarcity of literature on this topic is surprising, given the relevance of social cognition to eating pathology. Several evidence-based ED treatments or models target interpersonal or social-emotional factors (Fairburn, 2008; Wonderlich et al., 2015; Schmidt and Treasure, 2006), and inherent to body dissatisfaction and how one regulates emotions is the issue of how one interacts with others (Zaki and Williams, 2013). The lack of research leaves a hole in the fabric of our ED conceptualization and presents a glaring need for future research that delves into social cognition across all types of EDs and across all domains of social cognition. Therefore, it is important that future research prioritize clarifying the role of social cognition in the precipitation or perpetuation of eating pathology. Specific implications for future research include developing and testing of theoretical models of social cognition; more research in BN and BED; larger sample sizes; examining more than one construct in studies; increased fMRI research; examining effects of dimensionally-assessed ED symptoms and co-occurring psychopathology symptoms; and use of longitudinal and EMA research designs.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Credit author contribution statement

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Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2020.11.019.

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