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A systematic review of implicit attitudes and their neural correlates in eating behaviour

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Abstract

An increasing number of studies suggest that implicit attitudes towards food and body shape predict eating behaviour and characterize patients with eating disorders (EDs). However, literature has not been previously analysed; thus, differences between patients with EDs and healthy controls and the level of automaticity of the processes involved in implicit attitudes are still matters of debate. The present systematic review aimed to synthesize current evidence from papers investigating implicit attitudes towards food and body in healthy and ED populations. PubMed, EMBASE (Ovid), PsycINFO, Web of Science and Scopus were systematically screened and 183 studies using different indirect paradigms were included in the qualitative analysis. The majority of studies reported negative attitudes towards overweight/obese body images in healthy and ED samples and weight bias as a diffuse stereotypical evaluation. Implicit food attitudes are consistently reported as valid predictors of eating behaviour. Few studies on the neurobiological correlates showed neurostimulation effects on implicit attitudes, but how the brain automatically processes implicit evaluations remains an open area of research. In conclusion, implicit attitudes are relevant measures of eating behaviour in healthy and clinical settings, although evidence about their neural correlates is limited.

Key words: implicit attitudes; food preference; body image evaluation; weight bias; eating disorders

Introduction

Implicit attitudes are behaviours and judgements driven by automatic evaluations, which are triggered independently from conscious control (Greenwald *et al.*, 1998). In the context of eating behaviour, implicit attitudes towards food and body images are indices of individual preference for different categories of

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food and affective evaluation of bodies in self and other representations. In particular, there is evidence that implicit food attitudes predict the subsequent actual choice for different types of food (e.g. healthy or unhealthy food) and individuals' eating behaviours with modulatory effects of hunger state, craving and eating disorder (ED) symptomatology (Perugini, 2005; Ellis *et al.*, 2014; Richard *et al.*, 2019). On the other hand, implicit attitudes towards underweight or overweight body shape have been related to internalization of thin ideal, body dissatisfaction, drive for thinness and ED symptoms (e.g. Ahern *et al.*, 2008; Cserjési *et al.*, 2010; Heider *et al.*, 2015). The theoretical framework posits that implicit attitudes rely on associative spontaneous processes (in contrast to propositional processes underling explicit attitudes) that can be triggered automatically and independently from the overt consideration that a person has on the same association in explicit evaluations (Gawronski and Bodenhausen, 2006). Different models have been proposed accounting for the relationship between implicit and explicit attitudes in predicting behaviour, and studies on eating behaviour reported food choice as an example of spontaneous decisions predicted by implicit evaluations (Perugini, 2005; Conner *et al.*, 2007). In addition, strong affective evaluation of food and body image may represent a key aspect of dysfunctional eating and body dissatisfaction in patients with ED (Spring and Bulik, 2014).

However, previous literature on implicit attitudes and eating behaviour is not always consistent since some studies did not replicate findings on the predictive validity of implicit tasks above explicit measures (Ahern and Hetherington, 2006; Ayres *et al.*, 2012), and there are contrasting results from studies assessing implicit attitudes in patients with different ED diagnoses (Roefs *et al.*, 2005b; Khan and Petróczi, 2015; Smith *et al.*, 2018). Crucially, implicit attitudes are measured by indirect tasks, which assess associations between target stimuli and attributes without directly inquiring participants' beliefs and thus are less influenced by social desirability and strategies of self-presentation compared to explicit questionnaires (De Houwer, 2002). This is particularly relevant in clinical or subclinical populations with EDs, which tend to have a low level of therapeutic adherence and to mask symptoms as body dissatisfaction, food restraint or craving to avoid interventions and hospitalization (Halmi, 2013). Interestingly, discrepancy between explicit and implicit measures has been reported in individuals with obesity and predicted disinhibited eating (Goldstein *et al.*, 2014; Cserjesi *et al.*, 2016). Moreover, implicit attitude towards body images is a widely used measure of weight bias, i.e. the stigmatizing concept that people with obesity or overweight are lazy and lacking in self-control, which predicts prejudice and misbehaviour (O'Brien *et al.*, 2008; Flint *et al.*, 2016). Notably, weight bias is present also in healthcare professionals and in individuals with overweight with relevant clinical consequences (Anselmi *et al.*, 2013; Phelan *et al.*, 2015a; Tomiyama *et al.*, 2015). Indeed, self-directed weight bias in patients with obesity or binge eating disorder (BED), referred as internalization of weight bias, has been related to higher depressive symptoms, perceived stress and worse overall health (Pearl *et al.*, 2013; Hilbert *et al.*, 2014; Phelan *et al.*, 2015a). Considering healthcare professionals, including eating behaviour specialists, there is evidence of weight bias impact on interpersonal relationship, decision-making on treatments and quality of patiwents' care, although reciprocal influences between implicit and explicit weight bias of patients and healthcare providers are a recent matter of investigation (Forhan and Salas, 2013; Phelan *et al.*, 2015c).

Crucially, studies investigating implicit attitudes typically use indirect tasks as measures of automatic associations and affective evaluations of target stimuli, although it is still an issue of debate which is the level of automaticity of the processes involved in task execution and which are the underpinning brain mechanisms (De Houwer *et al.*, 2009; Forbes *et al.*, 2012). Results from neuroimaging studies and patients with brain lesions have shown that the Implicit Association Tests (IATs; Greenwald *et al.*, 1998), one of the most diffuse tasks to assess implicit attitudes, recruits structural and functional networks involved in cognitive control and inhibition processes as well as automatic self-representation and semantic representation of concepts, including the dorsolateral and ventromedial prefrontal cortex, the anterior cingulate cortex, the insula and the anterior temporal lobe (Chee *et al.*, 2000; Gozzi *et al.*, 2009; Forbes *et al.*, 2012). Moreover, electrophysiological studies with event-related potentials (ERPs) have reported effects related to congruency of blocks and score at the IAT in early time-windows at 90- to 130-ms post-target onset or at the N200 component, supporting the automaticity of brain responses for implicit associations (Forbes *et al.*, 2012; Healy *et al.*, 2015). Whether these automatic processes are common to implicit attitudes in different contexts, or have specific features related to the stimuli eliciting the bias, remains an open question. Research with neuromodulation techniques can be informative on this aspect, providing evidence of a causal relationship between induced modulation or interference in a target region and changes in implicit attitudes. Indeed, it has been shown that transcranial magnetic stimulation (TMS) applied to a different portion of the prefrontal cortex interfered with IAT on gender stereotype or food, whereas parietal stimulation affected implicit religiousness (Cattaneo *et al.*, 2011; Crescentini *et al.*, 2014; Mattavelli *et al.*, 2015). As stated above, implicit attitudes towards food and body are relevant in predicting eating behaviour; thus, it is of interest to investigate the neural bases of these attitudes as potential targets for therapeutic neuromodulation treatments. The reasons for combining neuromodulation and assessment with indirect tasks are twofold: on one hand, implicit measures can represent a feasible alternative to explicit questionnaires to evaluate patients with EDs with difficulties in recognizing/reporting their symptoms; on the other hand, applying neurostimulation on the neural correlates of automatic processes contributing to the maintenance of ED could boost the effect of therapeutic treatment.

Different paradigms have been proposed to evaluate implicit attitudes. The IAT (Greenwald *et al.*, 1998) measures associations of two opposite target categories (e.g. healthy *vs* unhealthy food) with opposite valence attributes, asking participants to categorize target stimuli and attributes congruently (e.g. healthy-positive and unhealthy-negative) and incongruently paired (e.g. healthy-negative and unhealthy-positive) in subsequent blocks. The Single Category IAT (SC-IAT; Karpinski and Steinman, 2006) consists in the same paradigm with opposite attributes to be associated with one category of stimuli. The affective priming (AP) task (Fazio *et al.*, 1986) is another frequently used paradigm based on reaction times in categorizing positive and negative targets (words or pictures) preceded by prime stimuli (e.g. food stimuli). Responses to targets are informative of participant's affective evaluation of primes, assuming faster responses when prime and target share the same valence (congruent trials). A modified version of the IAT is the Extrinsic Affective Simon Task (EAST; De Houwer, 2003). In this case, participants are asked to categorize valence words presented in white colour as positive/negative words and target stimuli based on their colour (e.g. blue/green). The EAST is based on the prediction that participants are faster in categorizing with the positive key coloured words that they consider positive. Other indirect tasks are the Implicit Relational Assessment Procedure (IRAP; Barnes-Holmes et al., 2010), which requires to select between two response options (e.g. true/false) for samples and target stimuli presented together (e.g. 'I am' + 'slim', Heider et al., 2015), and the Affective Misattribution Procedure (AMP; Payne et al., 2005), which asks participants to evaluate Chinese characters as pleasant or unpleasant ignoring the preceding stimuli and the difference in responses provide a measure of how the affect evoked by the first image is misattributed to the Chinese character. All these tasks have been used to assess food and body implicit attitudes in healthy and clinical populations.

In the past decade, the assessment of implicit attitudes related to eating behaviour has become widespread, but a review is missing so far. Since the introduction of the IAT by Greenwald et al. (1998) and its early application to assess weight bias and predict eating behaviour (Teachman and Brownell, 2001; Perugini, 2005), different tasks have been proposed and used in healthy, sub-clinical and clinical populations. Previous reviews focused on cognitive bias with food- and body-related stimuli in Stroop or attentional tasks and reported greater bias in patients with EDs compared to control participants (Johansson et al., 2005; Brooks et al., 2011). However, attentional bias is related to the salience of the stimuli, whereas the indirect tasks used to evaluate implicit attitudes involved affective associations and the automatic evaluation in terms of valence of the stimuli (De Houwer, 2002; Brooks et al., 2011).

This study presents a systematic review of studies published up to May 2019 (i.e. when literature search was conducted) concerning implicit attitudes towards food and body in different areas of research. The aim is to analyse and summarize methodological aspects and findings in healthy and clinical populations with EDs. To this purpose, we will provide readers a comprehensive guide of literature in this field giving particular attention to neuroscientific methodological approaches and recent evidence of neurobiological correlates related to implicit attitudes in eating behaviour.

Method

Design and eligibility criteria

The systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (Moher et al., 2015; Shamseer et al., 2015). Specific eligibility criteria were considered to systematically select and appraise studies (Grant and Booth, 2009). In particular, we included original studies, while systematic reviews, narrative reviews, meta-analysis, conference proceedings, case reports and conference abstracts were excluded. Only peer-reviewed papers published in English were selected. We were interested in studies on implicit attitudes towards food or body images in healthy populations or in patients with EDs. Thus, studies reporting assessment of implicit attitudes towards different targets were excluded (even if sample with EDs was involved). Similarly, studies assessing unconscious processing of food or body images, but with paradigm not related to implicit attitudes, were excluded.

Search strategy and studies selection

The following terms were combined to collect records from PubMed, EMBASE (Ovid), PsycINFO, Web of Science and Scopus: 'implicit attitudes', 'implicit association', 'affective priming', 'eating disorder', 'anorexia nervosa', 'bulimia nervosa', 'binge eating disorder', 'obesity', 'food preference', 'thin ideal' and 'fat phobia' (the search strategies are shown in Appendix 1). After removing duplicates, the records were independently filtered based on title and abstract by three researchers (G.M., A.G. and L.D.M.). To blind the process, we used Rayyan web-based reviews manager (Ouzzani et al., 2016), which allows to screen the records as 'include', 'exclude' or 'maybe'. When records were eligible for exclusion, specific labels were added to justify the reason of exclusion. At the end of the screening, the blind mode was turned off and conflicts were resolved by consensus. Researchers (G.M., A.G. and L.D.M.) independently reviewed the full text of the records in the 'include' and 'maybe' categories. Conflicting decisions were solved based on researchers' consensus.

Out of 633 screened papers, conflicts or unsure decisions for inclusion were 259 (i.e. the two raters gave different decisions of inclusion, exclusion or maybe). Percentage agreement among raters was computed (as suggested in Kottner and Streiner, 2011), resulting in a value of 59.1%, which is considered a moderate agreement (House et al., 1981; Nurjannah and Siwi, 2017). However, indecisions or disagreement were solved by consensus; thus, at the end of the screening procedure, a unanimous agreement on all papers was reached. A detailed presentation of decision percentages is reported in Supplementary Table S1.

Quality assessment

The Cochrane Collaboration's Risk-of-Bias Tool (Higgins et al., 2011) was used to assess the methodological quality of the studies yielded by the search process. The Cochrane Tool allows to rate the following sources of bias as 'high', 'low', 'unclear' or 'not applicable': random sequence generation, allocation concealment, blinding strategy, incomplete outcome data and selective outcome reporting. Three researchers independently evaluated the quality of the records included in the different sections (G.M. studies on neural correlates and food attitudes, A.G. studies on body image and L.D.M. studies on weight bias) by computing, for each Cochrane item, the percentage of the most frequent rating across the retrieved studies. Risk of bias of papers testing implicit attitudes on both food and body was calculated once.

Results

Studies selection and quality assessment

The systematic search retrieved 2840 papers. After removing duplicates, 633 papers were screened based on the abstract and 343 were excluded. The remaining 290 papers were examined as full-text readings and 107 were excluded. The most common reason for exclusion was lack of consistency with the review topic. In total, 183 studies met our inclusion criteria and were included in our review. Figure 1 summarizes the search procedure.

Results are presented on the basis of the main topics that emerged from studies meeting inclusion criteria. A small number of studies investigated the neurobiological correlates of implicit food or body attitudes in healthy individuals or patients with EDs and are described in a specific section ('Studies on neurobiological correlates'). Other studies were grouped depending on whether implicit measures were used to assess attitudes towards food ('Studies on food attitudes'), body image ('Studies on body image') or weight bias ('Studies on weight

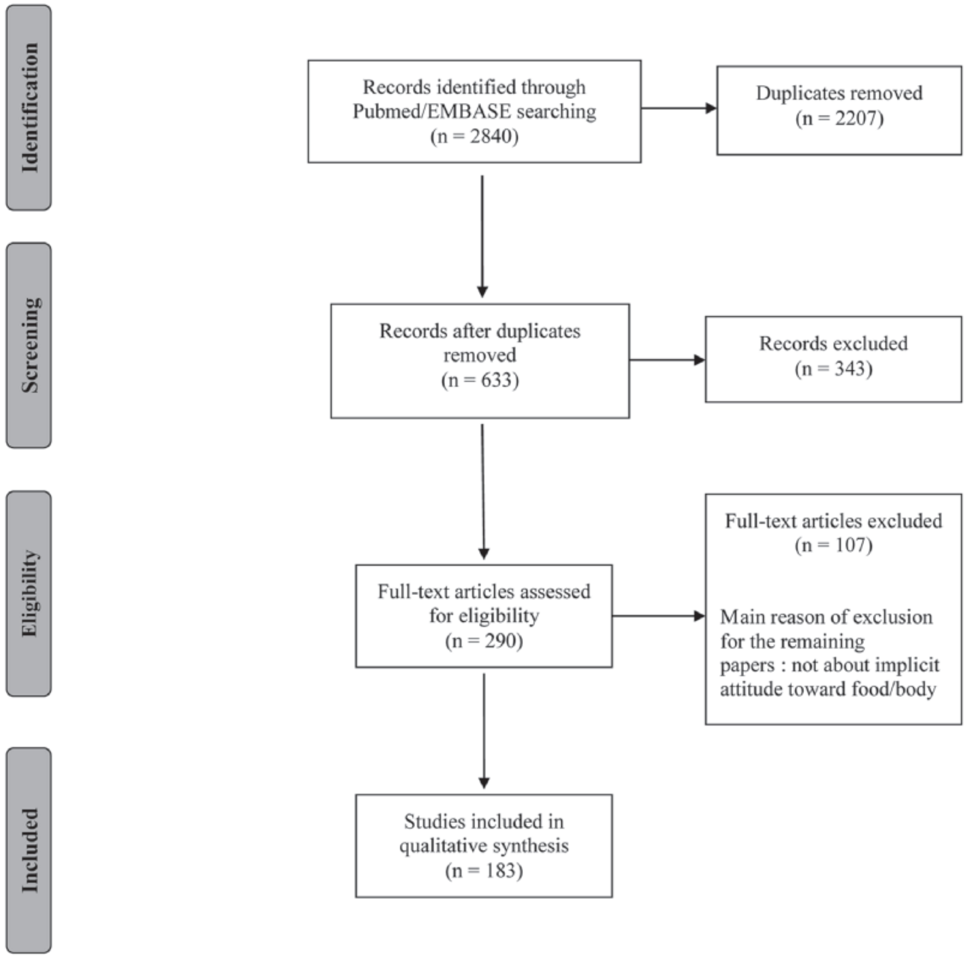

Fig. 1. Flow chart showing the selection process of papers.

bias'). Methodological aspects and main results are reported to capture the contribute of the studies in each specific subtopic. In particular, papers included in body image or weight bias sections were grouped considering the common focus across the studies on the implicit evaluation of different types of body images and shapes or on the assessment of the stigmatizing (and self-stigmatizing) concept of overweight or obesity (i.e. weight bias).

Regarding the quality evaluation, Table 1 reports the risk of bias assessment according to the Cochrane Collaboration's Risk-of-Bias Tool (Higgins *et al.*, 2011). Overall, considering only the applicable Cochrane items, the food topic had the best quality compared to the others.

Studies on neurobiological correlates

Six studies investigated the neurobiological underpinnings of implicit attitudes toward food or body images (Table 2). Three studies were carried out with healthy participants (Mattavelli *et al.*, 2015; Cazzato *et al.*, 2017; Hall *et al.*, 2018a), two involved patients with EDs (Blechert *et al.*, 2011; Mattavelli *et al.*, 2019) and one study assessed patients with Parkinson's disease (PD) treated with dopaminergic replacement (Terenzi *et al.*, 2018). Four of these studies investigated the possibility to modulate IAT performances with non-invasive brain stimulation techniques applied to different cortical regions (Mattavelli *et al.*, 2015, 2019; Cazzato *et al.*, 2017; Hall *et al.*, 2018a). In particular, the study by Mattavelli *et al.* (2015) applied TMS to the medial prefrontal cortex (mPFC) and left parietal cortex while healthy participants were submitted to three different IATs on food, self and flowers/insects. Results demonstrated the causal role of mPFC in monitoring implicit food attitudes and highlighted the impact of individual variability in modulating the effect of neurostimulation. Differently, neuromodulation of dorsolateral prefrontal cortex (dlPFC) by means of a continuous theta burst protocol (cTBS) did not affect the IAT score in the study by Hall *et al.* (2018a). The other study on healthy participants (Cazzato *et al.*, 2017) applied transcranial direct current stimulation (tDCS) on the extrastriate body area (EBA) in the right and left hemispheres and assessed participants' anti-fat bias with valence-IAT and aesthetic-IAT. tDCS was applied in anodal, cathodal and sham mode on each hemisphere. Only the cathodal stimulation (applied to induce a decrease in cortical excitability) of right EBA showed a significant effect in reducing anti-fat bias, measured by the valence-IAT, in male participants. Differently, female participants did not show a reliable anti-fat bias and their performance was not modulated by tDCS. Only one study investigated neurostimulation effects on IAT in patients with ED (Mattavelli *et al.*, 2019) applying anodal or sham tDCS to the mPFC and right EBA and assessing participants' implicit attitudes toward food, body images and flowers/insects. Results showed that the occipito-temporal

Table 1. Risk of bias evaluation of the papers extracted from the systematic review procedure

	Cochrane items						
	Selection bias		Performance bias	Detection bias		Attrition bias	Reporting bias
Studies topic	Random sequence generation	Allocation concealment	Blinding of participants[a]	Blinding of personnel	Blinding of outcome	Incomplete outcome data	Selective reporting
Neural correlates	67% ☐	83% ☐	83% ↓	67% ☐	67% ☐	100% ↓	100% ↓
Body image	78% ☐	74% ☐	89% ↓	81% ☐	81% ☐	59% ↓ 41% ↑	96% ↓
Food	58% ↓ 40% ☐	50% ☐ 44% ↓	71% ↓	53% ☐ 29% ↑	51% ☐ 46% ↑	96% ↓	97% ↓
Weight bias	74% ☐	74% ☐	91% ↓	87% ☐	74% ☐	74% ↓	92% ↓

↑ = high risk; ↓ = low risk; ■ = unclear; ☐ = not applicable;
[a]blinding of participants was rated as 'low risk' both when participants were randomly assigned to experimental groups and when participants were blinded about the purposes and procedure of the implicit attitudes' assessment.

Table 2. Details of studies on neurobiological correlates of implicit attitudes toward food or body shape

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Method
Blechert *et al.*, 2011	Study 1 AN (20, f = 20) BN (20, f = 20) H (20, f = 20) Study 2 H-UNRES (21, f = 21) H-RES (18, f = 18)	23.1 (4.64) 26.5 (7.78) 25.4 (4.80) 23.6 (5.02) 22.6 (3.27)	AP	Primes sentences on body shape and weight concern, self-esteem related word target	EEG (study 1)
Cazzato *et al.*, 2017	H (25, f = 13)	f: 22.08 (0.73) m: 22 (0.6)	IAT	Fat, slim body images	tDCS
Hall *et al.*, 2018a	H (37, f = n.r.)	21.6 (n.r.)	IAT	Flavourful snack, Flavourless foods	cTBS
Mattavelli *et al.*, 2015	H (36, f = 21)	23.25 (2.88)	IAT	Tasty and high-fat, tasteless and low-fat food	TMS
Mattavelli *et al.*, 2019	AN/BN/EDNOS (36, f = 36) H (36, f = 36)	25.53 (8.09) 24.03 (3.48)	IAT	Tasty high-fat, tasteless low-fat food; Underweight, overweight body images.	tDCS
Terenzi *et al.*, 2018	PD + BE (16, f = 8) PD (15, f = 7) H (20, f = 10)	67.1 (8.2) 64.9 (12.9) 68 (6.4)	AP	Food, non-food	

AN = anorexia nervosa; AP = affective priming; BN = bulimia nervosa; cTBS = continuous theta burst protocol; EDNOS = eating disorder not otherwise specified; f = female; H = healthy participants; H-RES = healthy restrained eaters; H-UNRES = healthy unrestrained eaters; IAT = Implicit Association Test; n.r. = not reported; PD = Parkinson's disease; PD + BE = Parkinson's disease with binge eating; tDCS = transcranial direct current stimulation; TMS = transcranial magnetic stimulation.

stimulation increased the implicit preference for high-fat tasty food in patients with ED and both mPFC and EBA stimulation increased reaction times in incongruent trials (i.e. tasty food—negative attributes and tasteless food—positive attributes associations). The effect was specific for food attitudes in patients, whereas no modulatory effects resulted for healthy participants and in the other IATs.

Only one study investigated the electrophysiological correlates of AP measuring the association of self-related targets with body shape and weight primes (Blechert *et al.*, 2011). ERPs were recorded in healthy participants and patients with anorexia nervosa (AN) or bulimia nervosa (BN) during the AP task. Results showed a significant congruent–incongruent difference in the N400 amplitude only in the BN group, suggesting that the stronger association of self-evaluation with body shape and weight concept in ED is encoded in early stage of brain processes in BN patients.

Finally, Terenzi *et al.* (2018) used an AP on food to evaluate reward sensitivity in patients with PD treated with dopaminergic medications and BED. These patients are at risk of developing impulse control disorder and represent a neurobiological model for striatal dopaminergic anomalous functioning (Dagher and Robbins, 2009). Patients with PD and BED showed reduced priming effect compared to controls for sweet foods, but no differences in explicit rating on liking and wanting the foods.

Studies on food attitudes

Implicit attitudes toward food were investigated in 75 studies (Table 3). Among these, three studies that considered both food and body stimuli (Spring and Bulik, 2014; Khan and Petróczi, 2015; Moussally et al., 2015) are presented in the body section and also in details in Table 4. Most of these studies ($N = 53$) measured implicit attitudes in healthy normal-weight participants using the two-categories IAT ($N = 26$). Ten studies used the SC-IAT, whereas three studies tested participants both with the two-categories IAT and the SC-IAT (Friese et al., 2008; Houben et al., 2010; Guidetti et al., 2012). Five studies used the AP task, one the semantic priming task (Misener and Libben, 2017), three the AMP (Ellis et al., 2014; Woodward and Treat, 2015; Woodward et al., 2017) and two the EAST or similar variants (Hoefling and Strack, 2008; Veenstra and de Jong, 2010). Four studies combined more than one task, to investigate the role of different implicit measures in predicting behaviour (Roefs et al., 2005a; Conner et al., 2007; Seibt et al., 2007; Genschow et al., 2017). One study assessed recovered and currently diagnosed patients with AN and healthy controls by means of AMP procedure including high- and low-calorie food as well as thin- and fat-related body images (Spring and Bulick, 2014; see Table 4). Nineteen studies evaluated food implicit attitudes in

Table 3. Details of studies on implicit attitudes toward food

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Healthy participants					
Ackermann and Palmer, 2014	H (101, f = 62)	n.r.	IAT	Healthy food, fast food	-
Adams et al., 2017	H (143, f = 134)	22.92 (n.r.)	SC-IAT	Chocolate	Response inhibition training
Alblas et al., 2018	H (125, f = 79)	20.17 (1.88)	IAT	Chocolate, fruits	Evaluative conditioning (health video-games)
Alkozei et al., 2018	H (17, f = 8)	24.53 (4.2)	IAT	High calorie, low-calorie food	Sleep deprivation
Ashby and Stritzke, 2013	H (132, f = 96) H (127, f = 97)	18.67 (3.3) 18.75 (3.1)	IAT	High-fat, low-fat food	Priming procedure
Ayres et al., 2012	H (80, f = 67) H (98, f = 80)	22.1 (7.3) 23 (4.6)	IAT	Chocolate, fruits	-
Becker et al., 2015	H (52, f = 52) H (104, f = 104) H (103, f = 103)	20.47 (2.34) 20.77 (2.94) 21.94 (3.59)	IAT AP AP	healthy, unhealthy food Healthy, unhealthy food, objects Chocolate, objects	Approach-avoidance training
Bongers et al., 2013	H (112, f = 112)	20.34 (2.24) and 19.83 (1.83) per condition	SC-IAT	High-caloric food	Emotion induction during milk shake consumption
Conner et al., 2007	H (123, f = 76) H (104, f = 84)	23.7 (5.8) 23.2 (4.9)	IAT EAST IAT	Sweets, shapes Sweets Chocolate, fruits	-
Coricelli et al., 2019	H (45, f = 22)	23.22 (3.12)	IAT	Natural food, utensils Transformed food, utensils	-
Ellis et al., 2014	H (107, f = 59)	27 (11.9)	AMP	Fruits	-
Eschenbeck et al., 2016	H (90, f = 79)	21.56 (3.83)	IAT	Healthy, unhealthy food	High and low distraction situations
Friese et al., 2008	H (88, f = 88) 69 (f = 69) 48 (f = 0)	23.19 (4.29) 22.48 (4.59) 24.11 (4.41)	IAT SC-IAT SC-IAT	Chocolate, fruits Chips Beer	Cognitive load or self-regulatory resources during food choice
Genschow et al., 2017	H (91, f = 73)	22.80 (5)	EAT AP MT	Chocolate, fruits	Affective or cognitive focus before food choice
Guidetti et al., 2012	H (85, f = 75)	18.86 (0.97)	SC-IAT IAT	Fruits Sweet, savoury snacks	-
Hensels and Baines, 2016	H (95, f = 70)	24.88 (6.16)	IAT	Healthy, unhealthy food	Evaluative conditioning
Hoefling and Strack, 2008	H (66, f = 37)	23.9 (3.7)	EAST	High-calorie, low-calorie food	Food deprived or satiated between groups
Hollands et al., 2011	H (134, f = 101)	24.2 (n.r.)	IAT	Fruits, snacks	Evaluative conditioning
Houben et al., 2010	H (59, f = 59) H (63, f = 63)	31.44 (9.61) 34.71 (13.28)	IAT SC-IAT	Snacks, fruits Snacks	-
Houben et al., 2012	H (112, f = 112)	24.88 (5.92)	SC-IAT	High-caloric food moderate-caloric food Low caloric food	-
Kakoschke et al., 2017	H (240, f = 240)	20.61 (2.43)	SC-IAT	Unhealthy food	Approach-avoidance training combined with Go/No-go training

Table 3. (Continued)

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Kraus and Piqueras-Fiszman, 2016	H (108, f = 68)	22.9 (2.9)	IAT-RF	Sandwich, sweets	Hunger state
Lamote et al., 2004	H (26, f = 17) H (29, f = 25)	36.96 (4.03) 19.55 (1.84)	AP AP	Individually positive and negative rated food	(Study 2) Strong or moderate prime condition
Lebens et al., 2011	H (85, f = 85)	E 34.14 (12.87) C 34.23 (13.49)	SC-IAT	Snack	Evaluative conditioning
Mai and Hoffman, 2015	H (203, f = 81)	23.0 (2.58)	IAT	Energy-dense, energy-poor food	-
Mayer et al., 2008	H (50, f = 50)	n.r. (undergraduate students)	IAT	High-caloric food, low-caloric food	Disgusting odour
Maas et al., 2017	H (83, f = 72)	n.r. (undergraduate students)	SC-IAT	High-fat food	-
McConnell et al., 2011	H (56, f = 35)	19.25 (n.r.)	IAT	Apple, chocolate	-
Misener and Libben, 2017	H (115, f = 115)	19.9 (1.47)	SP	ED, non-ED prime-target relation	-
Nederkoon et al., 2010	H (51, f = 51)	19.5 (2.2)	SC-IAT	Snack food	-
Papies et al., 2009	H (91, f = 91) H (100, f = 65)	20.5 (2.2) 20.07 (2.60)	AP AP	High-fat palatable, neutral, unpalatable food High-fat palatable, neutral food	-
Pavlovic et al., 2016	H (89, f = 73) H (40, f = 40)	21.7 (n.r.) 2.4 (n.r.)	IAT	Fruits, sweets	-
Pechey et al., 2015	H (732, f = 371)	51 (14)	SC-IAT	Fruit Chees Cake	-
Perugini, 2005	H (113, f = 62)	25.1 (6.8)	IAT	Snacks, fruits	-
Richard et al., 2019	H (66, f = 66)	20.3 (2.34)	SC-IAT	Chocolate	-
Roefs et al., 2005a	H restrained (32, f = 32) H unrestrained (37, f = 37) H restrained (26, f = 26) H unrestrained (30, f = 30)	19.5 (2) 19.5 (1.8) 19.6 (2.2) 19.3 (1.1)	AP EAST	High-fat, low-fat food High-fat palatable, high-fat Unpalatable, low-fat palatable, low-fat unpalatable food	-
Raghunathan et al., 2006	H (131, f = n.r.)	n.r. (undergraduate students)	IAT	Healthy, unhealthy food	-
Seibt et al., 2007	H (29, f = n.r.) H (74, f = n.r.)	n.r. n.r. (undergraduate students)	IAT EAST	Food, sport Food, flower, non-words	Deprived vs satiated between participant assessment
Stafford and Scheffler, 2008	H (30, f = 24)	30.4 (7.4)	IAT	Food, furniture	Pre-lunch vs post-lunch between participants assessment
Sato et al., 2016	H (34, f = 16)	23.3 (4.5)	AP	Fast food, Japanese diet food	-
Sato et al., 2017	H hungry (28, f = 13) H satiated (28, f = 13)	22.9 (4.4) 23.4 (4.7)	AP	Fast food, Japanese diet food	Hungry/satiated between groups conditions
Schakel et al., 2018	H (120, f = 97)	21.3 (2.4)	IAT	Healthy, unhealthy food	Gamified approach avoidance training and verbal suggestions
Songa and Russo, 2018	H (60, f = 38) H (80, f = 44)	32 (n.r.) 28 (n.r.)	IAT	High-energy, low-energy food	-
Storr and Sparks, 2016	H (183, f = 183)	27.29 (10.84)	IAT	high-calorie, Low-calorie food	Self-affirmation and ego-depletion
Trendel and Werle, 2016	H (283, f = 163) H (142, f = 74)	20.6 (n.r.) 20.6 (n.r.)	IAT	Chocolate, apple	Cognitive load during food choice
Van Dessel et al., 2018	H (389, f = 219) H (184, f = 59)	34 (13) 20 (2)	IAT	Healthy, unhealthy food	Approach avoidance training

Table 3. (Continued)

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Veenstra and de Jong, 2010	H (55, f = 55)	n.r. (undergraduate students)	AST-voice	High-fat, low-fat food	-
Wang et al., 2011	H (100, f = 100)	21.3 (2.4)	SC-IAT	Chocolate	Ego-depletion
Werle et al., 2013	H (94, f = 50)	19.6 (n.r.)	IAT	Healthy, unhealthy food	-
Werntz et al., 2016	H (10 115, f = 76.6%)[1]	27.6 (11.4)	IAT	High-fat, low-fat food	-
Woodward et al., 2015	H (238, f = 238)	18.98 (1.72)	AMP	Food	-
Woodward et al., 2017	H (238, f = 238)	19.08 (1.40)	AMP	Food	-
Yen et al., 2010	PMDD (60, f = 60) H (59, f = 59)	23.03 (2.45) 22.70 (2.37)	IAT	High-sweet-fat, high-salted-fat food	-
Overweight/Obesity					
Alabduljader et al., 2018	HW (33, f = 28) OB (20, f = 14)	38.85 (11.36) 40.25 (9.51)	IAT	Unhealthy, healthy food	-
Craeynest et al., 2005	HW (38, f = 21) OB (38, f = 21)	13.53 (2.52) 13.69 (2.63)	EAST	Healthy, unhealthy food; Sedentary, moderate intense, high intense physical activity	-
Craeynest et al., 2006	HW (39, f = 22) OB (39, f = 23)	14.00 (2.40) 14.12 (2.43)	IAT	Fat, non-fat food; Exercise, inactive child	-
Craeynest et al., 2007	HW (40, f = 29) OW (40, f = 29 =	14.83 (0.64) 14.83 (0.75)	IAT	Palatable food, hobby Palatable healthy, palatable unhealthy food	-
Craeynest et al., 2008a	OB (19, f = 12)	12.79 (2.68)	EAST	Healthy, unhealthy food; Sedentary, moderate intense, high intense physical activity	12-month multi-component inpatient programme
Craeynest et al., 2008b	HW (29, f = 16) OW (29, f = 17) HW (29, f = 14) OB (29, f = 17)	14.34 (1.11) 14.59 (1.27) 13.07 (2.09) 13.21 (2.11)	IAT	Fat, lean food	-
Cserjesi et al., 2016	HW (15, f = 7) OB (15, f = 7)	38.4 (9.5) 37.8 (9.5)	AP	Small, medium, large portion of a typical fast food	-
Czyzewska and Graham, 2008	UW (9, f = 9) HW (51, f = 51) OW (12, f = 12) OB (11, f = 11)	21.11 (2.80) 21.61 (3.97) 21.75 (2.30) 24.36 (3.96)	AP	High-calorie non-sweet, high-calorie sweet, low-calorie food, food-related items	-
Ferentzi et al., 2018	OB (129, f = 62)	48 (9.45)	SC-IAT	Unhealthy food	Four sessions of approach-avoidance training
Goldstein et al., 2014	HW/OW (95, f = 95)	19.87 (2.16)	SC-IAT	Chocolate	-
Kemps and Tiggeman, 2015	HW (56, f = 56) OB (56, f = 56)	44.95 (11.82)	IAT	Food (healthy and unhealthy items), non-food	-
McKenna et al., 2016	HW (24, f = 11) OB (25, f = 15) HW (32, f = 16) OB (25, f = 15) HW (42, f = 20) OB (32, f = 16)	20.92 (3.11) 41.57 (8.84) 20.81 (1.36) 41.36 (9.91) 20.76 (3.67) 36.88 (9.76)	IRAP	Healthy, unhealthy	Food restriction
Roefs and Jansen, 2002	HW (31, f = 25) OB (30, f = 24)	40.5 (14.4) 46.3 (14.8)	IAT	High-fat, low-fat food	-
Roefs et al., 2005b	HW (27, f = 27) AN (19, f = 19) HW (27, f = 27) OB (27, f = 27)	20.4 (5.8) 20.6, (6.3) 36.6 (8.7) 36.5 (8.8)	AP	High-fat palatable, low-fat palatable, high-fat unpalatable, low-fat unpalatable food	-
Roefs et al., 2006	HW (26, f = 26) OB (33, f = 33) HW (29, f = 29) OB (27, f = 27)	41.8 (8.1) 41.7 (6.9) 35.8 (10.0) 36.4 (9.9)	AP	High-fat palatable foods, low-fat palatable foods, high-fat unpalatable foods, low-fat unpalatable foods	(i) Focus attention on palatability or health aspects of food (ii) Food craving induction

Table 3. (Continued)

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Sartor *et al.*, 2011	HW (22, f = 15) OW/OB (11, f = 4) Study 2 H (12, f = 7)	23.1 (2.9) 22.2 (1.6) 26 (6)	IAT	Sweet, non-sweet foods and drink	(Study 2) 4 weeks soft drink supplementation
Verbeken *et al.*, 2018	OB (44, f = 23)	12.58 (1.43)	SC-IAT	Unhealthy food	10 sessions of approach-avoidance training
Warschburger *et al.*, 2018	OW/OB (59, f = 33)	13.23 (1.93)	SC-IAT	High energy snacks	Six sessions of approach-avoidance training
Werrij *et al.*, 2009	HW (19, f = 19) OW/OB (24, f = 24) HW (29, f = 29) OB (28, f = 28)	41 (12) 42 (10.3) 37 (8.5) 37 (8.9)	SP	Palatable food, neutral words, disinhibition words Palatable food, neutral words, restraint words	-

AMP = affective misattribution procedure; AP = affective priming; AST = Affective Simon Task; C = control group; E = experimental group; EAST = extrinsic affective Simon test; ED = eating disorder; H = healthy participants; HW = healthy weight; IAT = Implicit Association Test; IAT-RF = recording free variant of IAT; IRAP = Implicit Relational Assessment Procedure; MT = manikin task; n.r. = not reported; OB = obese; OW = overweight; PMDD = premenstrual dysphoric disorder; SC-IAT = Single category IAT; SP = semantic priming; UW = underweight; f = female. [1]part of a larger web-based data collection on other mental health domains.

Table 4. Details of studies on implicit attitudes toward body image

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Healthy participants					
Ahern *et al.*, 2006	H (86, f = 86)	Range 16–25 years	IAT	Fat and thin silhouettes	_
Ahern *et al.*, 2008	H (105, f = 105)	18.01 (0.15)	IAT	Underweight and normal-weight body images	
Benas and Gibb, 2011	H (202, f = 202)	18.93 (1.17)	IAT	Fat and thin related words	_
Elran-Barak and Bar-Anan, 2018	H (66 799, f = 47.265)	27.88 (11.9)	IAT	Fat and thin silhouettes	_
Expósito *et al.*, 2015	H (34, f = 34)	23.35 (1.35)	IRAP	Fat and thin women silhouettes	_
Glashouwer *et al.*, 2018	H (72, f = 72)	20.05 (1.41)	RRT	Actual or ideal body image related sentences	_
Heider *et al.*, 2015	H (68, f = 68)	18.72 (2.12)	IRAP	Actual or ideal body image related sentences	_
Heider *et al.*, 2018	H (68, f = 68)	18.72 (2.12)	RRT	Actual or ideal body image related sentences	_
Juarascio *et al.*, 2011	H (80, f = 80)	18.24 (0.68)	IRAP	Fat and thin silhouettes	_
Lydecker *et al.*, 2018	H (657, f = 488),	36.81 (7.96)	IATs	Thin or fat children related words	_
Marini, 2017	H (4.806, f = 3.253/67.7%)	28.32 (11.65)	IAT	Underweight, normal-weight, overweight and obese body images	_
Martijn *et al.*, 2013	Study 1 H (66, f = 66) Study 2 H (39, f = 39)	18.94 (0.99) 21.51 (1.83)	IAT Explicit ratings	Images of supermodels *vs* normal-sized models	Evaluative conditioning task
Matharu *et al.*, 2014	H (129, f = 91)	25.2 (2.9)	IAT	Fat and thin silhouettes	Standard lecture *vs* medical humanities intervention
Moussally *et al.*, 2015*	H (121, f = 121)	23.97 (4.80)	AMP	Thin and overweight women picture; permitted and forbidden food	_
Ritzert *et al.*, 2016	H (99, f = 75)	18.6 (1.0)	IRAP	Attractiveness *vs* disgust/fear related sentences	_
Robstad *et al.*, 2018	H (30, f = 30)	46.53 (n.r.)	IATs	Words related to the concept of obese *vs* normal body shape	_

Table 4. (Continued)

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Sabin et al., 2015	H (75, f = 41)	48 (-)	IAT	Fat and thin silhouettes	_
Watts et al., 2008	Study 1 H (87, f = 87) Study 2 H (72, f = 72)	18.91 (2.65) 19.28 (1.83)	AP	Images of body parts and body shapes	_
EDs					
Anselmi et al., 2011	OB (43, f = 25) H (331, f = 214)	34.30 (10.01) 26.16 (8.07)	IAT	Faces of thin and fat people	_
Cserjési et al., 2010	AN (35, f = 35) H (35, f = 35)	19.61 (3.42) 20.27 (3.93)	AP	Ultra-thin, average-size, overweight bodies	_
Izquierdo et al., 2019	FP-AN (39, f = 39) NFP-AN (13, f = 13) Low-weight ARFID (10, f = 10) H (32, f = 32)	19.5 (2.5) 18.3 (3.6) 15.2 (3.6) 17.4 (3.1)	IATs	EDI-3 statements; underweight or normal-weight body pictures	_
Keng and Ang, 2019	AN/BN/BED (81, f = 81)	Range 18–55 years	IAT	Body-related words	Mindful breathing exercise vs resting condition
Khan and Petróczi, 2015*	AN (14, f = 14) BN (24, f = 24) EDNOS (16, f = 16). At-risk ED (41, f = 41) H (23, f = 23)	27.00 (12.95) 21.54 (6.19) 20.19 (5.69) 21.56 (7.83) 23.00 (4.97)	IBI-BIAT PBI-BIAT FP-AAT	Normal vs thin silhouettes; High-fat foods vs low-fat foods	_
Parling et al., 2012	AN (12, f = 12) Sub-AN (5, f = 5) H (17, f = 17)	25.33 (6.0) 23.40 (4.4) 24.76 (5.5)	IRAP	'Pro-thin/anti-fat' or 'anti-thin/pro-fat' words	_
Smith et al., 2014	AN (30, f = 30) H (29, f = 29)	20.03 (2.83) 18.93 (1.41)	AP	'Beauty' words (e.g. glamorous, beautiful and attractive), 'ugly' words (e.g. hideous, gross and disgusting), 'neutral' word (e.g. mailbox, cloud and desktop), 'positive' words (e.g. happy, cheerful and elated) in a lexical decision task	Emaciation prime (photos of emaciated looking women) vs thin prime (photos of thin women)
Smith et al., 2018	AN/sub-AN (32, f = 31) BN/sub-BN (37, f = 36) Other ED (23, f = 21) H (85, f = 39)	28.34 (7.88) 32.00 (12.93) 40.35 (12.00) 36.38 (10.75)	AMP	ED-symptom images (emaciation, binge eating, hard exercise and vomiting); body stimuli images (average weight female bodies); eating stimuli images (women eating and words related to eating, e.g. dining, snacking and eating)	_
Spring and Bulik, 2014*	AN (9, f = 9) Recovered AN (14, f = 14) H (29, f = 29)	21.4 (5.79)	AMP	High/low calorie food images and fatness/thinness related images	_

AN = anorexia nervosa; AMP = Affective Misattribution Procedure; AP = affective priming; ARFID = avoidant/restrictive food intake disorder; BED = binge eating disorder; BN = bulimia nervosa; ED = eating disorder; EDNOS = eating disorder not otherwise specified; f = female; FP-AAT = Food Preference Approach Avoidance Task; FP-AN = fat-phobic anorexia nervosa; H = healthy participants; IAT = Implicit Association Test; IBI-BIAT = Ideal Body Image Brief Implicit Association Test; IRAP = Implicit Relational Assessment Procedure; NFP-AN = non-fat phobic anorexia nervosa; n.r. = not reported; OB = obese; OW = overweight; PBI-BIAT = Personal Self Identification Body Image Brief Implicit Association Test; RRT = Relational Responding Task. *Studies measuring implicit attitudes on both body and food (data on food implicit preferences are presented in the food section).

participants with overweight and obesity. With this population, seven studies employed the two-categories IAT, four studies the SC-IAT, three studies the AP and one a semantic priming paradigm (Werrij *et al.*, 2009). The EAST was used in two studies (Craeynest *et al.*, 2005, 2008a) and the IRAP in one (McKenna *et al.*, 2016). The study by Roefs *et al.* (2005) reported two separate experiments which compared performance at the AP task between patients with AN *vs* control participants and people with obesity *vs* control participants, respectively. Concerning the type of stimuli, 47 out of 75 studies used images of food in the implicit tasks, whereas 27 studies employed words of food representing different types of target categories and a study (Becker *et al.*, 2015) used both words or images in different tasks (see Table 3).

Studies investigating food attitudes in healthy normal-weight participants could be grouped on the basis of three main objectives: (i) to assess implicit and explicit measures as predictors of eating behaviour; (ii) to measure differences in implicit food attitudes between individuals or groups with different features in eating behaviour and their relationship with ED symptoms; (iii) to evaluate the impact of manipulations regarding the context, the hunger state or the type of stimuli on implicit food attitudes. Similarly, studies including participants with obesity or overweight aimed at (i) exploring between-group differences in implicit food attitudes or (ii) assessing the effect of manipulations and training programmes on eating behaviour and attitudes.

Implicit attitudes as predictors of eating behaviour. A first study by Perugini (2005) measured implicit and explicit attitudes toward snacks and fruits to test their validity to predict the following behaviour in food choice. Results are discussed as supporting a double dissociation model of the impact of implicit and explicit attitudes on behaviour, since the IAT was significantly related to spontaneous food choice whereas explicit questionnaire was significantly related to self-reported behaviour. Following studies supported this model (Pavlović *et al.*, 2016; Songa and Russo, 2018) and showed the moderating effect of ED symptoms (Ellis *et al.*, 2014) and of individual differences in habit in food behaviour and need for cognition (Conner *et al.*, 2007) on the relative predictive impact of explicit and implicit measures for the subsequent food choice. In line with this evidence, the study by McConnell *et al.* (2011) reported that both IAT and explicit preference predicted the actual affective experience for eating, but affective forecasting errors were predicted only by the implicit measure suggesting the role of unconscious evaluation in blind affective predictions. Moreover, implicit attitudes have been shown to predict everyday chocolate consumption with interactive patterns of relationship with hunger and craving (Richard *et al.*, 2019). Differently, other studies did not show incremental validity of implicit over explicit measures in predicting food choice, eating behaviour or body mass index (BMI) (Ayres *et al.*, 2012; Ackermann and Palmer, 2014; Woodward and Treat, 2015; Maas *et al.*, 2017; Woodward *et al.*, 2017)

Seven studies investigated how the relationship between implicit and explicit measures and food choice behaviour was influenced by different conditions of cognitive load or self-regulatory resources (Friesen *et al.*, 2008; Eschenbeck *et al.*, 2016; Trendel and Werle, 2016; Wang *et al.*, 2016), positive or negative priming manipulation (Ashby and Stritzke, 2013), emotional induction (Bongers *et al.*, 2013) or manipulation of cognitive or affective focus (Genschow *et al.*, 2017). Six of these studies consistently reported the predictive validity of implicit measures on the following choice behaviour and also found significant effects of the different manipulations (Friesen *et al.*, 2008; Ashby and Stritzke, 2013; Bongers *et al.*, 2013; Eschenbeck *et al.*, 2016; Trendel and Werle, 2016; Wang *et al.*, 2016). Similarly, Nederkoorn *et al.* (2010) showed that implicit preference for snack food interacted with response inhibition capacity in predicting weight change over a year. In contrast, the most recent study by Genschow *et al.* (2017) did not replicate the significant effect of different implicit measures [EAST, AP and manikin task (MT)] in predicting the actual behaviour, neither found significant impact of conditions focusing participants' attention on cognitive or affective aspects.

Another line of research on food perception demonstrated the automaticity of unhealthy–tasty food association and in turn its relationship with body fat (Raghunathan *et al.*, 2006; Mai and Hoffmann, 2015), although the opposite healthy–tasty food association has been reported in a French sample, suggesting intercultural differences in food evaluation (Werle *et al.*, 2013). Moreover, a relevant role of food type has been suggested by Coricelli *et al.* (2019), who showed different implicit attitudes related to restrictive eating habits and healthiness explicit evaluation, for natural and transformed food matched for calories content. Finally, one study did not assess the actual behaviour, but investigated food attitudes transmission in social contexts testing dyads composed by students with a parent or a friend: results revealed that students' implicit, but not explicit, attitudes toward fruits were associated with those of parents, whereas explicit, but not implicit, attitudes toward snacks were associated with those of friends (Guidetti *et al.*, 2012).

Individual differences and relation with ED symptoms. Five studies compared groups of restrained *vs* unrestrained eaters using implicit paradigms on high-fat and low-fat foods (Roefs *et al.*, 2005a; Papies *et al.*, 2009; Houben *et al.*, 2010, 2012; Veenstra and de Jong, 2010). Different results are reported depending on stimuli and tasks. Indeed, positive association with high-fat palatable food in both restrained and unrestrained groups is reported in studies using Simon paradigm tasks and AP (Roefs *et al.*, 2005a; Veenstra and de Jong, 2010), although stronger AP in unrestrained eaters is reported by Papies *et al.* (2009). No positive associations with high-caloric snacks and no group differences emerged using IAT with fruit and snack targets (Study 1 in Houben *et al.*, 2001); in contrast, positive associations with snacks resulted using SC-IAT and this positivity was larger in restrained eaters (Study 2 in Houben *et al.*, 2001). Restrained eaters also showed more positive associations than unrestrained eaters with palatable food in SC-IAT, independently from the caloric food density (Houben *et al.*, 2012).

One study compared women with premenstrual dysphoric disorder (PMDD) and controls assessed with an IAT on high-sweet-fat and high-salted-fat food (Yen *et al.*, 2010). Changes in appetite, overeating and increased food craving are some of PMDD diagnostic criteria; accordingly, the study reported higher implicit positive responses to high-sweet-fat food and higher craving response to food in PMDD group and in women in luteal phase, supporting differences in women's appetite related to menstrual cycle, the relevance of eating assessment in PMDD and the feasibility of implicit measure to evaluate these aspects (Yen *et al.*, 2010).

Four studies investigated the relationship between implicit food preferences and individual variables (Pechey *et al.*, 2015; Sato *et al.*, 2016; Werntz *et al.*, 2016; Misener and Libben, 2017). Sato *et al.* (2016) showed significant AP effect in evaluating faces subliminally primed by food or mosaic images, with no differences between high-fat and low-fat food and reported that this effect correlated with individual external eating. In line with this, a semantic priming paradigm showed that priming effect did not differ between ED-related word pairs and non-ED-related word pairs across the whole sample of female students, but higher scores on ED questionnaires and body dissatisfaction were associated with increased priming for ED-related word pairs as compared to non-ED-related word pairs (Misener and Libben, 2017). Moreover, data from website studies showed that implicit preferences for fruit measured with a SC-IAT were significantly related to socioeconomic variables and gender (Pechey *et al.*, 2015), and IAT with high-fat *vs* low-fat foods and shameful *vs* acceptable attributes predicted symptoms and concerns related to EDs with stronger high-fat food to shameful association in participants reporting higher score in a EDs questionnaire (Werntz *et al.*, 2016).

Finally, contrasting results come from studies measuring both food and body attitudes: correlations between thin preference and positive evaluation of permitted and forbidden foods are reported by Moussally *et al.* (2015), in line with results from Spring and Bulik (2014) of higher negative implicit affect toward high-fat food and overweight body images in patients with AN compared to healthy controls; in contrast, Khan and Petróczi (2015) showed that body implicit attitude discriminated between ED and control individuals whereas no differences emerged for food attitudes.

Manipulation effects on implicit attitudes. One study investigated the AP effect manipulating the strength of the positive or negative food prime stimuli, which were individually selected to be extremely or moderately related to positive and negative affects (Lamote *et al.*, 2004). Results showed that the significant AP effect was not moderated by the evaluative extremity of the prime.

Five studies measured implicit food attitudes in participants with different hunger states (Seibt *et al.*, 2007; Hoefling and Strack, 2008; Stafford and Scheffler, 2008; Kraus and Piqueras-Fiszman, 2016; Sato *et al.*, 2017). Administering both motivational and evaluation IATs, Kraus and Piqueras-Fiszman (2016) highlighted that hunger state affected the first, but not the latter implicit attitudes measure. Other studies reported that participants in high *vs* low hunger state showed increased food preference in an IAT with food and non-food stimuli (Seibt *et al.*, 2007; Stafford and Scheffler, 2008) and increased food preference in supraliminal and subliminal AP tasks with food and mosaic images (Sato *et al.*, 2017). Similarly, hunger state increased the positive association with both high- and low-calorie foods compared to control stimuli in an EAST paradigm (Hoefling and Strack, 2008). This last study compared groups of restrained and unrestrained eaters and reported the same effect of hunger state manipulation in both groups, although restrained eaters had larger positive automatic associations with high-calorie food (Hoefling and Strack, 2008).

One study investigated the effect of sleep restriction on IAT with high- and low-calorie food and reported that food attitudes were not affected by sleep condition in the whole sample, whereas a significant sex by condition interaction revealed that males had greater association of low-calorie food with positive attributes than females in rest condition; no sex difference appeared in sleep restricted condition (Alkozei *et al.*, 2018).

Eleven studies investigated the impact of different conditioning procedures on IAT: evaluative conditioning (EC; Hollands *et al.*, 2011; Lebens *et al.*, 2011; Hensels and Baines, 2016; Alblas *et al.*, 2018), approach-avoidance training (Becker *et al.*, 2015; Kakoschke *et al.*, 2017; Schakel *et al.*, 2018; Van Dessel *et al.*, 2018), response inhibition training (Adams *et al.*, 2017), ego-depletion and self-affirmation procedures (Storr and Sparks, 2016) and disgusting odour exposure (Mayer *et al.*, 2008). These studies used between groups designs comparing participants randomly assigned to different experimental procedures. EC procedures paired images of unhealthy foods with images of potential adverse health consequences, negative facial expressions or body shapes (Hollands *et al.*, 2011; Lebens *et al.*, 2011; Hensels and Baines, 2016) or used video games to strengthen positive associations with fruits and negative associations with chocolate snacks (Alblas *et al.*, 2018). Similarly, video games or computer tasks were used to train participants to approach healthy food and avoid unhealthy food (Bleckert *et al.*, 2015; Kakoschke *et al.*, 2017; Schakel *et al.*, 2018; Van Dessel *et al.*, 2018). Most of studies assessing implicit attitudes following experimental trainings or EC reported healthier food preference in experimental groups, who received manipulations aimed at increasing positive association to healthy food (Lebens *et al.*, 2011; Hensels and Baines, 2016; Kakoschke *et al.*, 2017; Schakel *et al.*, 2018; Van Dessel *et al.*, 2018). Differently, a study investigating the effect of a response inhibition training on implicit food attitudes reported the absence of manipulation-related modulations (Adams *et al.*, 2017), and one study reported that approach-avoidance training did not affect implicit preferences (Bleckert *et al.*, 2015). Other studies administered the IAT in pre- and post-assessment: Hollands *et al.* (2011) reported significant interaction between baseline IAT and intervention, with EC reducing preference for snacks *vs* fruits in individuals with stronger preference at baseline; Alblas *et al.* (2018) showed that preference for fruit *vs* chocolate decreased in the control group, but not in the EC group. Disgusting odours spread in the room while participants performed IAT with high- and low-calorie foods did not affect IAT score (Mayer *et al.*, 2008). Finally, Storr and Sparks (2016) reported stronger positive associations with high-calorie foods and negative associations with low-calorie foods in unrestrained compared to restrained eaters, but ego-depletion and self-affirmation procedures did not differently affect restrained and unrestrained eaters in implicit food attitudes.

Group differences in obesity and overweight. Different studies compared healthy-weight participants and participants with obesity for their implicit attitudes towards unhealthy-fat *vs* healthy-low-fat foods with different types of tasks (see Table 3). Seven of these papers consistently reported more positive attitudes towards healthy food both in healthy-weight adult participants and adult participants with obesity (Roefs and Jansen, 2002; Roefs *et al.*, 2005b; Alabduljader *et al.*, 2018) as well as in children with obesity and healthy-weight (Craeynest *et al.*, 2005, 2006, 2007, 2008b), with no differences between groups in implicit measures. The absence of group differences was also reported in a study showing that both women with obesity and healthy-weight associated high-fat food to restraint concepts (Werrij *et al.*, 2009). On the other hand, participants with obesity responded slower to the high-fat/positive combination than controls in an IAT (Roefs and Jansen, 2002) and showed more positive implicit attitude towards both healthy and unhealthy food in an EAST paradigm (Craeynest *et al.*, 2005). Five other studies reported group differences, with participants with obesity showing greater approach bias to food in a IAT with food and non-food categories and approach *vs* avoidance attributes (Kemps and Tiggemann, 2015), higher implicit preference for large fast food portion in an AP paradigm (Cserjesi *et al.*, 2016) and higher preference for sweet than non-sweet food in an IAT (Sartor *et al.*, 2011). Moreover, women with obesity showed significantly more negative attitudes to high-calorie sweet foods and positive attitudes to high-calorie savoury foods compared to healthy- and over-weight participants, with inconsistent results from explicit preference (Czyzewska and Graham, 2008). In line with this result, discrepancy between IAT score and explicit attitudes for chocolate predicted disinhibited eating in healthy- and over-weight participants in a following study (Goldstein *et al.*, 2014).

Effects of manipulations and training on implicit attitudes in obesity. One study reported that manipulation of focus of attention or craving induction affected AP of participants with obesity or lean participants in the same direction with no significant differences between groups (Roefs *et al.*, 2006). Differently, McKenna *et al.* (2016) reported that participants with obesity and normal-weight participants differed in the automatic responses to healthy and unhealthy food in an IRAP on hunger state and that the groups were differently affected by manipulation of food restriction prior to the assessment. The same paper reported the absence of group differences on IRAP measuring automatic food wanting (McKenna *et al.*, 2016). Five studies used implicit measures as outcome measures following treatments for individuals with obesity (Craeynest *et al.*, 2008a; Sartor *et al.*, 2011; Ferentzi *et al.*, 2018; Verbeken *et al.*, 2018; Warschburger *et al.*, 2018). Craeynest *et al.* (2008a) reported that children with obesity reduced positive attitude towards healthy and unhealthy food in post-treatment EAST. The other studies showed that IAT score was not affected by intervention of soft drink supplementation (Sartor *et al.*, 2011) and approach avoidant training in adults and children with obesity (Ferentzi *et al.*, 2018; Warschburger *et al.*, 2018; Verbeken *et al.*, 2018).

Studies on body image

Our search retrieved 27 studies about implicit attitudes toward body image (Table 4). Studies using body images to measure weight bias or to investigate neural correlates involved in body representation are reported in the weight bias and neurobiological section, respectively. Eighteen studies involved healthy normal-weight participants, whereas nine studies included samples with EDs. Considering the first groups, most of the studies recruited participants from general population ($N = 14$), whereas the other four studies involved special categories: parents of children with obesity (Lydecker *et al.*, 2006), nurses (Robstad *et al.*, 2018), medical students (Matharu *et al.*, 2014) and clinicians (Sabin *et al.*, 2015). Nine out of 18 studies measured implicit attitudes using the two-categories IAT, whereas in one study participants underwent a multiple-categories IAT (Marini, *et al.*, 2017). Two studies (Lydecker *et al.*, 2006; Robstad *et al.*, 2018) combined two different IATs to test both implicit valence attitudes (by using valence related words, i.e. good/bad) and stereotypes (by using judgement-related words, i.e. stupid/smart or lazy/motivated). Four studies used the IRAP (Exposito *et al.*, 2015; Juarascio *et al.*, 2011; Heider *et al.*, 2015; Ritzert *et al.*, 2016), two the Relational Responding Task (Glashouwer *et al.*, 2018; Heider *et al.*, 2018), one the AMP (Moussally *et al.*, 2015) and one the AP (Watts *et al.*, 2008). Concerning the type of stimuli, 10 out of 18 studies compared thin and fat body images ($N = 7$) or related words ($N = 3$). Two studies used underweight and normal-weight silhouettes (Ahern *et al.*, 2008; Martijn *et al.*, 2013), one study tested implicit attitudes toward underweight, normal-weight and overweight/obese categories (Marini *et al.*, 2017), whereas four studies used sentences to elicit implicit attitudes toward actual and ideal body images (Heider *et al.*, 2015 2018; Glashouwer *et al.*, 2018) or attractiveness *vs* disgust/fear toward being thin or fat (Ritzert *et al.*, 2016). One study considered images of body parts and of body shape (Watts *et al.*, 2008). The impact of experimental manipulations on implicit attitudes toward body images was explored in two studies (Matharu *et al.*, 2014; Martijn *et al.*, 2013).

Looking at results, 7 out of 18 papers reported negative implicit attitude towards overweight/obese body images (Ahern *et al.*, 2006; Lydecker *et al.*, 2006; Robstad *et al.*, 2018; Elran-Barak and Bar-Anan, 2018; Sabin *et al.*, 2015; Moussally *et al.*, 2015; Watts *et al.*, 2008), when the stimuli were presented both for a short and a long period of time, likely reflecting more automatic or more controlled responses, respectively (Watts *et al.*, 2008). In one study, the self-thin attractive bias was stronger than the self-fat attractive bias (Ritzert *et al.*, 2016). Two studies showed stronger implicit preferences for normal-weight than underweight or overweight/obese body images (Ahern *et al.*, 2008; Marini, 2017), whereas one study did not report a defined bias towards body image as participants showed similar pro-slim and pro-fat implicit attitudes (Exposito *et al.*, 2015). The experimental manipulations were demonstrated to effectively decrease the positive implicit attitude towards underweight people (Martijn *et al.*, 2013) or the negative implicit attitude towards fat people (Matharu *et al.*, 2014). Four studies showed that body implicit attitudes could predict disordered eating, body image dissatisfaction and changes in weight (Juarascio *et al.*, 2011; Heider *et al.*, 2015 2018; Glashouwer *et al.*, 2018). In particular, a study reported that individuals faster in categorizing own actual, but not ideal, body image as fat showed higher body dissatisfaction compared to individuals who represented their actual body image as slim (Glashouwer *et al.*, 2018). One study showed that eating-relevant implicit associations were valid variables to test the negative effects of stereotype (e.g. weight-related peer teasing; Benas and Gibb, 2011). Most of the studies investigating body attitudes in healthy normal-weight participants reported no correlation between implicit and explicit measures. In contrast, four studies showed pro-slim/anti-fat attitudes at both implicit and explicit levels (Robstad *et al.*, 2018; Elran-Barak and Bar-Anan, 2018; Sabin *et al.*, 2015; Benas and Gibb, 2011), and such correlation was confirmed by Matharu *et al.* (2014) at the baseline measure, but not after experimental manipulation. Three studies did not investigate the correspondence between implicit and explicit attitudes (Watts *et al.*, 2008; Martijn *et al.*, 2013; Moussally *et al.*, 2015). Among the two out of 18 studies testing the predictive value of implicit and explicit attitudes on the behavioural measures, one study reported a negative correlation between implicit and explicit anti-fat bias and the possibility of helping patients with obesity (Robstad *et al.*, 2018). The other study showed that explicit, but not implicit, actual and ideal body image predicted food selection, caloric intake and restraint eating (Glashouwer *et al.*, 2018).

Considering the studies that tested implicit attitudes toward body image in samples of individuals with EDs, most of the studies ($N = 7$) evaluated body implicit attitudes in patients with AN and BN *vs* healthy controls. One study involved participants with obesity (Anselmi *et al.*, 2011), while another study considered patients with AN, BN and BED (Keng and Ang, 2019). Four studies measured implicit attitudes using the two-categories

IAT (Izquierdo et al., 2019; Anselmi, 2011; Keng and Ang, 2019; Khan and Petróczi, 2015). Among these, Izquierdo et al. (2019) added a questionnaire-based IAT using items from the Eating Disorders Inventory (Garner, 2004), whereas Khan and Petróczi (2015) tested both the ideal body image and the personal internalized body image. Two studies used the AP (Cserjési et al., 2010; Smith et al., 2014), other two the AMP (Spring and Bulik, 2014; Smith et al., 2018) and one study applied the Relational Responding Task (Parling et al., 2012). Regarding the type of stimuli, three studies measured implicit attitudes towards underweight or normal-weight silhouettes (Khan and Petróczi, 2015; Izquierdo et al., 2019) or towards thin- or fat-related images (Spring and Bulik, 2014); one study compared thin and fat face images (Anselmi et al., 2011). Parling et al. (2012) used words to elicit body shape and weight concerns, while Keng and Ang (2019) used body-related and -unrelated words. The other three studies used ultra-thin, average-size, overweight body images (Cserjési et al., 2010), ED-symptom and body images (Smith et al., 2018) and beauty-related words in a lexical decision task (Smith et al., 2014). Records testing whether an experimental manipulation affected body implicit attitudes showed that exposure to primes of emaciated bodies increased pro-thin bias in women with AN (Smith et al., 2014), while exposure to mindfulness exercises did not alter implicit body dissatisfaction of patients with ED compared to resting condition (Keng and Ang, 2019).

Three studies reported that patients with AN and BN showed pro-thin implicit bias compared to healthy subjects (Izquierdo et al., 2019; Smith et al., 2018; Khan and Petróczi, 2015); similar results were shown by Anselmi et al. (2011) in a group of patients with obesity, compared to healthy controls. Conversely, Spring and Bulik (2014) reported that patients with AN, compared to recovered AN individuals and healthy controls, showed negative implicit affect towards overweight stimuli, but not an automatic attraction to thinness. Both pro-thin and anti-fat bias in patients with AN were reported by Parling et al. (2012), whereas only anti-fat bias emerged in Cserjési et al. (2010), and healthy samples of both studies were characterized by pro-thin preference, but not by anti-fat preference.

Concerning the correlation between implicit and explicit body attitudes, four studies out of nine reported mixed results (Parling et al., 2012; Khan and Petróczi, 2015; Cserjési et al., 2010; Spring and Bulik, 2014). While one study showed consistent null effect of mindfulness on both implicit and explicit body dissatisfaction (Keng and Ang, 2019), the other four records did not investigate possible correlation between implicit and explicit measures. Among the records on ED samples, only one study reported the predictive value of the implicit attitudes on the ED behaviours (Smith et al., 2018).

Studies on weight bias

Weight bias towards overweight and individuals with obesity has been investigated in 78 studies, using both explicit and implicit measures of preference for ‘fat’ or ‘thin’ attributes (Table 5). In order to measure weight stigma, the majority of these studies ($N = 66$) used the two-categories IAT. A minority of studies used either the SC-IAT (Lynagh et al., 2015; Aweidah et al., 2016), the AMP (Pryor et al., 2013; Skinner et al., 2017; Karsay and Schmuck, 2017) or the IRAP (Baker et al., 2017), whereas two studies (Roddy et al., 2010 2011) paired the two-categories IAT with the IRAP and four papers employed the AP (Degner and Wentura, 2009; Brochu et al., 2011; Glock et al., 2016; Rudolph and Hilbert, 2017). Concerning the type of stimuli employed in the implicit tasks, 27 out of 78 studies used images of thin and fat people, two studies (Anselmi et al., 2013; Penney et al., 2013) used morphed faces of normal-weight and overweight individuals and four studies employed pictures of average-weight and overweight children. Forty-five studies employed words representing different types of target categories whereas one study (Teachman et al., 2003) used both images and words as target categories in different IATs. Regarding the samples, five studies (Carels et al., 2009a, 2009b, 2010, 2011, 2014) recruited adults with overweight

Table 5. Details of studies on weight bias

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Agerström et al., 2007	Study 2A: Students (88, f = 58) Study 2B: Employers (166, f = 82)	22.25 (5.73) 43.19 (10.45)	IAT	Obese/normal weight	-
Agerström and Rooth, 2011	Managers (153, f = 77)	40.0 (10.41)	IAT	Obese/normal-weight	Manipulation of weight status of job candidates
Anselmi et al., 2013	UW (53) HW (331) OW (83) OB (43) f = 327 of the entire sample	27.06 (8.99)	IAT	Fat/thin people	-
Aweidah et al., 2016	Diagnostic radiography clinical educators (37, f = 23)	n.r.	SC-IAT	Fat	-
Baker et al., 2017	Five classes of medical students	No demographic data were collected	IRAP	Overweight/obese/ slim/thin	-
Bissell and Hays, 2011	H (601, f = 331)	n.r.	IAT	Overweight/thin children	Exposure to images of overweight/thin children
Brauhardt et al., 2014	BED (26, f = 21) OB (26, f = 21) HW (26, f = 21)	34.77 (10.29) 35.19 (11.08) 34.65 (10.70)	Weight Bias-IAT; Self-Esteem-IAT	Thin/fat Self/other	-

Table 5. (Continued)

Studies	Sample (*N*)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Brewis and Wutich, 2012	H from Paraguay (200, f = 200) H from the USA (66, f = 48)	38.9 (13.4) 23.68 (11.2)	IAT	Fat/thin people	-
Brewis *et al.*, 2016	Study 1: HW (116) OW (61) OB (27) f = 103 of the entire sample	23 (n.r.)	IAT	Slim/Fat	-
Brochu and Morrison, 2007	UW (2) AW (75) OW and OB (17) f = 61 of the entire sample	20.11 (4.0)	IAT	Average-weight/overweight people	-
Brochu *et al.*, 2011	University students (80, f = 53)	19.74 (5.05)	AP	Over-weight/normal-weight	-
Carels *et al.*, 2009a	OW and OB (58, f = 52)	47.6 (10.3)	IAT	Fat/thin people	Weight loss intervention
Carels *et al.*, 2009b	OW and OB (58, f = 52)	n.r.	IAT	Fat/thin people	Weight loss intervention
Carels *et al.*, 2010	OW and OB (54, f = 44)	48.7 (11.7)	IAT	Fat/thin people	Weight loss intervention
Carels *et al.*, 2011	OW and OB (53, f = 41)	47.15 (14.1)	Weight Bias-IAT; Self-Esteem-IAT	Fat/thin people Self/other	Weight loss intervention
Carels *et al.*, 2013	OW/OB (42, f = 30) following a weight loss intervention OW/OB (47, f = 38) before a weight loss intervention	46.9 (13.0) 53.7 (13.2)	Stereotype congruent IAT; Stereotype incongruent IAT	Fat/thin people	-
Carels *et al.*, 2014	OW/OB (44, f = 37)	53.2 (13.6)	IAT	Obese/thin people	Weight loss intervention
Cazzato and Makris, 2019	HW (18, f = 11) OW (18, f = 12)	25.28 (0.99) 24 (0.89)	IAT	Fat/slim	-
Chambliss *et al.*, 2004	Undergraduate H (136, f = 57) Graduate in exercise science H (110, f = 53)	Men = 22.7 (2.9) Women = 21.4 (2.9) Men = 25.79 (4.8) Women = 23.5 (2.4)	Weight-attitude IAT; Weight-stereotype IAT	Fat/thin people Fat/thin people	-
Degner and Wentura, 2009	Study 1 (47, f = 24) UW (8) NW (31) OW (8) Study 2 (50, f = 28) UW (5) NW (36) OW (9) Study 3 (65, f = 41) UW (7) NW (39) OW (10) Study 4 (55, f = 55) UW (4) NW (50) OW (1)	25 (n.r.) 21 (n.r.) 23 (n.r.) 47 (n.r.)	AP	Normal-weight/overweight individuals	-
Dimmock *et al.*, 2009	H fitness centre employees (70, f = 40)	27 (9.53)	IAT	Overweight/thin people; Overweight/thin exerciser	-
Domoff *et al.*, 2012	Psychology students (64, f = 42)	20.0 (2.9)	IAT	Fat/thin people	Exposition to a 40-min weight-loss reality shows

Table 5. (Continued)

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Flint et al., 2013	H (28, f = 11)	22.43 (3.59)	IAT	Fat/thin	Counter-conditioning using positive images of obese members of the general public and images of obese celebrities
Flint et al., 2015	H (2380, f = 1767)	27.71 (1.03)	IAT	Fat/thin	-
Flint et al., 2016	Employees (181, f = 74)	38.25 (8.99)	IAT	Fat/thin	Manipulation of weight status of job candidates
Fontana et al., 2013	Physical education teachers (47, f = 28)	37.07 (13.22)	IAT	Fat/thin people	-
Fontana et al., 2017	Professors in physical education departments (94, f = 47)	47.83 (12.18)	IAT	Fat/thin people	-
Gapinski et al., 2006	Undergraduate students (108, f = 108)	19.06 (1.01)	IAT	Fat/thin people	Exposition to a media-based videos intervention
Geier et al., 2003	H (59, f = 59)	19.1 (0.23)	Four IATs	Fat/thin	Exposition to a 'before and after' diet advertisement
Geller and Watkins, 2018	First year medical students H cohort	No demographic data were collected	Weight-attitude IAT; Weight-stereotype IAT	Fat/thin people Fat/thin people	Ethics group session
Glock et al., 2016	Teachers (51, f = 48)	21.12 (6.15)	AP	Words reflecting obesity/thinness	-
Grover et al., 2002	HW (42, f = 22) OW (41, f = 20)	HW men 36.3 (12.7) OW men 32.2 (11.4) HW women 27.8 (11.2) OW women 35.1 (13.8)	Weight-attitude IAT; Weight-identity IAT; gender attitude IAT; gender identity IAT; self-attitude IAT	Light/heavy Self/other Female/male Self/other Self/other	-
Gumble and Carels, 2012	Psychology students (85, f = 47)	19.9 (3.7)	Weight-bias IAT; Weight-identity IAT; Self-esteem IAT; Body image IAT	Fat/thin Self/Other Self/Other Self/Other	-
Halvorson et al., 2019	Hospital attendants (10, f = 7) Pediatric residents (10, f = 7) Pediatric nurses (8, f = 8) Patients (12, f = 7) Parents/caregivers (12, f = 10)	34 (n.r.) 29.0 (n.r.) 31.5 (n.r.) 15 (n.r.) n.r.	IAT	Thin/obese people	-
Hand et al., 2017	Students (302, f = 218)	16 (n.r.)	IAT	n.r.	-
Hart et al., 2016	H African American (207, f = 207) H Non-Hispanic Whites (310, f = 310)	34.45 (10.83) 32.42 (11.17)	Revised-IAT	Overweight/underweight, obese/underweight, overweight/obese	-

Table 5. (Continued)

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Hilbert and Meyre, 2016	Study 1: University students (128; f = 79) Study 2: Volunteers (128, f = 79)	23.01 (3.24) 35.31 (12.54)	IAT IAT	Thin/fat Thin/fat	Educational intervention about the multifactorial aetiology of obesity
Hinman et al., 2015	Students (117, f = 92)	19.3 (1.5)	Stereotype congruent IAT; Stereotype incongruent IAT	Fat/thin Fat/thin	-
Hutchison and Müller, 2018	Children (84, f = 43)	5.89 (1.11)	IAT	Fat/thin children	-
Jiang et al., 2017	104 Asian students UW (23, f = 23) HW (67, f = 67) OW (9, f = 9) OB (5, f = 5)	21.6 (3.3)	IAT	Fat/thin	-
Karsay and Schmuck, 2017	Adolescent (353, f = 176)	17.34 (1.09)	AMP	Obese/non-obese individuals	Exposition to a reality TV show 'The Biggest Loser Teens'
Lund et al., 2018	General practitioners (240, f = 86)	18.5 (10.2)	IAT	Fat/normal weight	-
Lynagh et al., 2015	H enrolled in the health and physical educational curricula for trainee teachers (62, f = 30) H nonspecialist trainee teachers (177, f = 104)	Three age groups: 18–20 years (Specialist = 38, nonspecialist = 106) 21–23 years (Specialist = 14, nonspecialist = 24) >24 years (Specialist = 7, nonspecialist = 16)	SC-IAT	Fat	-
Marini et al., 2013	Volunteers from 71 nations (338.121, f = 238.357)	27.8 (10.64)	IAT	Thin/overweight people	-
Miller et al., 2013	Medical students (310, f = 132)	<25 years = 131 (n.r.) 25–28 years = 145 (n.r.) >28 years = 29 (n.r.)	IAT	Fat/thin	-
O'Brien et al., 2007a	Study1 H (227, f = 140) Study2 H (134, f = 99)	19.98 (2.91) 20.09 (4.199	IAT	Fat/thin people	-
O'Brien et al., 2007b	H (344, f = 230) First (122) and third (58) year of physical education degree programme; First (95) and third (69) year of psychology programme	First year psychology 18.49 (0.75); First year physical education 18.68 (1.3); Third year psychology 21.8 (4.1); Third year physical education 21.6 (1.9)	Weight-attitude IAT; Weight-stereotype IAT	Fat/thin people Fat/thin people	-
O'Brien et al., 2008	H (104, f = 82)	20.35 (5.04)	Weight-attitude IAT; Weight-stereotype IAT	Fat/thin people Fat/thin people	Manipulation of weight status of job candidates
O'Brien et al., 2010	H (159, f = 135)	20.29 (2.32)	Weight-attitude IAT; Weight-stereotype IAT	Fat/thin people Fat/thin people	Tutorial classes

Table 5. (Continued)

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Penney and Lawsin, 2013	Students (186, f = 121)	19.7 (3.9)	IAT	Thin/obese faces	-
Phelan et al., 2014	Medical students (4.732, f = 2363)	23.9 (n.r.)	IAT	Fat/thin people	-
Phelan et al., 2015a	Medical students (4687, f = 2.344) HW (3378) UW (163) OW (922) OB (224)	23.9 (2.6)	IAT;	Fat/thin people	-
Phelan et al., 2015b	Medical students (1795, f = 917)	N = 575 19–22 years N = 456 23 years N = 473 24–25 years N = 281 >26 years	IAT	Fat/thin people	-
Pryor et al., 2013	H (100, f = 60)	19.62 (1.42)	AMP	-	Cyberball game
Robertson and Vohora, 2008	Fitness professionals (57, f = 25)	29–30 (10.239)	IAT	Fat/thin people	-
Robinson et al., 2014	Health and non-health students (479)	26.2 (7.6)	IAT	Fat/thin people	-
Roddy et al., 2010	Psychology students (80, f = 58)	21.1 (3.4)	IAT IRAP	Overweight/average-weight people Overweight/average-weight people	-
Roddy et al., 2011	Students (78, f = 5)	20.25 (3.67)	IAT IRAP	Overweight/average-weight people Overweight/average-weight people	-
Rudolph and Hilbert, 2017	Individuals from the community (144)	n.r.	AP	Normal-weight/obese full body pictures	Exposure to health messages
Rukavina et al., 2010	Kinesiology pre-professionals (78, f = 26)	21.63 (1.49)	Weight-stereotype IAT	Fat/thin	Classroom and service learning components
Russell-Mayhew et al., 2015	Preservice teachers (30, f = 25)	32	IAT	n.r.	Exposure to a professional workshop
Sabin et al., 2012	All test takers (3 59 261, f = 220) Medical doctors (2284, f = 1285)	26 (10.7) 33 (12.5)	IAT	Overweight/thin people	-
Schwartz et al., 2003	Professionals engaged in research and/or clinical management of obesity (389, f = 198)	n.r.	Weight-attitude IAT; Weight-stereotype IAT	Fat/thin people Fat/thin people	-
Schwartz et al., 2006	UW (128) HW (1756) OW (899) OB (899) EOB (600) f = ∼3.555 of the entire sample (approximately 95% of respondents completed demographic information)	34.6 (n.r.)	Obesity attitude IAT; Obesity stereotype IAT	Fat/thin people Fat/thin people	-

Table 5. (Continued)

Studies	Sample (N)	Mean age (SD)	Implicit measure	Target categories	Manipulation
Scrivano et al., 2017	Students (166)	20.48 (2.31)	IAT	Obese/thin individuals	Exposure to an education about the uncontrollable causes of obesity
Skinner et al., 2017	Children (114, f = 56)	10	AMP	Average-weight/overweight children	-
Solbes and Enesco, 2010	H (120, f = 60)	40 H 6.9 (n.r.) 40 H 8.9 (n.r.) 40 H 10.8 (n.r.)	IAT (child-oriented version)	Fat/thin children	-
Swift et al., 2013	H: CG (21, f = 18) IG (22, f = 18)	21.2 (0.8) 24.6 (7.2)	Weight-attitude IAT; Weight-stereotype IAT	Fat/thin Fat/thin	Anti-stigma films
Teachman and brownell, 2001	Health care specialist (84, f = 24)	48 (9.81)	Weight-attitude IAT; Weight- stereotype IAT	Fat/thin people Fat/thin people	-
Teachman et al., 2003	Study 1: H (144, f = 78) Study 2A: H (90, f = 90) Study 2B: H (63, f = 32)	35 (13.99) 21 (3.87) 42 (16.51)	Weight-attitude IAT; Weight-stereotype IAT Weight-attitude IAT; Weight-stereotype IAT Weight-stereotype IATs	Fat/thin people Fat/thin people Fat/thin people Overweight/under weight people Fat/thin people	Providing information about genetic *vs* behavioural causes of obesity Written stories of weight discrimination Story of a severe weight discrimination
Thomas et al., 2007	Study 2: Children (94, f = 49)	5	IAT	Fat/thin people	-
Tomiyama et al., 2015	Obesity specialists (232, f = 134)	42.52 (12.82)	Weight-attitude IAT; Weight-stereotype IAT	Fat/thin people Fat/thin people	-
Vallis et al., 2007	Healthcare providers (78, f = 69)	37.39 (10.72)	IAT	Fat/thin people	-
Venturini et al., 2006	Students (45, f = 31)	n.r.	IAT	Normal-weight/fat woman	-
Waller et al., 2012	Nursing H (45, f = 39) Psychology H (45, f = 35)	24.7 (n.r.) 25.60 (n.r.)	IAT	Normal-weight/overweight man and women; normal-weight/overweight man and women in a medical setting	-
Wang et al., 2004	Study 1: HW (64, f = 60) Study 2: OW (48, f = 33)	43.1 (9.4) 48.9 (9.2)	IAT IAT	Fat/thin people Fat/thin people	-
Weinsten et al., 2008	Students (50, f = 35)	n.r.	IAT	Obese/thin	-
Wijayatunga et al., 2019	H (67, f = 64) CG (34, f = 22) IG (33, f = 21)	21.76 (1.43) 21.5 (1.11) 22.03 (1.67)	IAT	Obese/thin people	Learning about uncontrollable cause of obesity and about weight bias

AMP = Affective Misattribution Procedure; AP = affective priming; AW = average weight; BED = binge eating disorder; CG = control group; EOB = extremely obese; f = female; H = healthy participants; HW = healthy weight; IAT = Implicit Association Test; IG = intervention group; IRAP = Implicit Relational Assessment Procedure; n.r. = not reported; OB = obese; OW = overweight; SC-IAT = Single category IAT; UW = underweight.

or obesity engaged in a behavioural weight-loss treatment. Five studies (Solbes and Enesco, 2010; Bissell and Hays, 2010; Hutchison *et al.*, 2018; Skinner *et al.*, 2017; Thomas *et al.*, 2007) involved healthy children, whereas 13 studies involved adult professionals treating obesity. Twenty-six studies analysed the weight bias in healthy university students, whereas two studies (Agerström and Rooth, 2011; Flint *et al.*, 2016) focused on samples of managers and employees. Eight studies included normal-weight, under-weight, over-weight participants or individuals with obesity (Wang *et al.*, 2004; Schwartz *et al.*, 2006; Brochu and Morrison, 2007; Degner and Wentura, 2009; Anselmi *et al.*, 2013; Brauhardt *et al.*, 2014; Brewis *et al.*, 2016; Jiang *et al.*, 2017). One study (Grover *et al.*, 2003) focused on gender differences in weight bias, recruiting normal-weight and overweight males and females. One study (Brewis and Wutich, 2012) involved a sample of healthy women from Paraguay, whereas Hart *et al.* (2016) recruited two samples of healthy African American and non-Hispanic white women. Marini *et al.* (2013) recruited volunteers from 71 different nations. Fifteen papers investigated the effect of different manipulations on weight stigma in healthy students and volunteers.

Looking at results, some studies proved evidence for weight stigma at both explicit and implicit level in medical students (Miller *et al.*, 2013; Phelan *et al.*, 2014 2015b; Baker *et al.*, 2017). Weight bias was also found in samples of university students from different fields including psychology, nursing, business and physical education (Agerström *et al.*, 2007; Chambliss *et al.*, 2004; Gumble *et al.*, 2012; Lynagh *et al.*, 2015; Roddy *et al.*, 2010; 2011; Waller *et al.*, 2012). A study showed that weight bias could be transferred to arbitrary stimuli following a training, which asked to associate weight-related and neutral stimuli (Weinstein *et al.*, 2008). The comparison between weight bias held by psychology and physical education students resulted in a stronger implicit anti-fat bias for the latter group (O'Brien *et al.*, 2007b), whereas Robinson *et al.* (2014) found similar levels of implicit and explicit weight bias among samples of health and non-health discipline students. O'Brien *et al.* (2007a) found a correlation between the propensity of making physical-appearance-related comparisons with both explicit and implicit anti-fat attitudes. In a different sample of normal-weight and overweight students involved in a weight discrimination task, Cazzato and Makris (2019) showed a better ability to discriminate actions performed by normal-weight as compared to overweight actors. Another group of students was tested in order to explore the relationship between weight prejudice and expressed and actual behaviour. The data collected showed that prejudicial attitudes toward fatness did not necessarily predict discriminatory behaviours (Penney *et al.*, 2013). However, the expression of weight bias was found to be influenced by the motivation to appear non-prejudiced to others and the perception of weight discrimination (Brochu *et al.*, 2011).

Studies examining weight stigma held by youngsters found evidence for weight prejudice among adolescent (Hand *et al.*, 2017) and children (Solbes and Enesco, 2010; Thomas *et al.*, 2007; Hutchison *et al.*, 2018; Skinner *et al.*, 2017), corroborating the hypothesis that the 'thin ideal' occurs in an early stage of life. A study examined media's influence on weight prejudice in young scholars, finding that more time spent watching television was associated with lower levels of anti-fat bias (Bissel and Hays, 2011).

Other studies investigated the weight bias of healthcare professionals. Some researches (Halvorson *et al.*, 2019; Teachman and Brownell, 2001; Sabin *et al.*, 2012; Schwartz *et al.*, 2003; Tomiyama *et al.*, 2015; Lund *et al.*, 2018; Robertson and Vohora, 2008) showed preferences for thinness compared to fatness at both implicit and explicit levels in individuals working in clinical management of overweight individuals, whereas three studies (Vallis *et al.*, 2007; Dimmock *et al.*, 2009; Aweidah *et al.*, 2016) found evidence for weight stigma only at the implicit level. Furthermore, a strong implicit weight bias was found in a group of physical education teachers (Fontana *et al.*, 2013) and in a sample of professors teaching pre-service physical education (Fontana *et al.*, 2017). However, a different research found neutral implicit attitudes toward obesity in sample of pre-service teachers (Glock *et al.*, 2016). An implicit preference to thinness relative to fatness was found in individuals with different BMI (Anselmi *et al.*, 2013) and a stigmatization of obesity has been found in samples of individuals with overweight or obesity and BED (Wang *et al.*, 2004; Brauhardt *et al.*, 2014), with an inverse relation between participants' BMI and the extent of the bias (Schwartz *et al.*, 2006; Brewis *et al.*, 2016). One study found strong evidence for the influence of weight status on the automatic weight evaluation, with overweight participants showing an implicit preference for overweight over normal-weight stimuli (Degner and Wentura, 2009).

Three papers (Agerstrom *et al.*, 2011; O'Brien *et al.*, 2008; Flint *et al.*, 2016) investigated discrimination of people with obesity at workplace, showing implicit and explicit stigmatization towards candidates with obesity in hiring personnel. Moreover, compared to normal-weight people, overweight individuals seem to be associated with positions characterized by restricted interactions with the public (Venturini *et al.*, 2006). Concerning gender differences in weight bias, one study suggested that males hold more negative attitudes toward obesity (Brochu and Morrison, 2007), whereas Grover *et al.* (2003) showed that anti-fat bias was ubiquitously held by men and women. A different line of research (Carels *et al.*, 2009a, 2009b, 2010, 2011) found evidence for implicit and explicit anti-fat attitudes in adults with overweight/obesity engaged in a behavioural weight-loss treatments, with higher weight stigma correlating with worse treatment outcomes (Carels *et al.*, 2009b).

Since the prevalence of obese and overweight population is growing worldwide, some studies were interested in understanding how weight-related attitudes vary across different cultural settings. Two studies found both implicit and explicit anti-fat attitudes in a sample of UK residents (Flint *et al.*, 2015) and in a group of individuals from 71 nations (Marini *et al.*, 2013). Implicit anti-fat bias was detected in two samples of Asian (Jiang *et al.*, 2017) and African American (Hart *et al.*, 2016) females, whereas explicit anti-fat stigma has been found in a group of Paraguayan women (Brewis and Wutich, 2012). Moreover, two studies (Carels *et al.*, 2013; Hinman *et al.*, 2015) showed that implicit weight bias was significantly greater when obese and thin people were pictured engaging in stereotype congruent than incongruent activities. However, a behavioural weight loss programme resulted in a reduction of the stereotype consistent bias in a sample of individuals with overweight or obesity (Careles *et al.*, 2014). Studies evaluating the impact of different manipulations on weight bias reported heterogeneous results. An exacerbation of weight stigma has been observed after the exposition to a weight-loss reality show (Domoff *et al.*, 2012; Karsay and Schmuck, 2017) and following the administration of a 'before and after' advertisement, typically picturing an overweight person on the left and the new slim version of the same person on the right (Geier *et al.*, 2003). Differently, a reduction of explicit weight bias has been found after informing participants about the uncontrollable causes of obesity (Wijayatunga *et al.*, 2019), after educating about the multifactorial aetiology of obesity (Hilbert and Meyre, 2016), after a multi-component intervention aimed at reducing weight bias (Rukavina et al., 2010) and after showing anti-stigma films (Swift et al., 2013). Teachman et al. (2003) showed the possibility to reduce implicit weight bias by evoking empathy with stories of discrimination against individuals with obesity, depending on the weight status of participants. A different intervention based on health messages aimed at enhancing physical activity and healthy habits showed a small reduction of implicit anti-fat stigmatization (Rudolph and Hilbert, 2017). Differently, a counter-conditioning intervention (e.g. presentation of positive images of general public or celebrities with obesity) did not result in more positive perception of fatness, at both implicit and explicit levels (Flint et al., 2013). Similarly, weight bias persisted after a media-based conditioning intervention, which relied upon the presentation of videos portraying obese people struggling with their weight status and discrimination (Gapinski et al., 2006). An ethics educational training partially improved attitudes towards obesity (Geller and Watkins, 2018), whereas Russell-Mayhew et al. (2015) showed a reduction of both implicit and explicit weight bias after performing an interactive professional workshop and O'Brien et al. (2010) demonstrated that it was possible to reduce or exacerbate both anti-fat explicit and implicit attitudes, depending on the information provided about causes of obesity. In contrast, Scrivano et al. (2017) found that informing about the causes of obesity had an impact only on the explicit beliefs about the controllability of obesity. In a research that involved an interactive computer game, the Cyberball game, Pryor et al. (2013) focused on the social influence on behavioural expression of weight bias, proving that both explicit and implicit anti-fat attitudes influenced interactions with an overweight player, but only when other players ostracized the overweight subject.

Analysing the relationship between implicit and explicit measures of weight bias, studies reported heterogeneous results. High levels of implicit bias were coupled with low or completely absent explicit pro-slim/anti-fat preference in some studies (Roddy et al., 2010; Lynagh et al., 2015; Aweidah et al., 2016; Dimmock et al., 2009; Halvorson et al., 2019; Teachman and brownell, 2001; Carels et al., 2009a; Jiang et al., 2017). Conversely, other studies found similar levels of implicit and explicit weight stigma (Schwartz et al., 2003; Sabin et al., 2012; Marini et al., 2013; Phelan et al., 2014; Tomiyama et al., 2015; Flint et al., 2015 2016). A minority of data suggested high levels of explicit preference for thinness, coupled with very low levels of implicit weight bias (Brewis and Wutich, 2012).

Discussion

We reviewed studies on implicit attitudes towards food and body in healthy population and in samples of patients with ED. One hundred and eighty three papers were evaluated for bias risks and synthesized. Some main findings emerge from this review. A first evidence is that very few studies explored the neurobiological correlates of implicit attitudes related to eating behaviour. Neuroscientific investigation of eating behaviour has increased in the past decades supporting a brain-based approach to eating disorders and outlining different neurobiological models, which represent the rationale for combining psychotherapy and biological treatments (Val-Laillet et al., 2015; Frank, 2019). Neuroimaging studies reported the involvement of emotional and reward neuronal circuits in monitoring eating behaviour, and neuromodulation treatments have been tested targeting these circuits (Val-Laillet et al., 2015; Hall et al., 2018b). Therefore, understanding the relationship between neural circuits underpinning eating behaviour and brain mechanisms related to implicit attitudes, which are measures of automatic affective evaluation of food or body (Greenwald and Farnham, 2003; De Houwer et al., 2009), is of great interest. The low number of studies prevents to delineate clear conclusions on this aspect, but it is worth noting that one paper assessing reward sensitivity for food in patients with PD in dopamine replacement treatment reported discrepancies between implicit and explicit food attitudes in patients with PD and binge eating, in line with findings with other samples of disordered eating (Papies et al., 2009; Terenzi et al., 2018). One ERP study showed task-related differences in the N400 component only in patients with BN, supporting the hypothesis that implicit attitudes in EDs could be associated to anomalous brain response at an early stage (Blechert et al., 2011). Neurostimulation studies are consistent in highlighting the crucial impact of individual features in modulating implicit attitudes. Indeed, one study showed that TMS on mPFC affected food attitudes only in a subgroup of participants with low preference for tasty food (Mattavelli et al., 2015), whereas two studies with tDCS on EBA found an effect only in male participants with anti-fat bias, but not in females, and in patients with EDs, but not in control females (Cazzato et al., 2017; Mattavelli et al., 2019). Although using different IATs, these latter studies are consistent in showing the lack of modulatory effect on body images IAT in female participants applying anodal stimulation on EBA. Interestingly, one study stimulating the left dlPFC with cTBS did not find significant effect of neuromodulation on IAT, but reported different correlational patterns between IAT and food consumption in active or sham cTBS condition, supporting a role for left dlPFC in control hunger disinhibition (Hall et al., 2018).

For what concerns food attitudes many different paradigms have been used, with preferences pointing to different directions depending on the type of food categories and evaluative attributes used as stimuli. A general conclusion that can be drawn concerns the fact that most of the studies support the predictive validity of implicit measures on the actual food behaviour. Crucially, the relationship between implicit and explicit measures and behaviour seems to be mediated by individual differences in food habits and ED symptoms (Ellis et al., 2014). In particular, discrepancies between implicit and explicit preferences were more evident in restrained eaters and predicted disinhibited eating with larger validity in individuals with higher level of impulsivity (Papies et al., 2009; Goldstein et al., 2014).

Studies assessing attitudes toward body images show substantially convergent findings of negative implicit attitudes toward overweight body images or stronger preference for normal-weight compared to underweight and overweight bodies in the healthy population (Ahern and Hetherington 2006; Ahern et al.,2008; Lydecker et al., 2006; Watts et al., 2008; Moussally et al., 2015; Sabin et al., 2015; Marini, 2017; Elran-Barak and Bar-Anan, 2018; Robstad et al., 2018), whereas greater pro-thin implicit bias in patients with AN and BN compared to healthy subjects has been reported (Khan and Petróczi, 2015; Smith et al., 2018; Izquierdo et al., 2019). Nevertheless, patients with AN also showed anti-fat bias, rather than attraction to thinness (Spring and Bulik, 2014). Moreover, experimental manipulation could be effectively used to modulate body implicit attitudes in ED samples (Smith et al., 2014), or in healthy subjects (Martijn et al., 2013; Matharu et al., 2014), even though this result was not consistent across the studies (Keng and Ang, 2019). The correspondence between implicit and explicit measures on body image as well as the predictive value of implicit and explicit attitudes on personal traits and behaviours were not consistently reported by studies on both healthy and ED samples. Interestingly, implicit measures toward body and food were found to be more predictive of ED symptoms maintenance than explicit preferences across the retrieved studies (Parling *et al.*, 2012; Khan and Petróczi, 2015). This consistent result has important clinical implications as an improvement in automatic, but not explicit, evaluation of overweight stimuli was considered a marker of treatment efficacy in patients with AN (Spring and Bulik, 2014).

Notably, results of the reviewed studies appeared consistent concerning the validity of implicit measures in discriminating between healthy and individuals with EDs. Between-group differences have been reported in different studies comparing samples of patients with AN and BN to healthy control participants, in particular when implicit attitudes toward body were assessed (Cserjési *et al.*, 2010; Parling *et al.*, 2012; Smith *et al.*, 2014; Khan and Petróczi, 2015; Smith *et al.*, 2018; Izquierdo *et al.*, 2019). Similarly, consistent results of differences between individuals with healthy-weight and overweight/obesity have been reported (Craeynest *et al.*, 2006, 2008b; Sartor *et al.*, 2011; Brauhardt *et al.*, 2014; Kemps and Tiggemann, 2015). In particular, patients with obesity, compared to healthy controls, showed larger implicit preferences for food (Kemps and Tiggemann, 2015), also when those preferences involved self-related concepts (Craeynest *et al.*, 2006). These results could be the evidence, at an implicit level, of the craving for food that clinically characterizes patients with obesity. Moreover, samples with obesity did not associate fat-positive *vs* fat-negative as strongly as controls (Craeynest *et al.*, 2006; Brauhardt *et al.*, 2014), suggesting an ambivalent actual and ideal body images. Anomalous brain responses to body and food images are reported in patients with AN and BN as well as with obesity (Martin *et al.*, 2010; Brooks *et al.*, 2011; Mohr *et al.*, 2011). Understanding whether these abnormalities are related to the automatic representation and evaluation of body and food at brain level is a challenge for future research.

A large body of literature has emerged on weight bias, and this review shows a notable consistency and pervasiveness, among different settings and populations, of weight discrimination towards individuals with overweight and obesity, typically considered worthless, lazier and less motivated than thin people (Schwartz *et al.*, 2003; Wang *et al.*, 2004). Indeed, in the last two decades a growing body of research has been focusing on weight stigma, due to its considerable negative impact on the social and psychological well-being of individuals with overweight and obesity. Evidence for low scores of overall health and body esteem, coupled with increased loneliness and a propensity to use alcohol or drugs to cope with stress, have been found in a sample of first-year medical students with overweight or obesity (Phelan *et al.*, 2015a), proving that weight bias internalization can considerably affect the quality of life. Indeed, weight bias was found to exist in different population groups, even among individuals with overweight and obesity (Wang *et al.*, 2004; Schwartz *et al.*, 2006; Brauhardt *et al.*, 2014), who internalize the negative attitudes toward overweight coming from the society. Moreover, since weight bias has been found even among medical students (Miller *et al.*, 2013; Phelan *et al.*, 2014, 2015b; Baker *et al.*, 2017) and within the healthcare setting (Teachman and brownell, 2001; Schwartz *et al.*, 2003; Vallis *et al.*, 2007; Sabin *et al.*, 2012; Tomiyama *et al.*, 2015; Aweidah *et al.*, 2016; Halvorson *et al.*, 2019), the possibility that the quality of patient's care can be negatively affected, leading people with overweight and obesity to avoid preventive healthcare, should be taken into account. Due to the potential negative implications of weight bias, some researches tried to verify the effects of different manipulations aimed to improve weight stigma (Geier *et al.*, 2003; Teachman *et al.*, 2003; Gapinski *et al.*, 2006; O'Brien *et al.*, 2010; Rukavina *et al.*, 2010; Domoff *et al.*, 2012; Flint *et al.*, 2013; Swift *et al.*, 2013; Russell-Mayhew *et al.*, 2015; Hilbert and Meyre, 2016; Karsay and Schmuck, 2017; Rudolph and Hilbert, 2017; Scrivano *et al.*, 2017; Geller and Watkins, 2018; Wijayatunga *et al.*, 2019), providing mixed results, but leading hopes about the possibility that negative attitudes towards fatness can be minimized (Teachman *et al.*, 2003; O'Brien *et al.*, 2010; Russell-Mayhew *et al.*, 2015; Hilbert and Meyre, 2016). A prospective research focusing on medical students (Phelan *et al.*, 2015b) found evidence for changes in weight bias, fostered by school training and interactions with patients with obesity, suggesting that curricula and lecturers should be shaped, taking into consideration such mediating variables, in order to improve weight-related attitudes of future professionals.

A clear limitation of studies included in this review is that most of research is based on female samples, as some studies included only female participants and so, in most of studies, gender is not balanced. Few studies introduced gender as factor in the analyses and all found differences between male and female participants in implicit food preferences and weight bias (Grover *et al.*, 2003; Pechey *et al.*, 2015; Alkozei *et al.*, 2018). This is critically relevant considering (Striegel-Moore *et al.*, 2009) gender differences in eating disorders and that gender differences have been reported in neuromodulation effects on implicit attitudes on weight bias and stereotype (Cattaneo *et al.*, 2011; Cazzato *et al.*, 2017). Thus, future research should take this issue into account in designing experiments and selecting samples.

In conclusion, implicit attitudes appear as valid tools to measure individual differences and predict behaviour in healthy population. Further research is needed to define the validity of implicit measure in distinguishing healthy individuals from patients with EDs and the advantage of using these measures in clinical settings. Neuroimaging research on brain mechanisms underpinning implicit attitudes toward food and body images is critically missing. Further research should shed light on neural mechanisms of automatic responses at brain and behavioural level, providing novel directions for the understanding of healthy and pathological eating behaviour.

Conflict of interest

Authors have no conflict of interest to declare.

Supplementary data

Supplementary data are available at *SCAN* online.

Appendix 1. Descriptors of search

Search engine	Search algorithm	Alternative keywords
PubMed (May 2019)	Implicit attitudes AND eating disorder: (implicit[All Fields] AND ('attitude'[MeSH Terms] OR 'attitude'[All Fields] OR 'attitudes'[All Fields])) AND ('feeding and eating disorders'[MeSH Terms] OR ('feeding'[All Fields] AND 'eating'[All Fields] AND 'disorders'[All Fields]) OR 'feeding and eating disorders'[All Fields] OR ('eating'[All Fields] AND 'disorder'[All Fields]) OR 'eating disorder'[All Fields])	Implicit association; Affective priming
	Implicit attitudes AND anorexia nervosa: (implicit[All Fields] AND ('attitude'[MeSH Terms] OR 'attitude'[All Fields] OR 'attitudes'[All Fields])) AND ('anorexia nervosa'[MeSH Terms] OR ('anorexia'[All Fields] AND 'nervosa'[All Fields]) OR 'anorexia nervosa'[All Fields])	
	Implicit attitudes AND bulimia nervosa: (implicit[All Fields] AND ('attitude'[MeSH Terms] OR 'attitude'[All Fields] OR 'attitudes'[All Fields])) AND ('bulimia nervosa'[MeSH Terms] OR ('bulimia'[All Fields] AND 'nervosa'[All Fields]) OR 'bulimia nervosa'[All Fields])	
	Implicit attitudes AND binge eating disorder: (implicit[All Fields] AND ('association'[MeSH Terms] OR 'association'[All Fields])) AND ('binge-eating disorder'[MeSH Terms] OR ('binge-eating'[All Fields] AND 'disorder'[All Fields]) OR 'binge-eating disorder'[All Fields] OR ('binge'[All Fields] AND 'eating'[All Fields] AND 'disorder'[All Fields]) OR 'binge eating disorder'[All Fields])	
	Implicit attitudes AND obesity: (implicit[All Fields] AND ('attitude'[MeSH Terms] OR 'attitude'[All Fields] OR 'attitudes'[All Fields])) AND ('obesity'[MeSH Terms] OR 'obesity'[All Fields])	
	Implicit attitudes AND food preference: (implicit[All Fields] AND ('attitude'[MeSH Terms] OR 'attitude'[All Fields] OR 'attitudes'[All Fields])) AND ('food preferences'[MeSH Terms] OR ('food'[All Fields] AND 'preferences'[All Fields]) OR 'food preferences'[All Fields] OR ('food'[All Fields] AND 'preference'[All Fields]) OR 'food preference'[All Fields])	
	Implicit attitudes AND thin idea: (implicit[All Fields] AND ('attitude'[MeSH Terms] OR 'attitude'[All Fields] OR 'attitudes'[All Fields])) AND (thin[All Fields] AND ('IDEA J Law Technol'[Journal] OR 'idea'[All Fields]))	
	Implicit attitudes AND thin ideal: (implicit[All Fields] AND ('attitude'[MeSH Terms] OR 'attitude'[All Fields] OR 'attitudes'[All Fields])) AND (thin[All Fields] AND ideal[All Fields])	
	Implicit attitudes AND fat phobia: (implicit[All Fields] AND ('association'[MeSH Terms] OR 'association'[All Fields])) AND (fat[All Fields] AND ('phobic disorders'[MeSH Terms] OR ('phobic'[All Fields] AND 'disorders'[All Fields]) OR 'phobic disorders'[All Fields] OR 'phobia'[All Fields]))	
EMBASE (May 2019)	Implicit attitudes AND eating disorder: implicit AND attitudes AND eating AND disorder	Implicit association; Affective priming
	Implicit attitudes AND anorexia nervosa: implicit AND attitudes AND anorexia AND nervosa	
	Implicit attitudes AND bulimia nervosa: implicit AND attitudes AND bulimia AND nervosa	
	Implicit attitudes AND binge eating disorder: implicit AND attitudes AND binge AND eating AND disorder	
	Implicit attitudes AND obesity: implicit AND attitudes AND obesity	
	Implicit attitudes AND food preference: implicit AND attitudes AND food AND preference	
	Implicit attitudes AND thin idea: implicit AND attitudes AND thin AND idea	
	Implicit attitudes AND thin ideal: implicit AND attitudes AND thin AND ideal	
	mplicit attitudes AND fat phobia: implicit AND attitudes AND fat AND phobia	
PsychINFO (May 2019)	Implicit attitudes AND eating disorder: noft('implicit attitudes') AND noft('eating disorder')	Implicit association; Affective priming
	Implicit attitudes AND anorexia nervosa: noft('implicit attitudes') AND noft('anorexia nervosa')	
	Implicit attitudes AND bulimia nervosa: noft('implicit attitudes') AND noft('bulimia nervosa')	
	Implicit attitudes AND binge eating disorder: noft('implicit attitudes') AND noft('binge eating disorder')	
	Implicit attitudes AND obesity: noft('implicit attitudes') AND noft('obesity')	
	Implicit attitudes AND food preference: noft('implicit attitudes') AND noft('food preference')	
	Implicit attitudes AND thin idea: noft('implicit attitudes') AND noft('thin idea')	
	Implicit attitudes AND thin ideal: noft('implicit attitudes') AND noft('thin ideal')	
	Implicit attitudes AND fat phobia: noft('implicit attitudes') AND noft('fat phobia')	

(Continued)

Search engine	Search algorithm	Alternative keywords
SCOPUS (May 2019)	Implicit attitudes AND eating disorder: TITLE-ABS-KEY (implicit AND attitudes AND eating AND disorder)	Implicit association; Affective priming
	Implicit attitudes AND anorexia nervosa: TITLE-ABS-KEY (implicit AND attitudes AND anorexia AND nervosa)	
	Implicit attitudes AND bulimia nervosa: TITLE-ABS-KEY (implicit AND attitudes AND bulimia AND nervosa)	
	Implicit attitudes AND binge eating disorder: TITLE-ABS-KEY (implicit AND attitudes AND binge AND eating AND disorder)	
	Implicit attitudes AND obesity: TITLE-ABS-KEY (implicit AND attitudes AND obesity)	
	Implicit attitudes AND food preference: TITLE-ABS-KEY (implicit AND attitudes AND food AND preference)	
	Implicit attitudes AND thin idea: TITLE-ABS-KEY (implicit AND attitudes AND thin AND idea)	
	Implicit attitudes AND thin ideal: TITLE-ABS-KEY (implicit AND attitudes AND thin AND ideal)	
	Implicit attitudes AND fat phobia: TITLE-ABS-KEY (implicit AND attitudes AND fat AND phobia)	

In each search algorithm, the 'Implicit attitudes' keyword have been replaced with the alternatives in the right column; noft = research in all filed excluding entire manuscripts due to the exceeding number of retrieved records; TITLE-ABS-KEY = research in title, abstract and keywords (excluding entire manuscripts) due to the exceeding number of retrieved records.

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