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THE WEIGHT OF WEIGHT STIGMA. NEGATIVE STEREOTYPES AND COGNITIVE PERFORMANCE IN CHILDREN AND ADULTS WITH OBESITY

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Contents

I. GENERAL INTRODUCTION

Overweight and obesity represents one of the most compelling global public health challenge of the 21st century (World Health Organization [WHO], 2016a). The prevalence of excess weight has doubled since 1980, and despite the problem was limited to the richest countries in its first phase, it now concerns developing countries, especially urban areas. According to the WHO’s Childhood Obesity Surveillance Initiative, around one third of 6-to-9-year-old European children were classified as overweight (i.e., with an age-adjusted Body Mass Index [BMI] between the 85th and the 95th percentile) or obesity (i.e., with an age-adjusted BMI over the 95th percentile) in 2010 (Wijnhoven et al., 2013), whereas 1.9 billion and 600 million adults aged 18 and older were with overweight and with obesity, respectively. According to the latest survey, 22.2% and 10.6% of the Italian children are with overweight and obesity, respectively, whereas the prevalence with overweight is 53.2% for woman and 65.7% for men among Italian adults, and the prevalence of obesity is around 21.5% for both sexes (Centro Nazionale di Epidemiologia, Sorveglianza e Promozione della Salute [CNESPS], 2014).

Obesity is a serious problem not only for the related medical conditions, but also for its psychological complications (e.g., Halfon, Larson, & Slusser, 2013). Depression, eating disorders, poorer health-related quality of life are more prevalent in adults and children with obesity than with average weight (Preiss, Brennan, & Clarke, 2013; Taylor, Forhan, Vigod, McIntyre, & Morrison, 2013; Wilson, 2010). Deficits in cognitive abilities were also observed in this population (Belsky et al., 2013; Li, Dai, Jakson, & Zhang, 2008; Wang, Chang, Ren, & Yan, 2016; Yu, Han, Cao, & Guo, 2010), especially concerning executive functions (e.g., Barkin, 2013; Prickett, Brennan, & Stolwyk, 2015; Smith, Hay, Campbell, & Trollor, 2011).

In addition, obesity is also a highly stigmatizing condition. Individuals with obesity are stereotyped as lazy, unsuccessful, lacking self-control, unintelligent, and are more likely to experience episodes of weight-based discrimination (Himmelstein & Tomiyama, 2015; Puhl & Heuer, 2009; Puhl & Heuer, 2010) than people with average weight. However, whereas evidence on the effects of weight-related stigma on health and psychological wellbeing of individuals with obesity has been demonstrated yet (e.g., Hunger & Major, 2015; Tomiyama, 2014), the impact of weight stigma on cognitive proficiency has never been studied to date. This gap in the literature is unfortunate, as past research has demonstrated that cognitive performance of people belonging to stigmatized social groups can be damaged by the anticipated concern that their performance in a stereotype-relevant domain may inadvertently confirm the stereotype, or prompt others to perceive them in a negative stereotype-consistent manner (i.e., stereotype threat effects; Schmader, Johns, & Forbes, 2008; Steele & Aronson, 1995). Past studies demonstrated the validity of the model in adults as well as in children in a variety of domains (for a review, see Spencer, Logel, & Davies, 2015), both in community (e.g., immigrants; Appel, Weber, & Kronberger, 2015) and in clinical samples (e.g., chemotherapy patients; Jacobs, Das, & Schagen, 2017).

Quite surprisingly, few studies to date investigated Stereotype Threat phenomena affecting people with excess weight, despite several studies underlined the susceptibility of people with obesity to identity threats concerning, for example, their ability to control eating or exercise behaviors (e.g., Carels et al., 2013; Inzlicht & Kang, 2010; Major, Hunger, Bunyan, & Miller, 2014; Shapiro, 2011). Only one study by Major, Eliezer, and Rieck (2012) demonstrated the impact of weight-based stereotypes on attention inhibition. However, no other work attempted to investigate stereotype threat effects on executive functions other than inhibitory control, and no study tested the model in children.

Building on these considerations, the purpose of the present research project is to investigate the relation between obesity and cognitive proficiency, by focusing on the role of stereotype threat as a possible cause of cognitive impairment. In addition, we will explore the role of weight-based experiences of discrimination and internalized negative attitudes toward excess weight as potential moderators of individuals' susceptibility to cognitive impairments under stereotype threat.

From a theoretical point of view, exploring this relation could enrich the literature concerning obesity and cognitive performance, obesity stigma research, and stereotype threat studies with both adults and children. From an applied point of view, clarifying the relation between obesity, weight-based stereotypes, and cognitive proficiency may inform future educational interventions aimed at combating weight-based stereotypes, and helping individuals with obesity to improve their cognitive and psycho-social functioning.

The present dissertation is organized in the following way.

Section 2 reviews the literature about obesity, health, and psychological status, weight-based stigma, and stereotype threat model. In particular, Chapter 1 underlines the relation between obesity, health status and psychological functioning, by focusing in particular on the relation between obesity and cognitive functioning. Chapter 2 focuses on obesity as a socially stigmatizing condition, by describing the content, the antecedents, and the correlates of weight-based stereotypes. Finally, Chapter 3, describes the Stereotype Threat Model and illustrates how this model helps explaining the relation between social stigma and cognitive impairment on executive functions.

Section 3 reports two empirical studies conducted to answer to our research questions. After a brief overview of the studies, chapter 4 describes a study conducted with pre-adolescent schoolchildren (Study 1), while chapter 5 reports a study with a sample of adults with and without obesity (Study 2). Each chapter includes a theoretical introduction to the study, the methods description, and the results presentation and discussion.

Section 4 concludes the present dissertation with a general discussion summarizing the two studies' outcomes, and the proposal of possible theoretical advancements, future studies and clinical and educational interventions that could ensure the continuity to the present work.

II. THEORETICAL BACKGROUND

1. OBESITY AS A MEDICAL CONDITION

II.1.1. Obesity and health status

Obesity is an important medical condition and a significant risk factor for several health complications. It represents a concerning medical situations for adults, but its negative effect begins during childhood as well (Park, Falconer, Viner, & Kinra, 2012; World Health Organization [WHO], 2016b).

Asthma, breathing problems, obstructive sleep apnea (Bhattacharjee et al., 2011; Papoutsakis et al., 2013), elevated blood pressure (Flynn, 20132), dyslipidemia (Cook & Kavey, 2011), and type 2 diabetes (Van Name & Santoro, 2013) are among the most common health problems that are related with obesity during childhood and adolescence. Furthermore, Katz and Bimstein (2011) showed that children and adolescents with obesity also have more caries and periodontal disease than children with average weight, whereas Paulis, Silva, Koes, and Middelkoopand (2014) displayed a positive relation between obesity and musculoskeletal pain, injuries and fractures, despite the relation is not yet clear. Further research is needed to clarify the relations between obesity and skin problems (Mahé, Gnossike, & Sigal, 2014), renal abnormalities (Savino, Pelliccia, Chiarelli, & Mohn, 2010), and gastroenterological problems (Luoto, Collaudo, Salminen, & Isolauri, 2013), in which the causality of the relation obesity and diseases still needs to be disentangled.

Childhood obesity also represents a risk factor for future health diseases. Thus, contrasting obesity since childhood would represent the best strategy to prevent obesity and its negative effects in a lifetime perspective. First, being with obesity during childhood increases the likelihood to be with obesity in adulthood (Lee, 2009; Singh, Mulder, Twisk, Van Mechelen, & Chinapawet, 2008). Second, childhood obesity is predictive of a variety of medical condition developed later in life, above and beyond concurrent weight status in adulthood: Obstructive sleep apnea (Inge et al., 2013), hypertension (Park et al., 2012), diabetes (Park et al., 2012), knee osteoarthritis (Macfarlane, de Silva, & Jones, 2011; Wills et al., 2012), nonacoholic fatty liver disease (Giorgio et al., 2013), polycystic ovary syndrome and infertility (Frisco & Weden, 2013; Reilly & Kelly, 2011). More controversial results concern the pediatric obesity's effects on cardiovascular disease (Park et al., 2012; Lloyd, Langley-Evans, & McMullen, 2012) and cancers, despite obesity during adolescence is a recognized predictor of kidney in boys and cervical cancer in woman (Bjørge et al., 2004; Bjørge et al., 2008).

Also, adults with obesity present several health conditions that have a deleterious impact on individuals' health. Type 2 diabetes (Ginter & Simko, 2013) appears among the main pathologies related with obesity (90% of people with diabetes are with overweight or obesity), and this prevalence rate further increases in presence of hypertension, sedentary life style and unhealthy diet, which are all common conditions in people with obesity (Colosia, Palencia, & Khan, 2013; Ginter & Simko, 2013). Obesity represents a major risk factor for cardiovascular disease (Poirier et al., 2006), to the point that weight loss is assumed as one of the main strategies for the ischemia heart attack reduction. Obesity's complications also lead to airway obstruction during sleep, comprises, central sleep apnea, or obesity hypoventilation syndrome (Akinnusi, Saliba, Porhomayon, & El-Solh, 2012). Obesity is also one of the main correlates of the Gastro-oesophageal reflux disease and related complications (Friedenberg, Xanthopoulos, Foster, & Richter, 2008), and it is also a cause (especially in association with high waist circumference and visceral obesity) of the nonalcoholic fatty liver disease (Chalasani et al., 2012; Ju et al., 2013). Finally, some metabolic alterations related with obesity (e.g., lipid accumulation, metaflammation, insulin resistance, adipokines), represent a risk factor for several forms of cancer, such as hepatocellular carcinoma, colorectal, esophageal cancer, pancreatic cancer, breast cancer, thyroid cancer (Renehan et al., 2008).

II.1.2. The psychological correlates of obesity

Beyond all the medical problems, people with obesity also suffer from several psychological complications, and the poor psychological wellbeing or health-related quality of life in people with obesity (for reviews, see Buttitta, Iliescu, Rousseau, & Guerrien, 2014; Taylor et al., 2013) further strengthens this evidence.

Lower self-esteem in children with obesity appears early in children's life, at the age of 5-7 (Williams et al., 2013) or 7–9 years (Danielsen et al., 2012), and persists into adolescence (Monteiro, Novaes, Santos, & Fernandes, 2014). Similar results were found in studies with adults: For example, the review by Saunders, Frazier, and Nichols-Lopezin

(2016) showed a negative correlation between body mass index and self-esteem, while Bonsaksena, Fagermoenb, and Lerdalc (2015) underlined that having high self-efficacy and being aware of one's own medical condition could positively affect self-esteem in individuals with obesity.

From childhood to adulthood, excess body weight is a predictor of body dissatisfaction (Evans, Tovéeb, Boothroyda, & Drewetta, 2013; Weinberger, Kersting, & Heller, Luck-Sikorski, 2016), despite some gender's differences exist: Austin, Haines, and Veugelers (2009), in a study with children aged 10 or 11 years old, showed that the relation between body weight and body dissatisfaction is linear for girls (i.e., heavier girls are more unsatisfied for their body weight), whereas it appears U-shaped in boys (i.e., both thinner and heavier boys have high body dissatisfaction). Similarly, Fallon, Harris, and Johnson (2014) conducted a study on body weight satisfaction with 1893 women and men, and showed that despite women have a lower body satisfaction than men, both male and female participants with average weight have a double and quadruple rate of body satisfaction than people with overweight and obesity, respectively. Overall, there is a positive relation between body weight and body dissatisfaction, despite the opposite direction that characterize men: They showed lower body satisfaction when they are underweight, probably for the muscle male ideal present in our society (McCabe & Ricciardelli, 2004).

Despite obesity is not an eating disorder, people with obesity are at more risk of being affected by eating disorders. In particular, 23%–46% of adults with obesity and 36.5% of children with obesity (vs. 9.3% of children with average weight) suffer from binge eating disorder (Bulik, Sullivan, & Kendler, 2002; Darby et al., 2009). The direction of this relation is not clear: On one hand, binge eating increases body weight status (Field et al., 2003). On the other hand, being with obesity positively relates with the frequency of binge eating episodes (Striegel-Moore et al., 2005). Several elements may intervene in the relation between obesity and eating disorders. For example, the systematic review by Braet et al. (2014) underlines that diet restrictions, emotional eating due by stressful situations, and the high neurophysiological responsiveness to food-related stimuli can lead to binge eating disorders (associated or not with anorexia or bulimia disorder). In addition, people with obesity are characterized for the food-attention bias, i.e., show a slower attention disengagement from unhealthy food stimuli than people with average weight or with obesity without binge eating (Castellanos et al., 2009; Deluchi, Costa, Friedman, Gonçalves, & Bizarro, 2017; Nijs & Franken, 2012). Finally, self-efficacy mediates the relation body weight and binge eating, by making self-efficacy another important element in determining binge eating (Saunders et al., 2016).

Both children and adults with obesity present more internalizing and externalizing problems than children with average weight (Abilés et al., 2010; Halfon, et al., 2013; Toups et al., 2013). Concerning anxiety, the meta-analysis conducted by Burke and Storch (2015) showed a weak but a consistent positive relation between body weight and anxiety in children (and adolescents), especially for girls or for children younger than 12 years (vs. boys or children older than 12 years old). Conversely, Haghighi et al. (2016), found no linear relation between body weight and anxiety in adults, but a U-shaped relation: Anxiety increases from medium to high body weight, but it is low for the very high or for the lowest BMI index.

As regards depression (for a review, see Mühlig, Antel, Föcker, & Hebebrand, 2016), Geoffroy, Li, and Power (2014) showed that children with obesity at 7 years of age have a lower probability to suffer for depression one year later, but being female and with obesity at this age is predictive of depression symptoms in the subsequent years. Conversely, depression symptoms at 10-11 years of age are predictive of weight gain one year later (Roberts & Duong, 2013). During adulthood, obesity represents of one the main somatic comorbidities of major depressive disorder (De Wit et al., 2010): In fact, people with obesity as well as patients with major depressive disorder have less gray matter in the same area of the medial prefrontal cortex (Opel et al., 2015). It is not clear whether obesity is a cause of depression, or depression is a cause of obesity, but it is possible that a bidirectional causal model may rather explain this relation (Markowitz, Friedman, & Arent, 2008). Finally, literature (e.g., Cortese et al., 2008) also suggests a positive correlation between obesity and Attention Deficit Hyperactive Disorder (ADHD), even though a recent investigation (Nigg et al., 2016) has shown that this relation has no significant clinical impact during childhood, it starts reaching significance in adolescence (especially for girls with comorbid disorders), and eventually achieves clinical relevance in adulthood.

Literature has also revealed that children and adults with obesity suffer from more social and relational difficulties than people with average weight. Children with obesity experience more episodes of bullying (both verbal and physical) and have a higher probability to be bullied than peers with average weight (Fox & Farrow, 2009; Lumeng et al., 2010; Van Geel, Vedder, & Tanilon, 2014). Anyway, Zeller, Reiter-Purtill, and Ramey (2008) showed that, despite pupils with obesity had lower evaluations in terms of attractiveness and sport abilities by their peers, there was no difference in reciprocal friendship links between children with obesity and those with average weight. Studies with adults present more contrasting results. For example, family problems were found in people with high levels of obesity (vs. obesity and lower body weight) or that were with obesity during adolescence (Carr & Friedman, 2006), and Ball, Crawford, and Kenardy (2004) showed that women with obesity have lower satisfaction for close relationships or social activities than those with average weight. Similarly, Oliveira, Rostila, Leon, and Lopes (2013) highlighted that men with obesity have less emotional support than woman with obesity, whereas the relation between visiting friends and being with obesity is positive for men but negative for women. Instead, Tamers et al. (2011) showed no significant relation between body weight and social support in the workplace. Finally, the relation between obesity and social relationship could be considered also in the opposed direction, because a reduced social support represents a risk factor for weight gain over time (Muckenhuber, Dorner, Burkert, Groschädl, & Freidl, 2015; Oliveira et al., 2013).

II.1.3. Obesity and cognitive functioning

Beyond investigating the psycho-social and affective correlates of obesity, several studies have also analyzed the relation between obesity and cognitive proficiency, by focusing on weight-related changes in academic achievement, in general intelligence, or in specific cognitive functions (e.g., executive control). This section reviews the literature about the topic, focusing at first on children and then on adults.

II.1.3.1. Obesity and cognitive functioning in childhood

Academic achievement. Despite some contrasting results (Kaestner & Grossman, 2009; MacCann & Roberts, 2013), several studies have highlighted a negative relation between body weight and academic achievement. The study by Datar and Sturm (2006) analyzed the relation between weight status and academic abilities in around 7,000 children from kindergarten through 3rd grade. Results showed that reading and math scores at the baseline were significant lower in children with overweight than average-weight children. Moreover, in third grade, girls who became overweight reported lower grades than girls who were never with overweight. Similarly, Datar, Sturm, and Magnabosco (2004) showed that, both at the beginning of kindergarten and at the follow-up (two years later), reading and math performance were significantly higher in children with average-weight than with excess weight. Importantly, this relation was insignificant when socioeconomic factors were controlled (for similar results, see Li et al., 2008; Judge & Jahns, 2007; Veldwijk et al., 2012). Other studies have analyzed the relation between obesity and mathematical or literature achievement. For example, Gable, Krull, and Chang (2012) in a longitudinal study from kindergarten to fifth grade showed that BMI has a negative impact on math learning during childhood, especially for boys, girls that were in obesity status during all the research project, and girls whose obesity emerge later (but only when math evaluation was done in first and third grade). Furthermore, researchers showed that social abilities mediate this relation for girls, whereas internalizing behaviors have a significant role for boys and girls in third and fifth grade (also in first grade for girls). A gender difference (in children in grade 3, 5 and 7) was explained also by Black, Johnston, and Peeters (2015): They showed the existence of negative relation between body weight and mathematical achievement for girls, but not for boys. A further investigation about the relation between obesity and mathematical achievement was conducted by Kranjac (2015). His study, with a sample of 21,260 children (from kindergarten to eighth grade), showed that there is a small difference between children with excess weight and with average weight in terms of math achievement, and that the difference increases when children become older. Furthermore, Kranjac (2015) showed that self-efficacy could have a positive effect on math attainment in children with overweight, but not in children with obesity. Finally, according to Cottrell, Northrup, and Wittberg (2007), children with overweight status and attending fifth grade present better academic performance than peer with underweight status, despite they perform worse than children at risk of overweight status.

A major limit of these studies is that academic performance is a multifaceted construct that is affected by emotional, motivational and psycho-social variables that are not referable to cognitive functioning. However, even though some studies revealed that during school age obesity is more related with lower school performance than cognitive abilities (Booth et al., 2014; Prickett et al., 2015), other researches underline that children with obesity have lower cognitive abilities than children with average weight, and that basic cognitive abilities (e.g., executive functions) are also meta-academic skills important for academic attainment (Burkhalter & Hillman, 2011; Shaw, Jankowska, & Claro, 2013).

Cognitive abilities. Recent research has investigated the relation between obesity and cognitive abilities by directly assessing intelligence quotient, intelligence performance, and basic cognitive functions such as attention. For example, the study by Li et al. (2008) reported that being with overweight is associated with low cognitive performance on the Wechsler Intelligence Scale for Children, Revised (WISC-R; Wechsler, 1974), and with a specific performance deficit in visuospatial organization (i.e., block-design subtest). Similarly, Miller et al. (2009) found that children with early-onset obesity had lower general intellectual ability (measured with the Woodcock-Johnson Test of Cognitive Abilities and Woodcock-Johnson Test of Achievement; Woodcock, McGrew, & Mather, 2001) than a sibling control group. More specifically, Azurmendi et al. (2005) confirmed this relation only for girls, while boy's weight status only predicted crystallized intelligence. Focusing on performance intelligence, Parisi et al. (2010) showed that weight status predicts only performance intelligence, whereas Jansen, Schmelter, Kasten, and Heil (2011) highlighted that being overweight at 10 years of age is related with impairments in mental rotation tasks (a specific non-verbal ability). The review and meta-analyses by Yu et al. (2010) demonstrates that cognitive deficits increase at increasing levels of severity of obesity. The authors found that children and adolescents from 7-to-17-years of age with severe obesity had lower total intelligence and performance intelligence scores than average-weight peers, whereas no significant differences emerged between mildly or moderately obese and average-weight children. Differently, Bisset, Fournier, Pagani, and Janosz (2013), by exploring the relation between body mass index and children's cognitive abilities, showed that children (aged 4-7 years) with underweight had the highest risk to obtain low score at the Kaufman Assessment Battery for Children (KABC; Kaufman & Kaufman, 1983), but this did not occur in children with excess weight. This evidence led the authors to hypothesize that a negative relation between obesity and cognitive functioning may appear later in life. However, Martin et al. (2016) conducted a longitudinal study with 12,349 children aged 3 (T_0) to 5 years (T_1), to better understand the relation between body weight, weight gain, and cognitive function in early childhood. By evaluating verbal, not-verbal, and visuospatial abilities, the authors showed that being with excess weight is related with lower scores in practical reasoning task for boys (also after controlling for possible covariates), whereas weight loss (from-3-to-5-year-old) is positively associated with pattern construct and naming vocabulary in boys (the first also after control for covariates), and with picture similarity scores in girls (but only for girls that have always been with obesity).

Finally, some studies also focused on attention abilities. For example, the study by Cserjési, Molnàr, Luminet, and Lènard (2007) found that overweight children have a poorer performance in the D2 attention duration test (Brickenkamp, 1981), a task used to examine the ability of protracted attention and distractibility. Interesting, Mond, Stich, Hay, Kraemer, and Baune (2007) showed that young girls with obesity aged 4.4-8.6 years had lower ability to focus attention continuously during the examination than average weight peers. Differently, boys aged 10-to-18 years with obesity had lower ability in attention focusing than average-weight children, and higher levels of impulsivity and hyperactivity than the control group (Braet, Claus, Verbeken, & Vlierberghe, 2007).

Executive functions. The relation between obesity and executive functions in children has been explored by several studies.

One of the main consistent evidence is the early onset of executive functioning impairment in individuals with obesity. In fact, Guxens et al. (2009) conducted a longitudinal study with preschooler children with the double aim to learn about the relation between cognitive functions at 4 years of age and body weight status at 6 years old, also considering the role of body weight status at 4-year-old, as well as the relation between cognitive functioning at 4 years and body weight changing by 2 years later. With this purpose, researchers involved around 400 children, and they assessed body measurement (height and weight) and executive functions (McCarthy Scales of Children's Abilities; McCarthy, 1972) at 4 years old and body weight and height at 6 years old. By means of this assessment, they demonstrated that children with higher executive function at 4 have a lower probability to be with excess weight or to maintain an unhealth body weight status at 6 years of age. Similarly, Bauer et al. (2015) conducted a study with older children than Guxens’ (2009) study, that were aged 6-to-8 years. The authors’ aim was investigating the relation between body weight (18 children with average weight vs 15 children with excess weight), brain structure, and cognitive functioning. By using the Neuropsychological assessment of children (Matute, Rosselli, Ardila, & Ostrosky-Solis, 2007) they showed that children with obesity (vs. average weight) had less verbal fluidity, lower attention, and lower executive function and attention performance. Furthermore, by using magnetic resonance imaging, Bauer and colleagues showed that children with obesity have a larger white matter in the left cerebellar and mid posterior corpus callosum (which are involved in executive control), but also a reduced left hippocampus volume.

Studies with only school age children as participants confirmed the negative relation between obesity and executive functions. For example, Pauli-Pott, Albayrak, Hebebrand, and Pott (2010) conducted a study with a sample of 177 children and adolescents (from 8 to 15-year of age) with overweight or with obesity to learn about the relation between body weight and inhibition control abilities (assed with the Go/No-Go task and an interaction test, Verdejo-Garcia & Perez-Garcia, 2007). According to their results, children with a higher body weight performed worst in the inhibition control tasks, as compared to their counter peers with average weight. The result was confirmed also when age, gender, mother level of education were included in the model. Thus, high impulsivity was associated with the highest body mass index.

Also Kamijo et al. (2012) adopted the Go/No-Go task to assess inhibitory control abilities. The sample was composed by 126 preadolescents (from 7 to 9 years of age), whom researchers assessed their body measurement, and asked to performed the cognitive task and other evaluation tests about academic abilities. Authors found a negative correlation between body weight and inhibitory control abilities, but only in the No-Go task (that requires a lot of control abilities), and not in the Go-Task (in which less control abilities occur for the task performance). Thus, current research showed that the relation between excess weight and poor inhibition control abilities concern only tasks in which high control level are required.

Consistently, Cserjési et al. (2007) explored the cognitive profile of children with obesity, and compare the children with obesity's task performance with children with average weight performance. The study included 12 schoolboys (average age is 12.44 years old) with obesity and a control group with average weight. Children performed the digit span memory task of WAIS III (Wechsler, 1997) to know memory and working memory abilities; Raven's progressive matrices (Raven, Court, & Raven, 1992) to assess fluid intelligence; semantic verbal fluency test (Benton, 1968; Milner, 1964) to evaluate verbal fluidity and inhibition abilities; D2 attention endurance test (Brickenkamp, 1981; Szilágyi, 1987) to measure attention and visual scanning; the Wisconsin card sorting test (WCST; Milner, 1963; Nelson, 1976) to measure cognitive flexibility and shifting ability. Results showed that children with obesity performed worse on tasks assessing shifting ability than peers with average weight, despite there was no significant difference in working memory and total IQ.

Similarly, Braet et al. (2007) explored the impulsivity in children with obesity, by using the Matching Familiar Figure Test (MFFT; Cairns & Cammock, 1978) and by a paper questionnaire. By including children with obesity as well as children with average weight (from-10-to-18-years-old), they showed that children with excess weight reported more impulsivity than children with average weight in the MFFT task. Furthermore, children' questionnaire revealed that girls and boys with excess weight reported more shifting attention than children with average weight, and boys indicted also more focus attention difficulties than the control group. In this study, they also explored personality trait associated with impulsivity, by underlying possible common mechanisms of childhood obesity and Attention Deficit Hyperactivity Disorder.

In line with previous works, Tsai, Chen, Pan, and Tseng (2016) explored the relation between childhood obesity and executive functioning, by focusing on visuospatial attention shifting and inhibitory control of attention. Fifty-two children aged 9–10 performed a Posner paradigm Task (Posner, 1980) during a ERPs recording, and results showed that, despite no differences in terms of response accuracy, children with obesity had a slower reaction time and a weaker inhibitory control in visuospatial attention tasks than children with average weight. Tsai and colleagues (2016) also showed that there is a significant difference in P3 amplitudes between children with obesity and with average weight: In fact, it was smaller in the first group than in the second one, despite there are not latency's difference. Being P3 amplitude responsible for attentional resources during task performance (Polich, 2007), this result confirms neurocortical dysregulation in the attentional network area.

In one of the most recent reviews on the topic, Reinert, Po'e, and Barkin (2013) collected 23 studies regarding the relation body weight and executive functions, and 13 of these were focused on childhood. The majority of this studies explored inhibition control abilities, by using both computer tasks and self-report questionnaires. Results showed that children with obesity obtained lower performance in these tasks than children with average weight, and that having poor inhibitor control abilities are predictive of weight gain in the following years. Beyond these studies, authors included the study by Van den Berg et al. (2011), that showed that reward sensitivity abilities negatively related with weight gain in the following year, and the researches by Riggs, Spruijt-Metz, Chou, and Pentz (2012), and Riggs, Huh, Chou, Spruijt-Metz, and Pentz (2012) showed that obesity is associated with poor working memory functioning. In their conclusion Reinert and colleagues (2013) suggest to measure executive functions in a uniform way, and to conduct longitudinal studies to better understand the direction of the relation between obesity and executive functions.

Consistently with this recommendation, some studies explored the correlation between body weight and executive functioning over time by implementing longitudinal

Table 1

Studies on the relation between body weight and executive functions in children

Authors	Sample (N)	Design	Executive Function	Measure	Main outcomes
Bauer et al. 2015	33 (6-to-8 years)	Correlational	Executive Functions	Neuropsychological assessment	O < AW
Braet et al., 2007	109 (from 10-to-18-year-old)	Correlational	Impulsivity	MFFT	O > AW
			Attention Shifting	Self-report Questionnaire	O > AW
Cserjési et al., 2007	12 (schoolboys aged around 12.44 years old)	Correlational	Working Memory	Digit span WISC III	O = AW
			Inhibition	Semantic verbal fluency test	O= AW
			Attention Shifting	WCST	O < AW
Goldschmidt et al., 2015	2450 girls (aged from 10 to 14)	Longitudinal	Impulsivity	Hyperactive-Impulsive Scale of the Child Symptom Inventory-4th edition	Lower performance predicts higher BMI
Groppe & Elsner, 2015	1657 (6-to-11-year-old)	Longitudinal	Attention shifting	Cognitive Flexibility Task	OW < AW
			Inhibition	Fruit Stroop Task	OW = AW
			Working Memory Updating	Digit Span Backwards Task	OW < AW
Guxens et al., 2009	400 (4-6 years of age)	Longitudinal	Executive Functions	MCSA subtests	High executive function at age 4 is associated to lower weight gain at age 6
Kamijo et al., 2012	126 (7 to 9 years of age)	Correlational	Inhibition	Go/No-Go task:	
				Go task	No relations were found
				No-Go task	BMI negatively relates with attention shifting

Table 1 *(Continued)*

Authors	Sample (N)	Design	Executive Function	Measure	Main outcomes
Pauli-Pott, et al., 2010	177 (from 8 to 15-year of age)	Correlational	Inhibition	Go/No-Go task and an interaction test	O, OW < AW
Reinert et al. 2016	13 studies with children	Review			
		8 studies regarding childhood (from 2 to 12)	Inhibition	Delay of gratification task, Social Behavior questionnaire, Child behavior questionnaire, Behavioral Rating Inventory of Executive Function (self-reporting), Go-No Go Task	O, OW < AW, Lower performance predict higher BMI
		1 study with children (8-9 years old)	Reward sensitivity	Sensitivity to punishment and sensitivity to reward questionnaire for children	Lower performance predicts higher BMI
		1 study with children (8-9 years old)	Working memory	Behavioral Rating Inventory of Executive Function (self-reporting)	O < AW
Tsai et al., 2016	52 (aged 9–10)	Correlational	Visuospatial attention shifting and inhibitory control	Posner Paradigm Task, ERP	O < AW

Note. O = participants with obesity; OW = participants with overweight; AW = participants with average weight; WISC III= Wechsler, 1997 MFFT = Matching Familiar Figure Test; WCST = Wisconsin Card Sorting Test; MCSA = McCarthy Scales of Children's Abilities.

studies. For example, Goldschmidt, Hipwell, Stepp, McTigue, and Keenan (2015) planned a 4 years' study with 2450 girls (aged from 10 to 14) to know the relation between executive functioning and weigh change during time. They used the Wechsler Intelligence Scale for Children-Third Edition-Revised (WISC-III-R: Wechsler, 1991) to assess children cognitive abilities. Specifically, they used Mazes and Vocabulary/Similarities subscales to evaluated planning abilities and verbal comprehension abilities, respectively. Furthermore, they adopted the ADHD, Hyperactive-Impulsive Scale of the Child Symptom Inventory-4th edition (Gadow & Sprafkin, 2002), to measure children's impulsivity. Consistent with previous researches, the authors found that a low impulsivity at 10 years old is predictive of weight gain at age 16.

Groppe and Elsner (2015) have instead involved boys and girls aged from 6 to 11 years for a longitudinal study. The first aim was evaluating children's executive functions with a battery of executive functioning task: Attention shifting with the Cognitive Flexibility Task (Roebers, Röthlisberger, Cimeli, Michel, & Neuenschwander, 2011; Zimmermann, Gondan, & Fimm, 2002), inhibition with the Fruit Stroop Task (Archibald & Kerns, 1999; Roebers et al., 2011), working memory updating by the Digit Span Backwards Task of the Wechsler Intelligence Scale for Children (HAWIK-4; Petermann & Petermann, 2007). The second aim was assessing the longitudinal association between executive functions and body weight. They showed that children with excess weight performed worse in attention shifting and working memory updating task (cold executive functions) than children with average weight, whereas no other differences in executive functions were reported. Furthermore, higher body weight is related to lower cold executive function a year later (but not when social economic status was included), while weaker attention shifting could lead to weight gain (also including social economic status).

II.1.3.2. Obesity and cognitive functioning in adulthood

Academic Achievement. Cohen, Rai, Rehkopf, and Abrams (2013) have conducted a systematic review showing that the relation between obesity and educational attainment depends on gender and country, i.e., the relation is negative in more industrialized countries, whereas it is positive in developing countries (especially for women). A gender difference was found also by Merten, Wickrama, and Williams (2008) who showed that women with average weight during adolescence attain higher socio-economic status (that also includes higher educational level) than women who were with obesity during adolescence.

Interestingly, Ball et al. (2004) highlighted that women with obesity have a lower probability to have high aspirations for further education, and Odlaug et al. (2015) showed that college students with overweight or obesity perceive themselves as having lower academic achievements than students with average weight.

Intelligence. The relation between obesity and cognitive functioning in adults was explored by several studies and in different ways. For example, Gunstad, Paul, Cohen, Tate, and Gordon (2006) showed that people with obesity obtain lower performance in verbal memory tests than participants with average weight or with overweight, whereas, by means the Telephone Interview for Cognitive Status (Brandt, Spencer, & Folstein, 1988), Xiang and An (2015) showed that adults with overweight or with obesity (as well as people with underweight) have higher cognitive impairments than those with average weight. Nilsson and Nilsson (2009) displayed that people with excess weight underperform participants with average weight in episodic memory, semantic memory and spatial ability. Specifically, there is a significant difference between individuals with average weight and excess weight in episodic memory only among older participants, whereas women with average weight outperform women with obesity in semantic memory task. A more global investigation was conducted by Gunstad, Lhotsky, Wendell, Ferrucci, and Zonderman (2010) in a study with 1,703 participants (from 19 to 93 years of age). The authors, by investigating global cognitive functioning, memory, and language, showed that there is a negative relation between body weight and all the explored cognitive abilities and functions.

Similar results were obtained when body status was measured by means of waist circumference, a more reliable measure of abdominal fat accumulation as compared to BMI (e.g., Kerwin et al., 2011; Kesse-Guyot et al., 2015). For example, Dore, Elias, Robbins, Budge, and Elias (2008), by involving a community sample composed by 917 adults, unveiled that waist circumference negatively relates with performance in global visuo-spatial organization task, measured by the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975), and the Maine-Syracuse neuropsychological battery (Dore, Elias, Robbins, Elias, & Brennan, 2007).

Furthermore, researchers have also implemented longitudinal studies to explore the relation body weight/cognitive functioning during time. One of the longer longitudinal study was conducted by Belsky et al. (2013) who assessed body weight and intelligence when participants aged 2 year until they were 38-year-old. By administering the Picture Vocabulary

Test (Dunn, 1965) and the Wechsler Scale (Wechsler, 1974; Wechsler, 2008), the authors highlighted that obesity did not cause a lower intelligence quotient (IQ), but that the poor IQ in adults with obesity had been always lower throughout individuals' life. In addition, they showed that children with a low IQ had a higher probability to develop obesity during adulthood. Instead, by involving 362,200 men (with juvenile-onset obesity and with average weight), Halkjær, Holst, and Sørensen (2003) displayed that weight gain was associated with a reduction of intelligence score (measured by Børge Priens Prøve; Rash, 1960) and a reduced educational level as well. Interesting, when both the dimensions were considered in the same hierarchical regression model, they continued to negatively predict the impact on body weight, despite the effect of intelligence's score was lower than the educational level's impact. Similarly, Cournot et al. (2006), in a longitudinal study with 2,223 participants (aged 32 to 62 years at the baseline), showed that increasing body mass index over time corresponds to a decreasing performance in cognitive functions assessments, and participants with a higher body weight at the baseline have a higher cognitive impairment at the follow up. In addition, in a longitudinal study with middle-age and older participants, Kim, Kim, and Park (2016) showed that being with overweight is related with a slower cognitive decline in the following six years, especially for women. Furthermore, having low cognitive abilities and being with excess weight is related to a higher impairment of cognitive abilities.

Executive functions. People with obesity manifest not only an impairment in the overall cognitive functioning (for a review, see Smith et al., 2011), but also in the specific executive functions. The review by Fitzpatrick, Gilbert, and Serpell (2013) showed people with obesity obtain poor scores no on all task tapping into executive functions, but only in decision making tasks and in one task concerning set-shifting domain. However, the recent review by Prickett et al. (2015), explored several dimensions related to executive function. For example, they showed that concept formation and set-shifting abilities (e.g., using abstraction, flexibility, problem solving to form concepts, etc. …) are lower in people with obesity than with average weight. Similarly, they showed that decision making (the ability to select an option out of several alternatives), usually assessed with computerized gambling task, are deficient in people with obesity. Other investigations dealt with delay discounting, i.e., the ability to waive delay smaller more immediate rewards for delayed larger rewards, but these studies have found contrasting results, which indicate that further investigations are needed to verify the relation between obesity and delay discounting. Researchers have also explored the relation between body weight and inhibition abilities (the ability to correctly answer by inhibiting the habitual response), commonly measure with the Stop Signal Task or the Stroop Task, and they reported that inhibition abilities are usually compromised in people with obesity. Despite authors did not classify working memory on the executive function section, they reviewed the relation between obesity and working memory as well. Only two studies tested this relation, and they have not found significant results: In fact, no performance's differences in body weight groups appear in the N-back task (Jaeggi et al., 2010), in the forwards and backwards digit span subtest total score (Wechsler, 1997), and in the Letter-Number Sequencing (Crowe, 2000).

Also, Dore et al. (2008), by exploring the relation body weight and cognitive functions, focused on working memory proficiency. With this purpose, they included in their neurocognitive assessment also the digit span forward and backward (WMS-R; Wechsler, 1987), the letter number sequence (WAIS III), and the controlled oral word associations (Benton, Hamsher, & Sivan 1989) as measure of working memory performance. Correlational analyses evidenced a negative correlation between body weight and working memory performance, whereas regression analyses showed that body weight is a significant predictor of working memory performance. Specifically, the result was confirmed when age, educational level, gender, number of prior exams were considered in the model, but not when health status and life styles were included too.

Gunstad et al. (2010) have explored the relation between obesity and cognitive functioning exploring the role of executive functions with the Trail Making Test (TMT) by Tombaugh (2004) and with the digit span of the Wechsler Adult Intelligence Scale – Revised (WAIS-R) by Wechsler (1981). Research's results revealed that participants (1702 adults aged 19–93 years) with a higher body weight obtain higher performance in Trail Making Test A. Furthermore, in a longitudinal prospective, the interaction body weight and Trail Making Test A has a significant value, by proving that older people with obesity better perform on tests of attention/psychomotor speed and visuospatial skills, but not on working memory.

In addition, the study by Boeka and Lokken (2008) share the common aim to explore the relation between obesity and neuropsychological performance, especially on executive functions. To assess executive functioning, they used the Rey Complex Figure Test (CFT; Rey, 1941) as index of perceptual and organizational skills and nonverbal memory, the Trail making test (TMT, Parts A and B; Reitan, 1958) and Wisconsin card sorting test (WCST; Grant & Berg, 1948) as measure of processing speed, cognitive flexibility, problem-solving ability, and ability to shift set. Statistical analyses demonstrated a negative relation between body weight and the executive functions, and that the reduced abilities in planning, mental flexibility, problem solving, and monitoring are present also regardless the other medical conditions commonly related with obesity (e.g., hypertension, type II diabetes, and obstructive sleep apnea), which are also responsible for poor cognitive performance.

Furthermore, Fagundo et al. (2012) conducted a study with a clinical sample (aged between 18 and 60 years) composed by 224 people with extreme weight conditions (i.e., anorexia and obesity) and average weight. Participants were invited to perform three cognitive computer tasks (presented in a randomized order): The Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1981) as measure of planning abilities, cognitive flexibility, response shifting and inhibition; The Stroop Color and Word Test (SCWT; Golden, 1978) for the evaluation of flexibility and attention; The Iowa Gambling Task (IGT; Bechara, Damasio, Tranel, & Damasio, 1997) as measure of decision making and delay discounting. Multiple regression models were performed to test the role of body weight on the used cognitive tasks, and results showed that adults with obesity perform worse in inhibition and shifting tasks.

Other researchers focused on executive functions also to explore the relation between these specific cognitive abilities with the most common eating disorders in people with obesity. For example, Pignatti et al. (2006) conducted a study with 20 participants with obesity (mean age was 43.40) and 20 participants with average weight (mean age was 46.65) with the aim to detect the relation between excess weight and executive functions, specifically with decision making and delay discounting which could be related with overeating behaviors. By using the Iowa Gambling Task (IGT; Bechara, et al. 1997), they showed that participants with obesity perform worse in decision making task than participants with average weight. Subsequently, other researchers conducted some studies to investigate the poor cognitive functions in people with obesity with or without eating problems. Davis, Patte, Curtis, and Reid (2010) included in their investigation women aged 25 to 65, specifically 65 were with obesity and binge eating disorder, 73 with obesity, and 71 with average weight. Participants were asked to perform the Iowa Gambling Task (IGT; Bechara et al. 1997) and the Discounting Task (Richards, Mitchell, de Wit, & Seiden, 1997; Richards, Zhang, Mitchell, & Wit, 1999) to evaluated respectively decision making and delay discounting. Results revealed that women with average weight perform better than people with excess weight (no differences were found between people with excess weight and with average weight), however when educational level entered in the model as control variables the model's significance disappears, as there was a significant difference on educational level between the experimental groups. In addition, Manasse et al. (2014), with the aim to study the relation between excess weight and overeating, explored the role of executive functions and of loss of control for eating in a clinical sample of 80 women with overweight or with obesity. In detail, they hypothesized that participants with obesity with loss of control (vs. without loss of control) obtain lower results in cognitive task concerning regulatory control, planning, delayed discounting, working memory, and set-shifting. With this purpose, they asked participants to answer a paper questionnaire and to perform some cognitive tasks, i.e., the Delis Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan, & Kramer, 2001) to assess executive functions, the Color-Word Interference and Tower Tasks to measure response inhibition and planning, respectively; Letter N-Back Task (Ragland et al., 2002) to know the working memory functioning, the Penn Conditional Exclusion Task (Kurtz, Ragland, Moberg, & Gur, 2004) to evaluate set-shifting, and the Delayed Discounting Task (Robles & Vargas, 2007) to learn about delayed discounting. Results showed a negative association (but not significant) between excess weight and working memory, and that people with overweight and obesity with low loss of control (vs. high loss of control) obtain lower results in working memory, response inhibition, and planning tasks. When depression was added in the model, working memory was not a significant outcome.

Other investigations dealt with other the clinical sample of patients with obesity. Indeed, Lokken, Boeka, Yellumahanthi, Wesley, and Clements (2010) investigated the relation between obesity and both cognitive and psychological dimension in 169 patients with morbid obes(i.e., seeking bariatric surgery). They showed that patients with obesity do not differ in IQ from other patients, but they obtained specific poor results only in tasks involving executive control (e.g., problem solving and planning). Also, Sargénius, Lydersen, and Hestad (2017) explored the relation between obesity and cognitive functioning in a specific group of patients, people with obesity in weight-loss treatment (96 men and women aged around 43 years old). Results showed that participants with obesity obtain poorer results in executive functions, assessed with the Delis-Kaplan Executive Function System Tower Test (D-KEFS; Delis et al., 2001), and that also working memory (measured with the Trail Making Test and Wisconsin Card Sorting Test, WCST) resulted to be impaired.

Table 2

Studies on the relation between body weight and executive functions in adults

Authors	Sample (N)	Design	Executive Function	Measure	Main outcomes
Boeka & Lokken, 2008	68 participants (20–57 years)	Correlational	Cognitive flexibility Problem solving, shifting	TMT B WCST	O = AW O < AW
			Perceptual and organizational skills	CFT	O < AW
Davis et al., 2010	209 participants (aged 25 to 65 years old)	Correlational	Decision making and delay discounting	IGT, Discounting Task	O < AW
Dore et al. 2008	917 adults	Correlational	Working memory	Digit span (WMS-R), letter number sequence (WAIS III), controlled oral word associations	BMI significantly predicts EF
Fagundo et al., 2012	224 participants (from-18-to-60)	Correlational	Inhibition and Shifting Task	WCST	O < AW
			Flexibility and Attention	Stroop task	O = AW
			Decision Making, Delay Discounting	IGT	O = AW

Table 2 *(Continued)*

Authors	Sample (N)	Design	Executive Function	Measure	Main outcomes
Fitzpatrick et al., 2013	35 Studies with adults	Review			
		9 studies	Inhibitory Control/Impulsivity	Stroop task, Stop Signal Task, Go- No Go Task, Hayling Sentence Completion Task	Incongruent results
		14 Studies	Set-Shifting	TMT, WCST	Incongruent results
		11 Studies	Decision-Making	IGT, Maze Task, Game of Dice Task	O < AW
		1 Study	Planning and Problem-solving	BADS	O < AW
Gunstad et al., 2010	1073 participants (aged 19–93 years)	Longitudinal	Executive Functions	TMT A	O > AW, BMI significantly predicts EF
				TMT B	O = AW
				Digit Span	O = AW
Lokken et al., 2010	169 patients	Correlational	Problem solving and planning	WSCT	O < AW
				RCF	O < AW

Table 2 *(Continued)*

Authors	Sample (N)	Design	Executive Function	Measure	Main outcomes
Manasse et al., 2014	80 women	Correlational	Overall Executive Functions	D-KEFS	O < AW
			Response inhibition and planning	Color-Word Interference and Tower Tasks	O < AW
			Set-shifting	Penn Conditional Exclusion Task	O < AW
			Working Memory	N-back task	O < AW
			Delayed Discounting	Delayed Discounting Task	O = AW
Pignatti et al., 2006	40 participants (meand age 43)	Correlational	Decision making and Delayed Discounting	IGT	O < AW
Prickett et al., 2015		Review 5 Studies	Seft-shifting	WCST, category test	O < AW
		3 Studies	Decision Making	Gambling task	O < AW
		3 Studies	Delay discounting	Delay discounting task	Contrasting results
		3 Studies	Inhibition	Stop Signal Task, Stroop Task	O < AW
		2 Studies	Working memory	N-back task, digit span (WAIS), Letter-Number Sequencing	O = AW
Sargénius et al., 2017	96 patients (aged 18 to 60)	Correlational	Global Executive Functions	D-KEFS	O < AW
			Working Memory	TMT, WCST	O < AW

Note. O = participants with obesity; OW = participants with overweight; AW = participants with average weight; TMT = Trail Making Test; WCST = Wisconsin Card Sorting Test; MMSE = Mini Mental Status Examination; RCF = Rey Complex Figure task; BADS = Behavioural Assessment of Dysexecutive Syndrome; CFT = Rey complex figure test; IGT = Iowa gambling task; WMR-R = Wechsler, 1999; WAIS III = Wechsler Adults Intelligence Scale; BADS; D-KEFS = Delis-Kaplan Executive Function System.

II.1.3.3. Physiological explanations for reduced cognitive performance in obesity

Several studies show that some medical conditions commonly associated with obesity impair cognitive functioning, such as diabetes (McCarthy, Lindgren, Mengeling, Tsalikian, & Engvall, 2002), sleep and respiratory disorders (Alchanatis et al., 2004; El-Ad & Lavie, 2005; Spruyt & Gozal, 2012; Vitelli et al., 2015), or hypertension (Cottrell et al., 2007). In fact, hyperinsulinemia causes altered glucose metabolism (Miller et al., 2006), sucrose in excess (Jurdak, Lichtenstein, & Kanarek, 2008), low level of leptin in brain and, consequently, affect those brain regions (such as frontal lobes and hippocampus) that are involved in performance intelligence abilities (Craft & Stennis Watson, 2004; Farr, Banks, & Morley, 2006; Li et al., 2008). Similarly, the hypoxemia usually related to sleep apnea disorders (obstructive type) causes lower cognitive performance (Carvalho et al., 2005). Likewise, poor cognitive abilities are associated with low-degree inflammation of brain's vessels (Welch, Roizen, & Daniels, 2003). Furthermore, differences in brain structure (Ho et al., 2010), abnormal testosterone and androstenedione's levels (Azurmendi et al., 2005), altered brain functioning (Halkjær et al., 2003), white matter lesions in orbitofrontal cortex (Miller et al., 2006) are other factors that are related with reduced cognitive efficiency among individuals with obesity. Regarding the brain structure, Wang et al., (2016) individuated insulin/leptin resistance, increased oxidative stress, cerebrovasculature changes, reduced blood-brain barrier integrity, inflammation, reduced neurotrophins that alter the brain structure and functioning, and that cause a detriment in cognitive proficiency.

In addition, other researchers found diet among the factors responsible of low cognitive abilities. Noble and Kanoski (2016) showed that high fat diets or sugar can damage hippocampus-dependent learning and memory processes. Similarly, Florence, Asbridge, and Veugelers (2008) found specific components of overall diet that were significantly related to academic performance: Fruit and vegetable as well as the reduction of caloric intake of fat food was related with higher reading and writing ability in children in 5th grade. The importance of a healthy life style is confirmed also by the positive effects that physical activity could have on cognitive performance (e.g., Carvalho, Rea, Parimon, & Cusack, 2014; Hillman, Erickson, & Kramer, 2008; Lees, 2013). Chang, Chu, Chen, Hung, and Etnier (2016) explored the relation between obesity, physical activity and cognitive functioning, by reviewing researches that compare these variables. They found that past studies have explained the relation by detecting obesity and physical activity as independent predictor, or as overlapping factors that affect cognitive functioning, or by evaluating obesity or physical activity as moderators or mediators of the relation physical activity/cognitive functioning or obesity/cognitive functioning. Despite the way in which these variables interact is not clear and future investigations are needed, the effect of physical activity on cognitive functioning is widely confirmed. In addition, Song et al. (2016) conducted an experimental study by involving a sample of college students that they classified in four different groups according to their body weight and cardiovascular fitness: 1) Average weight and high fitness activity; 2) average weight with low fitness activity; 3) obesity and high fitness activity; 4) obesity and low fitness activity. They asked participants to performance the Stroop Task (Stroop, 1935) as computer task, while event related potential measure of P3 and N1 were assessed. Results showed that the first group of participants showed the shortest response time and largest P3 amplitudes than other groups. Specifically, the fourth group showed the longest response time. Thus, being with average weight and with high physical activity is associated with the better task performance, as task performance and recorded physiological reactions show.

II.1.4. Conclusion

In this first chapter, we described obesity as a health condition, and we underlined the psychological complications that are related with excess weight. Specifically, we focused on cognitive functioning, exploring the relation between obesity and intelligence, operationalized as academic achievement, intelligence, attention, and executive functioning. We concluded with a description of the possible mechanisms responsible of the negative relation between obesity and cognitive impairment. However, despite physiological mechanism causes may play a crucial role in determining cognitive deficits related with obesity, we could suppose that psychosocial factors as well may interfere with cognitive proficiency, and partially contribute to the observed cognitive impairment in individuals with obesity. Obesity is a socially stigmatized condition, and the consequences of weight-based stigmatization should also be considered as a potential predicament affecting the cognitive proficiency of individuals with excess weight.

2. OBESITY AS A STIGMATIZED CONDITION

II.2.1. Obesity stigma

People with obesity are negatively evaluated for their excess weight, and are commonly stereotyped as lazy, unsuccessful, lacking intelligence, and with poor self-control (Puhl & Heuer, 2010).

The negative evaluation affecting people with obesity is possibly due to the thin ideal present in our society, that stresses the importance of a thin body weight (Grabe, Ward, & Hyde, 2008). In fact, the common idea that “thin is good and fat is bad” is so widely interiorized in Western societies, that endorsing negative weight-based stereotypes is considered ordinary, and it is consequently commonly accepted at the societal level (Puhl & Brownell, 2003). Furthermore, endorsing the belief that individuals are responsible for their weight status lead to blame people with obesity for their health condition (Crandal & Martinez, 1996; Crandall & Schiffhauer, 1998), despite the fact that obesity is a multi-factorial disease, related with individuals’ behaviours as well as with genetic components and environmental factors (WHO, 2016a). It is for this reason that obesity stigma is deemed as one of the strongest form of discrimination of this century (compared, for example, to LGBT stereotypes; Latner, O’Brien, Durso, Brinkman, & MacDonald, 2008).

Several studies, focused on blame and responsibility attributed to people with obesity (Brewis, 2011; Brewis, 2014; Gimlin, 2007; Saguy, 2013), confirm that considering obesity as matter of personal responsibility is a cause of negative weight-based attitudes, and also predicts social exclusion of individuals with obesity. Iobst et al. (2009) showed that endorsing the idea that being with obesity is an individuals’ blame decreases the acceptance of children with obesity from their peers, especially in pre-schooler children (vs. children aged 8-11 years old). Other studies informed by the attribution-emotion approach (Weiner, Perry, & Magnusson, 1988) showed that blaming people with obesity for their weight status increases feelings of disgust, which in turn increase negative weight-based stereotypes (Vartanian, 2010). Consistently, Vartanian, Thomas, and Vanman (2013) showed that people feel more contempt and disgust than anger toward people with obesity, and that disgust is the only significant predictor of weight-based stereotypes. Similarly, Wirtz, van der Pligt, and

Doosje (2016) demonstrated that the relation between blame and anti-fat reactions is partially mediated by contempt: In fact, the negative relation between blame and anti-fat reactions increased when contempt was added in the model. Finally, in line with this evidence, other studies revealed that weight-based attitudes change when participants are informed about the multifactorial ethiology of obesity (Fitzgerald, Heary, & Roddy, 2013), whereas other investigations underlined that people who do not blame individuals with obesity are also more supportive for policies oriented to reduce weight-based discrimination (Puhl et al., 2015).

Currently, weight-based stigma is both strengthening and spreading worldwide (Brewis et al., 2011). Specifically, countries with higher prevalence of obesity show stronger implicit negative associations for overweight and obesity than for average weight (Marini et al., 2013), and despite individuals with a high body weight manifest lower implicit negativity toward obesity than thinness (Marini et al., 2013), adults and children with obesity also endorse negative weight-based stereotypes at the explicit level (Kornilaki, 2014; Schwartz, Vartanian, Nosek, & Brownell, 2006). In fact, other studies reveal that weight-based negative stereotypes do not depend on personal body weight. Rather, body weight dissatisfaction, body weight-perception, and beliefs about personal control seem to be three key elements associated with negative weight-based stereotypes (Himmelstein & Tomiyama, 2015).

Anti-fat biases are common not only among adults (for reviews, see Puhl & Heuer, 2019; Puhl & Heuer, 2010), but also among children (Puhl & Latner, 2007). A recent study by Ruffman, O'Brien, Taumoepeau, Latner, and Hunter (2016) showed that infants aged 11 months presented a stronger attentional bias toward characters with obesity than characters with average weight, whereas the attention bias at 32 months shifted toward characters with average weight. The changing from the first to the second assessment was related with mother's weight-based attitudes, and it could therefore represent a precursor for the development of later negative weight-based attitudes in the following years. Similarly, by presenting a doll to a sample of pre-schooler girls, Worobey and Worobey (2014) showed that children associated positive feature (e.g., pretty, smart, has best friend, etc.) more often to thin dolls, whereas negative features (e.g., sad, tired, gets sick, etc.) were more likely to be attributed to fat dolls. The same preferences also emerged among 84 children in a study by Kornilaki (2014): Regardless of children's body weight, participants indicated as a preferred playmate, and assigned positive characteristics, to a picture with a thin child (vs. with obesity).

Weight-based stereotypes are also evident during middle-childhood. Latner and Stunkard (2003) conducted a study with 458 children attending fifth and sixth grade, and asked to them to rank six pictures according to their preferences. The pictures portrayed six different kind of child: One in a healthy status, four with a visible disability (i.e., holding crutches, or sitting in a wheelchair, or without a hand, or with a facial disfigurement), and one with obesity. Children classified the "healthy" child in the highest rank, whereas the child with "obesity" was in lowest position. Furthermore, this study has compared children's choices with those from the research by Richardson, Goodman, Hastorf, and Dornbusch (1961), and showed that negative evaluation of the target picture with obesity among children attending 5th and 6th grade has become significantly stronger from 1961 to 2003. In addition, Solbes and Enesco (2010) showed that children (aged 6–11 years) endorse no only explicit, but also implicit weight-based stereotypes: In fact, at the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998), they are more rapid and more accurate in associating obesity with negative than with positive attributes.

II.2.2. Sources of weight-based stigma

One of the main consequences of the societal prevalence of negative weight-based attitudes and stereotypes is that individuals with obesity are especially likely to experience weight-based stigma episodes in their life (Puhl & Heuer, 2009; Puhl & Heuer, 2010; Himmelstein & Tomiyama, 2015), and there are several contexts of daily life in which this can occur.

Family, for example, could represent the first place in which stigmatization occurs. In fact, both parents with average weight and parents with obesity endorse negative weight-based stereotypes, and parents' negative beliefs can affect their children's anti-fat attitudes, especially for girls (Davison & Birch, 2004). In Wolfenden et al.'s (2013) study, authors telephonically told a story about a child with different body weight and subsequently they asked how was the probability that them and their children presented prosocial behavioural toward the story's character. What emerged that parents imagine that themselves and their children would have more pro-social behaviour toward children with average weight than with obesity, thus potentially affecting future interactions of their children with peers with obesity. In addition, Puhl and Latner (2007) as well as Puhl and King (2013) highlighted that people with excess weight (especially women) indicate parents, spouses, and sibling among the main source of weight-related discrimination.

The second context of socialization for individuals is school. In this context, teachers as well as peers could represent a second source of weight-based discrimination. For example, by means of an online questionnaire proposed to 140 teacher, Wilson and colleagues highlighted that teachers considered children with other health conditions (e.g., asthma) in a more positive way than pupils with obesity, and that they considered a burdensome having children with obesity in their classroom (Wilson, Smith, & Wildman, 2015). In addition, the study by Glock, Beverborg, and Muller (2016) showed that pre-services teachers manifested more positive attitudes toward thin body shapes than negative attitudes toward obesity at the implicit level, but mixed explicit attitudes.

Also, concerning the school environment, youths with overweight and with obesity experience more episodes of bulling than others with average weight (Van Geel et al., 2014). McCormack et al. (2011), in lines with the other studies (Haines, Neumark-Sztainer, Hannan, van den Berg, & Eisenberg, 2008; Neumark-Sztainer et al. 2002; van den Berg, Neumark-Sztainer, Eisenberg, & Haines, 2008), showed that children with overweight and obesity experiences more episodes of weight-related teasing than children with average weight at school.

If during childhood school represent one the main context of individuals' life, the employment settings plays this role during adulthood, and as well as it happens in school place, people with obesity could experience episodes of weight-based discrimination in the workplace (Puhl & Heuer, 2009; Rudolph, Wells, Weller, & Baltes, 2009). For example, O'Brien et al. (2008), in a study on personnel selection, showed that people with obesity (vs. with average weight) are evaluated with less leadership potential, less likely to succeed, received a lower overall evaluation, and were less likely to be employed than average-weight candidates. Similar results were also obtained by Ruggs, Hebl, and Williams (2015), who investigated formal and subtle forms of weight-based discrimination in the workplace. The authors created an experimental situation in which a confederate entered in a mall's store, by dressing up as a man with obesity (obesity prostheses were adopted) or with average weight, to seek for a job (job applicant condition) or to buy for a present (costumer condition). Formal discrimination (to assess mandatory behaviours requested to the store's personnel), and observed not-verbal behaviour (e.g., affirmative gestures such as nodding, friendliness, eye contact, rudeness, smiling, comfort level, attempts to end the interaction, eye brow furrowing, pursed lips, hostility, and standoffish behaviour of the employee) were rated. According to the results, the store personnel showed the same level of formal discrimination toward people with obesity and with average weight, whereas the interpersonal discrimination was higher against the man with obesity. In this study, weight-based discrimination was higher in the job applicant condition than in the costumer condition, but interpersonal differences between confederates with average weight and with obesity were also in the costumer condition, and these differences were confirmed also in the study by King, Shapiro, Hebl, Singletary, and Turner (2006). In addition, Sikorski et al. (2015) showed that adults present higher social distance toward people with obesity for job recommendation, introduction to a friend, someone with obesity marrying into the family and renting out a room to a person with obesity. These relations were mediated by sympathy and incomprehension, suggesting that working on emotions could decrease the level of social distance toward individuals with obesity.

However, people with obesity experience weight-based discrimination also in the context that should be helpful, i.e., in the healthcare context. Attitudes and behaviours from physicians or nurses could be a source of weight-based discrimination, and several studies demonstrated this relation (for a review, see Tomasetto & Privato, 2013). For example, Phelan et al. (2014) showed that medical students on average endorse negative weight-bias stereotypes, and that low body weight, being male, and not belonging to African American ethnicity group predicted these attitudes. Furthermore, they displayed that implicit anti-fat biases were comparable to the implicit stereotypes for other social groups, whereas explicit weight-related attitudes were stronger than explicit attitudes for other stigmatized groups. Negative weight-based attitudes are endorsed, despite in a slightly way, also by dietitians and nutritionists (Jung, Luck-Sikorski, Wiemers, & Riedel-Heller, 2015), and by professional treating eating disorders (Puhl, Latner, King, & Luedicke, 2014).

There are also other professionals, related with health settings, who could endorse negative weight-based stereotypes, and could indirectly manifest their beliefs in professional practice. They are the physical trainers or physical education teachers whom children or adults may find in a gym, and could play a determinant role in deciding to engage in sport activity or to avoid them. In fact, weight-based discrimination during a physical activity is one of the cause of disengagement in sport in people with obesity (Vartanian & Shaprow, 2008), and it is also a cause of poor emotional and physical health among individuals with overweight and obesity (Schvey et al., 2016). O'Brien, Hunter, and Banks (2007) conducted a study with university students attending Psychology and Physical education, and showed that the latter hold more implicit negative weight-based attitudes than the former, and negative weight-bias were more present in students in the third than in the first university year.

Beyond all this interpersonal form of discrimination, people with obesity could experience weight-based stigmatization indirectly though media messages. Latner, Rosewall, and Simmonds (2007) showed that weekly time spent with media (especially reading magazines) negatively affect weight-based stereotypes. For example, Pearl, Puhl, and Brownell (2012) in an experimental study displayed to participants an image with either a stigmatizing or a non-stigmatizing representation of a person with obesity, and showed that the former group of participants showed more anti-fat bias and social distance than participants in the non-stigmatizing condition. Similarly, Hinman, Burmeister, Kiefner, Borushok, and Carels (2015) showed that visual portrayals of obesity could influence individuals' implicit weight-based stereotypes: Participants performed an implicit association test composed by weight-related stereotypical images or by no-weight-related stereotypical images, and they showed stronger implicit weight-based stereotypes when the implicit association test presented stigmatizing images of people with obesity than stereotype-incongruent stimuli. The negative effect of stigmatizing images is concerning, because children and adults with obesity are represented according to weight-based stereotypes in online news video and in newspaper (Flint, Hudson, & Lavallee, 2016; Puhl, Peterson, & Luedicke, 2013), and this could perpetuate obesity bias and its consequences: In fact, people with obesity are often portrayed as eating unhealthy foods, in sedentary behaviours, or dressed in inappropriately fitting clothing, thus strengthening the negative weight-bias attitudes in the observers.

Finally, because the identity develops though social interaction (Cooley, 1956), the direct and indirect forms of discrimination described above could lead people with obesity to endorse negative beliefs about obesity, and to apply these stereotypes to themselves (Corrigan, Larson, & Rüsch, 2009). The internalization of weight bias, similarly to the internalization of societal stigma in other stigmatized social groups (e.g., mental illness, Corrigan, Watson, & Barr, 2006; Drapalski et al., 2013), represents a cognitive and emotional process that negatively affects the individual's wellbeing (Durso et al., 2012), and may have a major negative impact on wellbeing than external experiences of discrimination (Pearl & Puhl, 2016).

II.2.3. Consequences of weight-based stigma

As documented by decades of research on the psychology of stigma, being the target of negative stereotypes, prejudice, and discrimination (i.e., experiencing stigma in one's life) or endorse the negative stereotypes about one's social identity, has a disruptive impact on individuals' physical and psychosocial well-being (Major & O'Brien, 2005). For adults struggling with excess weight, stigma experiences increase the vulnerability to a variety of negative consequences for emotional (e.g., depression, low self-esteem, poor body image, etc.), behavioural (e.g., reduced participation or avoidance of physical activity), social (e.g., reduced satisfaction with romantic and sexual relationships), and physical functioning (e.g., increased risk of coronary events, hypertension, abdominal adiposity and glucose intolerance), above and beyond the mere effects of excess body weight (for reviews, see Puhl & Heuer, 2009; Puhl & Heuer, 2010). Similarly, Puhl and Latner (2007) reviewed the forms, mechanisms and consequences of weight stigma for children and adolescents, and provided compelling evidence that experiencing weight stigma is a stressful experience with harmful and enduring effects on individuals' well-being before entering adulthood.

Thus, direct, indirect and interiorized forms of weight-based discrimination affect individuals with obesity's life from a psychological to a physiological point of view. After these important reviews, other investigations and researches dealt with this topic, offering new insight in the obesity stigma's literature (for a review, see Papadopoulos & Brennan, 2015).

II.2.3.1. Self-esteem

Weight-based stigma has a negative impact on individuals with obesity self-esteem. Regarding childhood, a study with 495 participants in fifth and sixth grades (Bang et al., 2012) showed that self-perception (a composite measure including the self-concept of physical appearance and global self-worth) was lower in participants with excess weight or obesity. The perception of appearance-based teasing from parents mediated the relation between BMI and self-perception. However, only the physical appearance self-concept was significantly lower in children with obesity, whereas global self-worth did not differ as a function of weight. Instead, Kornilaki (2014), in a study with children (mean age 11.5 year old), evidenced the children with obesity have less global self-worth, athletic competence, social acceptance and physical appearance than children with average weigh, and that weight-related attitudes, assessed with the short vignettes by Cramer and Steinwert (1998) and by Penny and Haddock (2007), moderated the relation between body weight and physical appearance, athletic competence and global self-worth, but not the sub dimensions of scholastic competence, social acceptance, and behavioural conduct. Davison et al. (2008) assessed the relation between endorsement of weight-related stereotypes and psychological well-being in a community sample of 163 girls with or without excess weight, and found that the relation between weight-related stereotypes and global self-esteem at age 9 was not significant. Moreover, weight-related stereotypes endorsed at age 9 failed to predict self-esteem at age 11. Similarly, a study with 382 children aged 10 and 11 revealed that the relation between weight-related teasing experiences and self-esteem was not significant, whereas a negative relation was found between experiences of non-weight-related criticism and self-esteem (Nelson et al., 2011).

Among studies with adults, we mentioned at first Durso, Latner, and Ciao (2016) that, by involving 90 participants (aged 21 to 73) with excess weight (obesity and overweight), investigated the relation between internalized weight-related stigma and self-esteem, body dissatisfaction, and mood symptoms. With a hierarchical regression analysis, they showed that body weight, weightbased attitudes and weight bias internalization were significant predictors of the self-esteem value. The negative effect of weight-based internalized stigma was confirmed also by Durso et al. (2012) with treatment-seeking obese patients, whereas Pearl, White, and Grilo (2014) analyzed the role of weight-based internalization as predictor of self-esteem, by hypothesizing, and then confirming, that body weight mediates the relation. However, also weight-based experiences of discrimination have a negative impact of self-esteem during adulthood (Friedman, Ashmore, & Applegate, 2008).

II.2.3.2. Body image

Several studies investigated the relation between weight stigma and body image. A first group of studies examined the impact of weight stigma by measuring children’s personal attitudes or stereotypes about weight. Davison et al. (2008) found that endorsed weight-related stereotypes was not associated with perceived appearance at the age of 9. In the study by Gray et al. (2011), including 7- to 17-year-old participants, body dissatisfaction (generally due to a desire of a thinner body) emerged as a moderator of the relation between child's degree of overweight and negative attitudes toward persons with excess weight. As the positive relation between BMI and weight-based negative attitudes increased in strength, children with excess weight who were satisfied with their body image were also less prone to endorse negative attitudes toward obese persons. However, as no separate analysis was reported on different age groups, it was not possible to determine the significance and the strength of this association in children aged 7 to 10. In the study by Solbes and Enesco (2010), an implicit measure of anti-fat bias (i.e., IAT; Greenwald et al., 1998) was used to study the impact of individual weight-related beliefs on body image in a sample of 120 children from 6 to 11 years of age. Results showed that the implicit measure of anti-fat bias was correlated with body dissatisfaction, but only among older children (10 and 11 years of age). The link between weight stigma and body image has been also examined with regards to weight-based teasing and bullying experiences. In a cross-sectional study with 431 children aged 7 to 10 years, Kostanski and Gullone (2007) found that weight-based teasing experiences were related with poorer body image in girls and boys with excess weight, as well as in underweight boys. In a longitudinal study with 474 girls and 400 boys, Lunde et al. (2007) measured body esteem relative to appearance, weight, and attribution (i.e., evaluations attributed to others about one's own body and appearance), in relation to three victimization and appearance-related teasing measures. Results showed that for boys, but not for girls, appearance-related teasing at 10 years of age predicted body esteem at 13 years of age, whereas for girls, but not for boys, victimization at age 10 negatively predicted weight-related body esteem at age 13. In a similar vein, a study conducted by Nelson et al. (2010) with a community sample of 382 students in fifth and sixth grade confirmed that the relations between weight-related teasing and body size dissatisfaction were moderated by weight level. Particularly, the positive relation between weight-related criticism and body size dissatisfaction was significant and with a medium effect size for participants with overweight but not for the average-weight group. Sinton et al. (2012) also found that weight based teasing increased shape- and body-concerns in a sample of 204 children with excess weight aged 7 to 12. Two studies also pointed at parents as sources of teasing. Bang et al. (2012) revealed that perceived parental teasing mediated the relation between BMI and self-perception of physical appearance in a sample of 400 fifth- and sixth-graders in Korea. In contrast, Tyler et al. (2009) found that teasing among African-American girls (97students in grades 3 to 5) did not mediate the relation between BMI and neither body dissatisfaction nor body esteem.

Body weight is a predictor of body dissatisfaction, not only during children's life, but also later when the child become adult. In fact, the study by Stevens, Herbozo, Morrell, and Schaefer (2016) showed that the history of childhood overweight as well as the actual body weight and experiences of weight-based discrimination negatively affect body image dissatisfaction in a sample of 299 female undergraduate students. The review by Menzel et al. (2010) explored the relation body weight-related or appearance-related teasing and body dissatisfaction with 41 studies. According to the results, there is a positive relation between teasing experiences and body dissatisfaction, specifically there is a medium-large and a moderate effect size for weight teasing and appearance teasing respectively as predictor.

Exploring possible moderators of the relation, emerged that multi-item teasing instruments, unpublished publications, cross-sectional studies were significant moderators for both the relations, whereas age and gender were significant moderators only for the weight-based teasing and body dissatisfaction: The relation became stronger with children, adolescents, and females as participants. In line with these results, Farrow and Tarrant (2009) showed that weight-based experiences of discrimination (assessed by a 6-item questionnaire) in a sample of 198 undergraduate students represent a significant predictor for body dissatisfaction, whereas Essayli, Murakami, Wilson, & Latner (2016) demonstrated that being simply labelled as "overweight" could be a cause of body dissatisfaction: In their study, with 113 female college students, they recorded weight and height measures, and randomly gave to participants (with overweight as well as with average weight) a positive or negative feedback about their body weight ('accurate'' or ''inaccurate''). Analysis of main effect revealed that the interaction "body weight" and "assigned body weight" was more negative for women with excess weight. In fact, they displayed more body dissatisfaction in the "inaccurate" condition than in the "accurate" one. This did not happen with women with average weight. Finally, studies showed that also weight-bias internalization could have a negative impact in body weight satisfaction. For example, Durso et al (2016) showed that body weight and weight bias internalization were significant predictors of body image dissatisfaction.

II.2.3.3. Eating behaviour

As previously underlined, obesity positive relates with eating disorders, and the effect of weight-based stigma on eating behaviours, eating pathology, decreased motivation to diet is broadly confirmed in the literature (see also Vartanian & Porter, 2016). In line with this consideration, the meta-analysis by Menzel et al. (2010), which explored the relation between weight-based teasing and eating behaviour, indicated that weight-based teasing is a predictor of eating behaviours, and that age was a significant moderator of the relation (children and adolescent showed a stronger relation than adults.)

Regarding childhood, the study by Eddy et al. (2007) involved 122 boys and girls (8-18 years) seeking treatment for overweight, and demonstrated that teasing experiences have an indirect effect on overall eating disorders that are partially mediated by negative affect (e.g., anxiety, depression, internalizing and externalizing problems). However, as the majority of participants were adolescents, no conclusions can be drawn as to the presence and strength of these relations among children aged 8-to-10 years. More informative toward our goal is the cross-sectional study by Kostanski and Gullone (2007), who found no relation between reported teasing experiences and weight-related attitudes among 7-to-10-year-old children. In addition, the longitudinal study by Davison et al. (2008) also revealed that girls' endorsement of weight-related stereotypes is not related to maladaptive eating attitudes at 9 years of age, but significantly predict maladaptive eating attitudes at 11 years. The longitudinal study by Jendrzyca and Warschburger (2016) found a gender's difference in the relation body weight, weight-related stigma, and eating behaviour. With their research, including 1486 children (773 girls) aged 6-11-year-old, they showed that weight-based teasing is a significant predictor of restrained and external eating behaviours on year later, despite the result is valid only for girls.

Several studies have also explored the relation between weight-based stigmatization and eating disorder during adulthood. Specifically, weight-based stigma was explored as experiences of weight-related discrimination or as weight bias internalization. Concerning the first line of investigation, Almeida, Savoy, and Boxer (2011), in a study with a clinical sample composed by 99 patients and 100 undergraduate students, showed that weight-based stigmatization negatively impact binge eating disorder (but only in the community sample of participants), regardless the other eating disorders' risk factors. Similarly, Simone and Lockhart (2016) studied the relation between weight-based stigmatization and eating disorders by involving a sample of female undergraduate students. They displayed that the relation between weight-based stigmatization and emotional eating and between weight-based stigmatization and dietary restrain is partially mediated by stress and social withdrawal, respectively. The role of stress was explored also considering the role of weight-bias internalization. O'Brien et al. (2016) showed a chain process in the weight-based stigmatization's effects. In fact, the relation between weight-based stigma and disordered eating behaviors is mediated by two serial mediators, weight-bias internalization and psychological distress. The negative impact of weight-based internalization was discussed also by Mensinger, Calogero, and Tylka (2016). They tested the efficacy of two different programs for weight-management with a sample of 72 women, and they showed that regardless the weight-program, people with high weight-bias internalization did not present improvement in disordered and adaptive eating.

II.2.3.4. Depression

The impact of weight-based stigmatization in depression was explored in studies involving children as well as adults.

Studies addressing the relation between weight stigma, obesity, and depression in youths also included children aged 9-to-10 years. For example, the study by Bang et al. (2012) revealed that perceived teasing from parents partially mediated the relation between BMI and depression in fifth and sixth graders. In addition, the work by Mustillo and colleagues (2013), with European and African-American girls aged 9 to 21, examined the impact of fat labelling (especially the experience of being named fat) on depressive symptoms. By means of a longitudinal design, the authors demonstrated that obesity at 9 and 10 years of age affected depression symptoms at 10 and 11 years, and this effect was partially mediated by experiences of fat-labelling by friends and parents. Furthermore, parent labelling (but not friends labelling) at 9 and 10 years of age directly predicted depressive symptoms one year later. Importantly, even though labelling was more prevalent among African-American girls, its effect on depressive symptoms was significant only for European-American girls.

The impact of weight-related stigma on depressive symptoms is widely confirmed also in studies with adults. For example, the study by Stevens et al. (2016), with a sample of undergraduate students, displayed that weight-based discrimination (evaluated with the Stigmatizing Situations Inventory by Myers and Rosen, 1999) mediates the relation between body weight and depression. They showed the validity of this model also considering body weight during childhood: In fact, the relation between being a child with excess weight and depression at 20 years of age is mediated by weight-based discrimination. Differently, Koball and Carels (2011) extended the validity of the negative impact of weight-based discrimination on depression, by confirming the results also in a clinical sample (participants in weight loss treatment seeking), and regardless the adopted copying strategies. Also, Mooney and El-Sayed (2016) investigated the effect of weight-based stigmatization in depression symptoms. Based on the awareness that depression is more common in places with less people with obesity, they demonstrated that discrimination occurs when people are perceived as different from the social norm, and that, consequently, weight-based discrimination happen because excess weight is something distant from the average weight (i.e., the norm in the society). They showed that people with obesity presented more depression in locations where being with obesity was less frequent, than in places where there were less people with obesity. This distance positively related with depression in people with obesity. Concerning the role of weight bias internalization, Durso et al. (2016), by involving 90 participants with excess weight, identified body weight, anti-fat attitudes, and weight bias internalization as significant predictors of participants' depressive symptoms (no effect were found on level of anxiety and perceived stress).

II.2.3.5. Social relationships

Endorsing negative weight-based stereotypes or being responsible for discriminatory behaviours are themselves index of negative social relationship. However, endorsing negative weight-based stereotypes could be unrelated with social behaviour, or differently they could fatherly affect social behaviour (e.g., intention to help), and consequently impair social relationship.

Regarding peer relationships, the study by Solbes and Enesco (2010) investigated the relation between explicit and implicit weight bias and peer preferences among 120 children aged 6 to 11 years. Participants were asked to indicate their preference (vs. rejection) for average and overweight figures (i.e., explicit weight bias), to attribute positive and negative adjectives to average-weight (vs. overweight) story characters (i.e., explicit weight-based stereotypes), and to complete a IAT as a measure of implicit weight bias. Moreover, children were invited to complete a socio-metric task to indicate their most-preferred and least-preferred peers. Results revealed that the preference for the average figure, as well as the rejection of the overweight figure, predicted the sociometric preference for average-weight peers and the rejection of schoolmates with obesity. Furthermore, negative adjectives attributed to overweight figures were predictors of sociometric rejection of peers with weight in excess, with small to medium ES. In contrast, the implicit measure of weight bias was not related with socio-metric variables. Differently from this work, the research by Patel and Holub (2012) yielded more conflicting results. The authors measured 4-to-8-year-olds' willingness to help peers with thin vs. overweight figures as well as their attitudes toward a thin, average, and overweight figure. Results revealed that in general children were less inclined to help peers with excess weight. Importantly, children with more positive attitudes toward the thin figure were less inclined to help peers with excess weight, whereas no relation was found between attitudes toward the average and the overweight figure and children's willingness to help peers with excess weight. However, a positive correlation emerged between the intention to play with and the willingness to help peers with excess weight. Research of Roddy and Steward (2012) also showed contrasting results. By analyzing implicit and explicit weight-bias in 33 children aged from 6 to 13 years, this study yielded no correlations between either implicit or explicit attitudes and the willingness to share activities with peers with average weight or with obesity.

II.2.3.6. Physical health

Some studies showed that exposure to weight-based stigmatization is also predictive of physical health complications. For example, Juvonen, Lessard, Schacter, and Suchilt (2016) showed that the perception of weight-based discrimination at 7th grade is a significant predictor of somatic symptoms (e.g., nausea, headaches, poor appetite, etc.) at 8th grade (limited to girls). Similalrly, Schafer and Ferraro (2011), in a 10-year longitudinal study, showed that perceived weight based-stigmatization increases problems with mobility (e.g., transporting groceries or walking over a mile) in people with obesity.

Furthermore, weight-based discrimination could have an indirect and a direct effect on individuals' weight status (Brewis, 2014). Indirectly, weight-based teasing reduced the involvement in sport activities (Gray, Janicke, Ingerski, & Silverstein, 2008; Vartanian & Novak, 2011; Vartanian & Shaprow, 2008) and increase unhealthy life style (e.g., consumption of convenience foods and less regular meal timing) that could increase weight gain (Sutin, Robinson, Daly, & Terracciano, 2016). Furthermore, stigmatizing situation could increase stress level, and consequently negatively affect individuals' health condition. For example, Tomiyama and colleagues (2014) investigated whether weight stigma, by increasing cortisol level and consequently disrupting the activity of antioxidant enzymes (Patel et al., 2002), increases the oxidative stress-related activity. Results showed that past experiences of weight-based discrimination, as assessed by the Stigmatizing Situations Inventory (Myers & Rosen, 1999), have a negative impact on cortisol level and on F2-isoprostane levels (an index of oxidative stress) regardless of actual body weight. The frequency of weight-based experiences and the stigma consciousness furtherly increased the cortisol level. Directly, researchers showed that mere weight-based labeling at 10years of age is predictive of weight gain 9 years later (Hunger & Tomiyama, 2014), while experiences of weight-based discrimination increase the likelihood for people with average weight to develop obesity and for people with obesity to maintain the obesity status (Sutin & Terracciano, 2013). Thus, weight-based discrimination is not a factor that increases the likelihood of engaging in weight loss: To the contrary, it raises the odd to retain or even to gain weight (Major et al., 2014). The Cyclic OBesity/WEight-Based Stigma model (COBWEBS; Tomiyama, 2014) clarifies the "vicious cycle" that characterizes the reciprocal relations between weight-based stigma experiences and obesity, and underlines the importance to address weight stigma as an important cause of the negative consequences of excess weight on individuals' psychological and physical health. However, a recent investigation by Puhl, Quinn, Weisz, and Suh (2017) found that internalized weight-based stigma and body weight perception were significant predictors of weight-loss maintenance, contrasting the Tomiyama's (2014) model as well as other previous studies. Future investigation are need to clarify this relation, and detect all the psychological and social processes involved in the relation between weight-stigma and health-related behaviors.

II.2.4. Conclusion

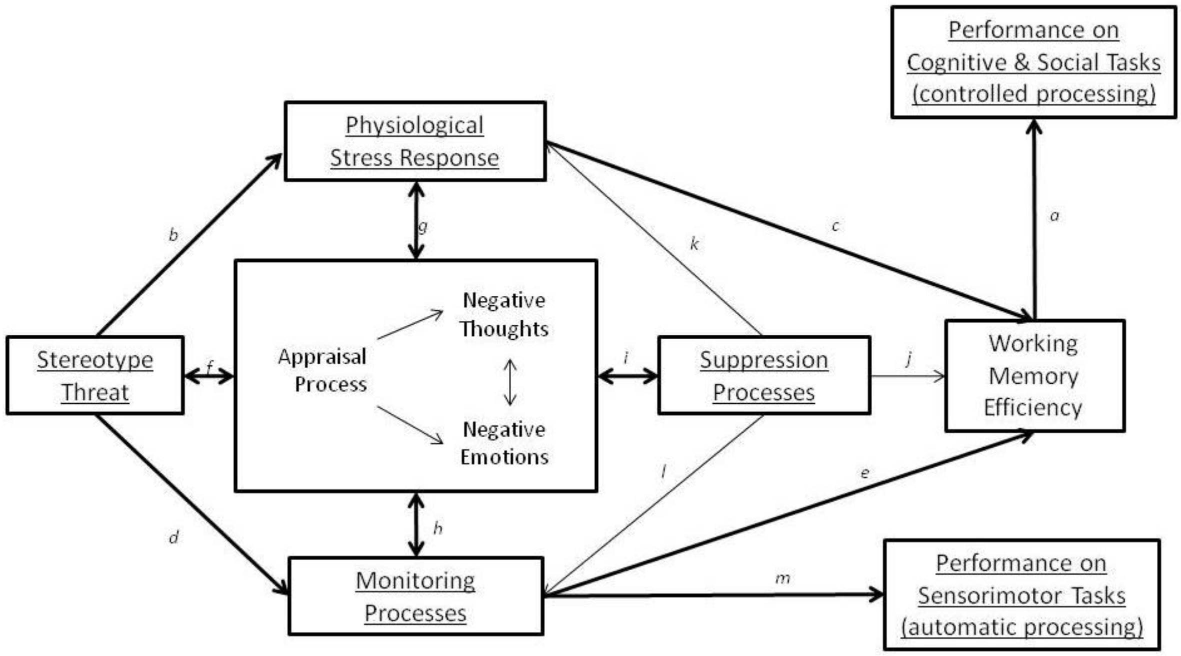
Obesity is a highly stigmatizing condition. Individuals with excess weight are negatively evaluated for their health condition, and they are also considered responsible for their excess weight. Negative weight-based stereotype could be endorsed by people with obesity as well (weight-bias internalized), and they could lead to experience, directly and indirectly (e.g., family's behaviour, teacher attitudes, social relationship, media), episodes of weight-based discrimination. Several studies have demonstrated the negative impact of weight-based stigmatization on psychological as well as on health status. Anyway, the effect of weight-based stigmatization on the compromised executive functions was only partially explained, despite experiences of discrimination, typical in social stigmatized group, could damage cognitive performance. The mechanism that explains the negative effect of social stereotypes on cognitive task is known as Stereotype Threat Model, and the following chapter explains it as well as some attempt to explained the low cognitive results in people with obesity by considering the social dimension.

3. SOCIAL STIGMATIZED GROUPS AND COGNITIVE FUNCTIONING

II.3.1. The Stereotype Threat Model

According to the Stereotype Threat Model (Steele & Aronson, 1995), individuals who are labeled with negative stereotypes underperform in cognitive tasks when their disadvantaged social identity becomes salient. The general model that explains how this mechanism works is the Integrated Process Model of Stereotype Threat (Schmader et al., 2008; see Figure 1).

Figure 1. Integrated Process Model of Stereotype Threat Effect (Schmader et al., 2008).



Note. Stereotype Threat condition arises physiological stress response, monitoring processes and negative psychological state that activate suppression process and consume working memory resources, that are necessary for controlled processing.

According to the model, situational factors could activate a stereotype threat condition in different ways: a) By signaling the negative association between the group and a particular ability; b) by stressing the fact that one belongs to the group; c) by underlining that the test examines the ability for which the group has a negative stereotype. Threatening situations activate physiological stress responses (path b), appraisal processes, negative emotions (anxiety), negative thoughts (paths f, h, g), and monitoring processes (path d). Suppression processes are then activated to buffer all these negative states (paths i, l, k), but the cognitive resource consumed by suppression efforts reduce the efficiency of working memory (paths c, j, e). In turn, reduced working memory efficiency damages a wide range of cognitive tasks that require coordinated information processing (Engle, 2002).

Recently, the validity of the Stereotype Threat Model was debated. The review by Stoet and Geary (2012) points at the low methodological quality of most works in the area, and suggests that stereotype threat phenomena are not demonstrated in high-quality controlled studies. In addition, the study by Ganley et al. (2013) shows that gender differences in math performance exist, but cannot be explained by stereotype threat manipulations in three different samples of children and adolescents in the US. However, also the strength of the arguments by Stoet and Geary (2012) and Ganley et al. (2013) was questioned (see, Régner, Steele, Ambady, Thinus-Blanc, & Huguet, 2014). For example, Régner and colleagues underline that Ganley et al. (2013) do not use a condition of stereotype nullification, which is necessary to demonstrate that performance change when stereotype operate as compared to when stereotypes are not salient. In fact, for stereotypes that are widely endorsed at the societal level, individuals who belong to stigmatized group may be chronically exposed to highly salient negative stereotypes in their environment. Therefore, for these individuals, performing stereotype-relevant tasks both in condition of stereotype activation (i.e., stereotype threat) or in control conditions (i.e., when the salience of the stereotype is at the habitual level) may mean being a situation of unsafe identity. Moreover, Ganley et al. (2013) in their control condition, present the experimental task as a "math test", which is a sufficient condition (see, Schmader et al., 2008) to subtly activate stereotypes related to girls' alleged inability in the domain.

As a matter of fact, stereotype threat is never assumed as a factor capable of assuming fully explaining performance differences between stigmatized and not-stigmatized groups (e.g., Sackett, Hardison, & Cullen, 2004). In fact, reviews and meta-analyses, as well as numerous empirical studies in different domains, support the validity of the model and its adequacy in identifying *one of the* causal factors that explain impairments of highly stigmatized individuals during performance test (for reviews, see Kit, Tuokko, & Mateer, 2008; McKown & Strambler, 2009; Nguyen & Ryan, 2008), as well as during preparation and learning (Appel & Kronberger, 2012).

A recent review by Pennington, Heim, Levy, and Larkin (2016) explored mediators of the stereotype threat effect on cognitive function, and, by analyzing 38 papers about the topic, they detected anxiety, negative thinking, mind-wandering as well as motivation to disconfirm the negative stereotypes as possible mediators of performance deficits induced by stereotype threat. However, they also underlined that mediators could change in relation to the kind of examined social groups, that the effect could be different according to the trigger's method adopted. Future examinations are necessary to clarify the model's mechanisms.

II.3.2. Stigmatized groups and Stereotype Threat

Support for the predictions of the Stereotype Threat model was obtained with regard to different social groups (ranging from community to clinical samples) and for numerous ability domains. The first studies about this topic dealt with ethnic minorities (i.e., the Afro-American or Hispanic-American) and intelligence (Good, Aronson, & Inzlicht, 2003; Steele & Aronson, 1995), gender differences in math (Inzlicht & Ben-Zeev, 2000; Sekaquaptewa & Thompson, 2002) and spatial abilities (Ortner & Sieverding, 2008), and verbal abilities among members of low socio-economic status groups (Croizet & Claire, 1998). Unfortunately, few studies on stereotype threat were conducted with children. The study by McKown and Strambler (2009) demonstrated that Afro-American and Latino children aged 5-11 years, who were aware of negative racial stereotypes concerning the intellectual ability of their groups, performed worse on a working memory test. In a similar way, other studies reported that young girls aged 5-7 years had lower arithmetical performance when gender identity became salient (Ambady, Shih, Kim, & Pittinsky, 2001; Neuville & Croizet, 2007; Tomasetto, Alparone, & Cadinu, 2011). Also, concerning math-gender stereotype, Galdi, Cadinu, and Tomasetto (2014) demonstrated that stereotype threat occurs, even though 6-year-old children have not an explicit awareness of math-gender stereotypes, as the decrease in cognitive performance depended on the activation of automatic associations between the group and the negative stereotype (i.e., girls and low math ability).

More recently, researchers have expanded the investigation of Stereotype Threat effects among a variety of social groups, and have especially focused on members (or individuals at risk of becoming members) of clinical samples. Mazerolle, Régner, Morisset, Rigalleau, and Huguet (2012), for example, showed that older people, who are negatively stereotyped as regards their memory, obtained lower results in a memory span task when the assessment was presented as a “memory test” rather a task “under construction” (i.e., no fully diagnostic for their alleged memory impairments). In line with these findings, Barber and Mather (2013) conducted a study with older-age people (approximately 69-year-old) who performed a working memory task in two different experimental manipulations. In fact, the task was presented after reading a lecture about the decline of memory with age (stereotype threat condition) or after reading a text concerning the preservation of memory (no-stereotype threat condition). In addition, half participants received a monetary reward for each good answer (gain condition), whereas half participants lost part of their initial endowment (loss condition). Results revealed that older participants obtained lower performance in stereotype threat condition with the gain condition, whereas the performance increased in the stereotype condition in loss condition. This result is explained by the regulatory fit model, according to which people perform better in task when they regulatory state fits with the task reward condition. Barber, Mather, and Gatz (2015) confirmed again, in this population, the effect of regulatory focus also on three critical cognitive examinations: The Word List Memory Test from the Consortium to Establish a Registry on Alzheimer’s Disease (Welsh, Butters, Hughes, Mohs, & Heyman, 1991), the Addenbrooke’s Cognitive Examination-Revised (Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006), and the Mini Mental State Examination (Cockrell & Folstein, 2002).

II.3.3. Obesity and Stereotype Threat

Unfortunately, few studies to date investigated Stereotype Threat phenomena affecting people with excess weight, despite several studies underlined the susceptibility of people with obesity to identity concerns.

For example, based on the awareness that stigmatized groups could be affected in different way by negative stereotypes, Shapiro and Neuberg (2007) elaborated the Multi-Threat Framework to describe that there are 6 different stereotype threat situations that change according to the stigmatization’s source and the target of stereotype threat: Self-Concept Threat vs. Group-Concept Threat, when either the self or group-belonging is the source of the stigma; Own-Reputation Threat (Outgroup) vs. Group-Reputation Threat (Outgroup), when the stigma source is an outgroup member; Own-Reputation Threat (Ingroup) vs. Group-Reputation Threat (Ingroup), when the ingroup is the source of stigma.

The susceptibility to one of these conditions depends on group identification and stereotype endorsement. Based on the considerations that people with obesity, as well as people with disease, difficultly identify themselves in the obesity's group both because weight identity develops later in individual's life, and because the stigmatized experiences that characterized also the family setting reduce the probability to identify the self in the group, Shapiro (2011) tested the role of stereotype endorsement and stigma consciousness in people with excess weight with the aim to detect the stereotype threat condition to which people with obesity are more susceptible. The author showed that people with obesity have a low group identification, and that participants with excess weight reported less group-as-target stereotype than self-as-target identity threats.

In line with this consideration, Carels et al. (2013) conducted a study with a sample of participants with overweight or with obesity to furtherly test the Multi-Threat Framework by Shapiro (2011). In detail, Carels and colleagues were interested in identifying different forms of stereotype threat that characterized people with excess weight, detecting the other dimensions that could be related with stereotypes (e.g., group identity, stereotype endorsement, stigma consciousness, weight-based attitudes, self-esteem, etc.), and understanding the role of characteristic that could increase the stereotype threat susceptibility (e.g., high body weight status, female as gender). Their findings confirmed that people with excess weight experience a stronger threat when the attack is against their self or reputation (Shapiro, 2011), but it also added new considerations. For example, people with past experiences of weight-based discrimination are more sensible to stereotype threat situations, and, among people with excess weight, those whit high group identification and stereotype endorsement are more susceptible to stereotype threat. Finally, being women, with high body weight, stigma consciousness, having weigh concern and low self-esteem are other factors that could furtherly increase the impairing effects of stereotype threat.

The role of self-reputation in threatening situation was also confirmed by Neel, Neufeld, and Neuberg (2013). The authors dealt with the identity management strategies that people belonged to stigmatized groups usually adopt in stereotype-threatening situations. In fact, previous study showed that some people (usually with a physical abnormality) are avoided by others. This behavior is explained by the disease-avoidance system, a heuristic behavioral reaction to lead people to avoid a person rather than interact with him/her (Schaller, 2011). This heuristic association occurs in case of deviations from a normative human body shape, and obesity, as a condition of excess weight from the average weight, fits with this condition. This heuristic could lead to the stigmatization of people with obesity (Park, Schaller, & Crandall, 2007) and to discriminatory and ostracizing behaviors. Thus, to contrast this situation, people belonging to stigmatized group try to buffer the negative effects of others' disease-avoidance system by adopting behaviors that could contrast the negative stereotypes that are associated to them. Based on these considerations, authors asked people with excess weight (but not with average weight) to complete an impression management task in which they had to list the actions to do in order to produce a positive first impression on a stranger. Before (stereotype threat condition) or after (no stereotype threat condition) this task, participants had to complete a questionnaire with items associated to disease and disgust. Results highlighted that participants in the stereotype threat condition were more likely to activate impression-management strategies finalized at hiding the negative features associated with obesity (e.g., wearing clean clothes) than participants in the no-threat condition.

II.3.3.1. Obesity, Stereotype Threat, and health-related behaviors

Several studies have explored the effect of stereotype salience on other dimensions related with eating behaviors. Major and colleagues explored the effect of media stigmatizing messages on eating behavior (Major et al., 2014). In fact, despite some researchers suggested that stigmatized messages could motivate to weight loss (e.g., Bayer et al., 2008; Callahan, 2013), other studies revealed that negative weight-based stereotypes could lead to unhealthy life style and decrease motivation to exercise (Puhl & Brownell, 2006; Vartanian & Novak, 2011; Vartanian & Shaprow, 2008). Based on these considerations, they experimentally tested the role of weight-stigmatizing messages on eating behavior. Specifically, they hypothesized that stigmatizing news (1) lead to eat more unhealthy foods, (2) decrease the self-efficacy in control diet behaviors, (3) increase the fear to be victim of weight-based discrimination. With this purpose, they involved 93 women (49 perceived themselves as overweight, while 44 perceived them as average weight) in the study, which they presented as a study about the relation among verbal, non-verbal, and physiological responses. After recording their baseline blood pressure, they randomly assigned participants to the reading of two different newspaper's article: "Loss Weight or Loss Your Job" in the stereotype threat condition, and "Quit Smoking or Lose Your Job" in the no-stereotype threat condition. Then, they asked participants to explain the articles' contents to someone that had not read the article with a video message, and they gave some minutes of time to prepare their speech.

During this period, they were in front of a computer post, and they were allowed to serve themselves with some available snakes (Skittles, M&M's, Goldfish Crackers). Finally, researchers asked participants to fill in a questionnaire assessing self-efficacy for dietary control and weight stigma concerns, and the availability, if they agree, to register their body measurement. Results showed that stigmatizing messages reduce the perception to be able to manage daily diet, arise concerns relative to weight, and increase the highly caloric snakes' intake when individuals perceive themselves as overweight (regardless of objective body weight). Thus, it appears that stigmatizing media messages could have the paradoxical effect to increase the consumption of food and reduce the probability of successful dieting behavior, thus eventually leading to weight gain.

With the aim to verify if this effect was due to weight-based stereotypes or to a negative message related with health, Shentow-Bewsh, Keating, and Mills (2016) conducted a study with 120 female students and asked them to read a newspaper article concerning the negative effects of obesity on health, on social status, on appearance (obesity health message), or alternatively to read a paper about sun exposition (non-obesity health message), or to perform a neutral control task (no-health message). Researchers found, contrasting some previous studies, that participants' body weight had a significant impact on high caloric food intake, but conditions do not. In fact, participants with high body weight showed a greater food intake in the neutral condition (no-health message).

Similarly, Pearl, Dovidio, Puhl, and Brownell (2015) tested the role of stigmatized messages in media on exercise intentions, motivation, and behaviors, by exploring past experiences and current media exposure. They hypothesized that past experiences of weight-based stigmatization make people more sensitive to actual experiences of stigmatization, but they wanted verify whether past experiences lead to increase or reduce exercise intention, motivation, and behaviors. They involved 74 women with different body weight levels, and by using a weight-based stigmatizing video (i.e., popular television shows with negative images associated with excess weight) or neutral video (documentaries about nature), they manipulated the salience of weight-related stereotypes. After the video presentation, they said that they had to change room because another experimenter needed to use that. Thus, they moved in another laboratory that was upstairs, and asked participants whether they preferred going by stairs or by elevator, and they signed their decision. In the second room, participants completed a questionnaire to explore the dimensions of interest, and received a new questionnaire (about exercise intention) to complete online one week later. Data analyses showed that participants in a stigmatizing condition and with past experiences of weight-based discrimination presented more exercise intentions and more drive for thinness (than other participants). However, stigmatizing condition and past stigmatized experiences were associate with drive for thinness behaviors, and this could have a negative impact on health as well as overeating behaviors.

II.3.3.2. Obesity, Stereotype Threat, and physiological reactivity

Other researchers focused on the effects of weight-based stereotypes on physiological reactivity. Indeed, Schvey, Puhl, and Brownell (2011) explored the role of weight-based stereotypical messages, but they focused not only on the impact of stigma on food consumption, but also on mood and bloody pressure. In their study the authors included 102 university students (participants with overweight and with average weight), who answered a questionnaire concerning positive and negative affect, weight-based attitudes, and depression, after researchers measured their blood pressure. Following, researchers showed them a video with stigmatizing images derived from popular television (stereotype threat condition) or a video with no-stigmatizing images, e.g., insurance commercials (neutral condition). After video exposure, participants' blood pressure was measured again. Participants also answered a final questionnaire, and were invited to eat some snacks (M&Ms, Jelly Belly Jellybeans, and SunChips). Results showed no effects of stereotype salience on negative and positive emotions, weight-based attitudes, depression, or bloody pressure, whereas participants with overweight in the stereotype threat condition ate more than three times the calories of participants with overweight in the neutral condition, and significantly more than participants with average weight.

Despite in this study the effect of stereotype salience on bloody pressure was not supported, there are other evidences of the effect of stereotype salience on physiological measures. Schvey, Puhl, and Brownell (2014) tested again the effect of stereotype salience on physiological measure, but they explored the cortisol activation (and not blood pressure) during a stigmatizing message exposition. They involved women with overweight and with average weight. Baseline cortisol level was recorded, then participants were randomly assigned to a stereotype salience condition (video with stigmatized images) or to a stereotype deactivation condition (neutral video). Following the video exposure, participants filled out a questionnaire, and after 30 minutes from the video exposure, the cortisol level was measured again. Analyses revealed that participants with obesity exhibited a higher cortisol activation when exposed to stigmatizing media messages from popular television programs than to neutral contents.

Himmelstein, Incollingo Belsky, and Tomiyama (2015) explored the role of weight-stigma on physiological reaction as well, by including a sample of 110 undergraduate female students. The aim of the study was to examine the cortisol level after a stereotype threat situation by considering both the perceived body weight and the objective body mass index. Specifically, they hypothesized that participants in a stereotype threat condition presented increased levels of cortisol reaction (vs. neutral condition), but they expected that this reaction was moderated by body weight perception. With this purpose, participants provided a baseline salivary cortisol sample and body weight measures, and then went in a waiting room in which a confederate said that they were selected for a group shopping activity. Thus, participants moved in another room in which another confederate advised that "unfortunately the group shopping was full now" (neutral condition) or that "unfortunately, your size and shape just aren't ideal for this style of clothing and we really do want everyone to have fun and feel good" (stereotype threat condition). Thus, they were invited to do an on-line shopping task, and, at the end, a second saliva sample for the assessment of the cortisol level was taken. Results confirmed the hypothesis, by showing that weight-related stigma exposure increases the cortisol reaction, and this relation is moderated by body weight perception (i.e., it increases when people perceive themselves as with overweight).

II.3.3.3. Obesity, Stereotype Threat, and cognitive functioning

Despite several studies showed the susceptibility to identity threat in people with obesity, there is only partial evidence of stereotype threat effects on cognitive functioning. Specifically, only Krukowski et al. (2009) and Major et al., (2012) presented some results in this direction.

The study by Krukowski et al. (2009) examined the relation between weight status, cognitive performance and weight-based teasing in childhood. In this study, 2358 parents of elementary and middle school's students were interviewed to assess school performance and experiences of weight-based teasing of their offspring. Weight status had a significant and negative relation with school performance (for female students in particular), and parent-reported weight-based teasing experiences were found to mediate this association. Even though this evidence is merely correlational, and the stigma measure is indirect, these findings raise the intriguing possibility that teasing experiences chronically remind children with excess weight of the negative stereotypes attached to their group, which may in turn disrupt their academic performance – as posited by the Stereotype threat model (Steele & Aronson, 1995). Unfortunately, available data do not allow a direct test of this hypothesis, but further research could fill this gap.

Instead, Major et al. (2012) directly demonstrated the impact of stereotype threat on attention inhibition. They invited 99 women (with average weight and with excess weight) to a study about "first impressions between potential dating partners", and for the research purpose they were asked to do a speech about why they could be a good dating partner. Baseline arterial blood pressure was recorded for 5 minutes, but it was recorded also during their speech, that was video-taped (stereotype activation condition), or audio-taped (stereotype deactivation condition). After that, participants performed a task assessing executive control (i.e., the Stroop color-naming task). At the end, they answered a questionnaire to assess their emotion during the speech, and consented to be measured (body weight and height) to have an objective measure of their body size. Results demonstrated that women with obesity obtained lower performance in the task assessing executive control (i.e., the Stroop color-naming task), and higher arterial blood pressure, as compared to women with average weight, but only when the risk of being judged for physical appearance was made salient (i.e., when the speech was videotaped).

This research represents the first evidence of the stereotype threat effect on executive functions, but no other studies explored its effect on executive functions other than inhibitory control, nor tested the model in children.

II.3.4. Conclusion

With this chapter, we concluded the theoretical background presented the Stereotype Threat Model. We described how it works, the current theoretical development, and the several stigmatized group which detriment cognitive abilities whose explained by stereotype threat model. Only Krukowski et al. (2009) and Major et al. (2012) tried to explained the impaired cognitive function in people with obesity, but not in a comprehensive way. The aim of the present Ph.D. project is to closing this gap present in the literature, and the following section described the studies implemented with the objective.

III. EMPIRICAL STUDIES

4. OVERVIEW AND RATIONALE FOR THE EMPIRICAL STUDIES

The analysis of the literature shows that there is a negative relation between weight status and cognitive performance. Simultaneously, the Stereotype Threat Theory (Steele & Aronson, 1995) offers strong evidence that members of groups that are negatively stereotyped as intellectually inferior perform worse on cognitive tasks when the relevant stereotype is made salient in the testing situation. Building upon these considerations, the purpose of the present research is to investigate the relation between obesity and cognitive functioning, by focusing on the role of Stereotype Threat phenomena as a possible cause of cognitive deficits in individuals with obesity. To reach the presented goal, the body of work will be organized in two studies, each one with specific aims and hypothesis.

Study 1 has the general purpose to test the predictions derived from the Stereotype Threat Model in children with obesity. Specifically, the first aim is to examine whether making the negative stereotype about the intellectual ability of individuals with obesity salient in the testing environment moderates the relation between obesity and the efficiency of executive functions. In detail, we hypothesize that the impairment in working memory in children with obesity is higher in the stereotype-threatening condition than in the no-stereotype-threatening condition. Conversely, we do not expect to observe working memory impairments in neither condition in children with average weight. The second aim of the study is to analyze the role of the negative emotions experienced in the testing situation (i.e., state anxiety) on the relation between obesity and working memory. We hypothesize that anxiety associated to test performance may be responsible (at least in part) for the depletion of executive resources. Finally, we have also taken into account the role of three additional factors as potential moderators of the relation between body weight and working memory performance in stereotype (vs. no-stereotypes) situation. First, we focused on the role of experiences of weight-based teasing, by assuming that children chronically exposed to stigma experiences may be more vigilant as regard to stereotype-relevant cues in the testing environment, and may therefore be more prone to stereotype threat effects than children who were never or rarely exposed to such experiences (Barrett & Swim, 1998). Second, because stereotype endorsement make more susceptible to stereotype threat (Schmader, Johns, & Barquissau, 2004), and because weight-related attitudes and body dissatisfaction represent a direct and indirect index of stigma consciousness, we hypothesized that negative weight-related attitudes and body dissatisfaction could also act as possible moderators of stereotype threat susceptibility in young children with obesity.

Study 2 explores the role of Stereotype Threat on working memory proficiency as well, but in an adult population. Basically, the Study 2 pursues the same aims and tests the same set of hypotheses as Study 1. However, in addition to Study 1, the experimental paradigm adopted in Study 2 also included a control condition in which weight-related negative stereotypes were neither purposely reinforced (as in the stereotype threat condition) nor deactivated (as in the no-stereotype condition).

A description of each study follows in the remainder of this work.

5. STUDY 1

Study 1 is an experimental study aimed at investigating the relation between weight status, weight-based stigma, and cognitive functioning in pre-adolescent schoolchildren. To date, only Krukowski et al. (2009), by means of parents' interviews, examined the relation between weight status, academic performance (but not cognitive functioning), and weight-based teasing in childhood, and found that weight status had a significant and negative relation with school performance (especially for girls), with weight-related teasing mediating this association. However, no study to date addressed the relation between body weight and cognitive functioning in children by also taking into account the possible interference of weight-related negative stereotypes. The present study addresses this gap in the literature.

Does stereotype threat matter with obesity?

Our hypotheses were that (H1) children with obesity perform worse than children with average weigh in working memory tests, when the negative stereotype about cognitive abilities is made salient (Steele & Aronson, 1995; Schmader et al., 2008).

Furthermore, we contended that (H2) the salience of the negative stereotype could increase the level of anxiety in children with obesity (vs. with average weight) and, consequently, compromise the working memory efficiency.

In addition, we supposed that (H3a) a continue exposition to stigma experiences (for example, experiences of teasing by peer) could further increase the vulnerability of children with obesity to stereotype-threatening cues, thus disrupting their working memory efficiency under stereotype threat to a greater extent than children with obesity who were not exposed to stigma.

Finally, we also tested the role of negative weight-related attitudes and body weight dissatisfaction as additional moderators of the relation between body weight and working memory under stereotype threat (vs. no stereotype threat) conditions. We hypothesized indeed that children who internalized negative weight-related attitudes (H3b) and manifest higher body weight dissatisfaction (H3c) may be more prone to stereotype threat effects hampering their executive functions.

III.5.1. Method

Participants

After obtaining the approval from the ethical committee of University of Bologna and the collaboration from twelve Primary Schools in different Italian districts, we invited children (and their parents) in grades 3 to 5 to participate in our study.

Procedure

Data collection took place in two sessions.

During the first session (screening phase), we asked both children and one of their parents to fill out a paper-and-pencil questionnaire. The questionnaire was part of a bigger investigation about body weight, well-being and weight-related experiences, but, for the purpose of this study, we used only the sections concerning children's weight-based discrimination, body weight dissatisfaction, and weight-based attitudes. Parents were asked to provide information about children's high and weigh, health and psychological status. For preliminary screening purposes, parent-reported weight and height information were used to compute children's standardized body mass index (zBMI), an age-and gender-adjusted BMI based on the World Health Organization's growth charts (Onis et al., 2007). All children with obesity (BMI: ≥ 95th percentile) were recruited for the second phase of the study, and, for each child with obesity, one classmate with average weight (BMI: 5th–84th percentile) and one classmate with overweight (BMI: 85^{th}- 94^{th} percentile), matched for age and gender, were also recruited.

The second session (experimental phase) took place through an individual interview in a quiet room at school. We assessed children's weight and height to obtain objective anthropometric data. Children were subsequently assigned to a stereotype threat (ST) or to a stereotype-nullification (NST) condition, before administering them two computer tests (working memory and probabilistic learning task), presented in alternated order, and one measure of anxiety. Allocation of participants to the two experimental conditions followed a predefined random sequence. For ethical purposes, in the debriefing phase participants were invited to talk about one positive personal feature, a validated self-affirmation technique with positive effects on individuals' wellbeing (Steele, 1988).

Experimental Manipulation. We invited children to perform the cognitive tasks in one of two experimental conditions, in which the diagnosticity of the tasks with respect to the assessment of cognitive proficiency was manipulated. In the ST condition, we labelled the experimental tasks as extremely sensitive tests to assess children's intelligence – a domain in which children with obesity are negatively stereotyped. In the NST condition we asked children to play with two computer games, thus labelling the tasks as non-diagnostic of stereotype-relevant abilities. In both conditions, children were invited to perform at their best, by seeking to complete the tasks as fast and as accurately as possible. Before being thanked and dismissed, all participants were reassured that they had performed at an optimal level.

Measures

Parents level of education. By means of an open question, we asked parents to report their educational degree. Then, we classified each answer according the number of school years they had successfully accomplished. Thus, primary school correspond to 5, middle school to 8, high school to 13, bachelor degree to 16, master degree to 18, and doctoral degree to 21 years of school education.

Children Health Status. Parents provided information regarding their children health status by answering to a question about health pathologies (e.g., diabetes, hypertension, chronic disease) and sleep difficulties (e.g., snoring, sleeping with mouth open, episodes of sleep apnea) of their child. For each reported pathology, we attributed 1 point, whereas for sleep difficulties we attributed 0, 1, or 2, if children never, sometimes, or often manifest that symptoms respectively. The sum of all the reported item resulted in the composite Children Health Status score.

Children Psychological status. Parents filled out the Strengths and Difficulties Questionnaires (SDQ; Goodman, 1997) to provide information about children's general psychological wellbeing. The questionnaire is composed by 24 items with 3 answer options (not true, partially true, absolutely true) concerning emotions, behavioural problems, attention/hyperactivity, social relationship, and prosocial behaviour. Cronbach's α for this sample is equal to .69.

Weight-based discrimination. The *Perception of Teasing Scale* (POTS; Thompson, Cattarin, Fowler, & Fisher, 1995), a 5 point Likert scale composed by 6-item, was used to assess the frequency of weight-related teasing experiences by peers. The reliability of the perception of POTS scale computed for this sample is .84.

Weight-based attitudes. The *Obesity Stigmatization Questionnaire* (Latner, Simmonds, Rosewall, & Stunkard, 2007) was adopted to evaluate the explicit attitudes about body-weight. Children had to rank a set of six pictures of children (non-overweight, a child on crutches, a child in a wheelchair, a child with a missing left hand, a child with a facial disfigurement, a child with excess weight) according to their personal preference, and to express attitudes toward the figure with excess weight in a 10 points' semantic differential scale composed by 6 items (e.g., s/he is intelligent, s/he is lazy). The questionnaire provides two different score: The first is the obesity picture ranking (from 1 = best preferred to 6 = least preferred). The second is the average score derived from the 6 items assessing attitudes toward the children with obesity. For the purpose of this study, we used only the latter score, which reliability in the present sample is .553.

Body Dissatisfaction. Children's body dissatisfaction was assessed by using the Children's Body Image Scale (Truby & Paxton, 2002). The instrument consists of 7 pictures of a Caucasian child with increasing levels of adiposity numbered from 1 (extremely slim) to 7 (obese). Participants asked to point at the figure representing their body size and to point the figure they would like to look like. The difference between the two choices determined the level body satisfaction/dissatisfaction.

Working Memory. The N-back task (Jaeggi et al., 2010) was used to assess working memory. The task is composed by a series of letters that appear (one after the other) in the centre of the screen. Children have to push a keyboard's key when the letter that they have seen at the beginning of the task (N=0), or in the precedent position (N=1), or in the two precedent positions of series (N=2) appears in the screen. After instructions, participants receive nine trials of practice for each level tested, and, after practice, they complete three randomly determined blocks per three levels of N tested. N-back scores were separately computed for the levels 0, 1, and 2.

Probabilistic Learning. The Probabilistic Selection Task (Frank, Seeberger, & O'Reilly, 2004) evaluates associative learning abilities that do not involve executive control. The Probabilistic Selection Task was therefore used as filler task, in order to rule out the possibility that children in the ST condition may perform at a lower level not because of increased working memory load, as posited by the stereotype threat model, but merely because of a reduced effort in the task. In detail, two pairs of aliens were used as stimuli (see Arciuli and Simpson, 2011) and appeared appear in the centre of the screen for 60 times. For each trial, children had to guess the "winning symbol" of each pair. The win-probabilities of each symbol are controlled in such a way that A-alien wins over B-alien in 80% of the times; C-alien wins over D-alien in 70% of the times.

Anxiety. Children were presented with the thoughts and automatic reactions subscale (16 items in a 4-Likert point scale) of the Children's Test Anxiety Scale (CTAS) by Wren and Benson (2004), to assess the children's state anxiety during the task performance. The scale is composed by 9 items concerning negative though and 7 items about arousal reaction in response to specific situations. In the present sample, Cronbach's α for the 16-item of the anxiety scale was calculated at 0.66, whereas the α value for its subscale is .618 and .787 for the physiological reaction (7 items) and for the negative thoughts (9 items), respectively.

Statistical analyses

By using SPSS, we computed descriptive statistics and correlational analyses between the main measures, and performed univariate ANOVA analyses to test differences according to participants' body weight (average weight, overweight, and obesity).

To address Hypothesis 1, we used the SPSS PROCESS macro, model 1 (Hayes, 2013), to test the hypothesis that stereotype salience affects working memory performance in children with obesity. We mainly focused on the n-back level 2 score, i.e., the most demanding in terms of executive control, because stereotype threat especially affects the performance in highly demanding tasks (Spencer, Steele, & Quinnet, 1999; Quinn & Spencer, 2001). We repeated the same analyses for the lower n-back levels of difficulty (i.e., level 0 and level 1), and for the filler task (i.e., the Probabilistic Learning Task).

Then, to address Hypothesis 2, we used the SPSS PROCESS macro, model 5 (Hayes, 2013), in which anxiety was modelled as a mediator of the relation between body weight and working memory performance. Specifically, standardized BMI was the independent variable, n-back performance was the outcome, experimental condition was the moderator, and the anxiety subscales (i.e., global anxiety, negative thoughts, arousal reaction) were inserted as mediators.

Finally, to test the role of weight-based experiences of discrimination, negative weight-based attitudes, and body dissatisfactions as moderators of the relation between body weight and working memory performance in the ST condition (vs. NST), we used the SPSS PROCESS macro, model 3 (Hayes, 2013). Also in this model, standardized BMI and n-back performance were the predictor and the outcome respectively, the experimental condition was the mediator of the relation between body weight and working memory performance, while experiences of weight-based discrimination, weight-based attitudes, and body dissatisfactions were inserted as further moderators. R^2 change was inspected to verify whether the inclusion of each of the further moderators significantly increased the predictivity of the model, as compared to the baseline model with zBMI as the predictor, and experimental condition as the main moderator.

III.5.2. Results

Sample characteristics

From the whole sample enrolled in the screening phased, composed by 1292 participants, we randomly selected 106 boys and 70 girls (N = 176) aged 8–11 years (M_{age}= 116.07 months, *SD*= 10.43) according to the parents-reported body mass index (BMI). Specifically, 63 children were with average weight, 49 children were with overweigh, and 64 children were with obesity. The standardized body mass index of the participants selected for the experimental phase was 1.43 (*SD*=1.099).

Children participating in the experimental phase were randomly allocated to the two experimental conditions, so that we have 30 children with average weight, 25 children with overweight, and 31 children with obesity in the ST condition, and 33 children with average weight, 24 children with overweight, and 33 children with obesity in the NST condition.

Means and standard deviations for all the measures are reported in Table 3.

Descriptive analyses

By using ANOVA to test means differences between weight-based groups, we identified a significant difference for the POTS scale, $F(2,170) = 14.25$, $p = .000$, between children with average weight ($M = 6.50$, $SD = 1.905$), with overweight ($M = 7.28$, $SD = 2.531$), and with obesity ($M = 9.893$, $SD= 5.294$). A significant difference also emerged in body dissatisfaction, $F(2,163) = 27.067$, $p = .000$, with lower levels of dissatisfaction among children with average weight ($M = .283$, $SD = 1.136$) as compared to children with overweight ($M = .851$, $SD = .833$), and children with obesity ($M = 1.83$, $SD = 1.379$). No other significant difference emerged as regards the other explored variables. Thus, there were no differences between children with average weight, with overweight, and with obesity in terms of health status, $F(2, 165) = .051$, $p = 950$, and psychological status, $F(2, 163)= 1.397$, $p = 250$, mothers' level of education, $F(2, 160) = 1.009$, $p = .367$, fathers' level of education, $F(2, 159) = 2.517$, $p = .084$, and weight-based attitudes, $F(1, 166) = .240$, $p = .787$.

Bivariate correlation among the measured variables are described in Table 4.

Table 3

Means and standard deviation of variables

Variables	Min	Max	*M*	SD
Age	95	136	116.07	10.434
Health status	3	7	3.934	1.111
SDQ	33	61	41.753	5.177
M Edu	5	18	13.803	3.390
F Edu	5	18	11.950	3.515
zBMI	-.74	4.43	1.470	1.042
POTs	6	28	7.976	3.970
Weigh-based attitudes	1.60	10	7.295	2.046
BD	-3	6	0.994	1.328
N-back 0	-2.333	5	3.935	1.434
N-back 1	-5.667	5	3.359	1.740
N-back 2	-4.333	5	1.732	1.636
PLT AB	.30	9.500	8.542	2.215
PLT CD	.15	9	1.000	2.330
Tot Anxiety	1.06	3.44	1.775	0.484
AR Anxiety	1	3.5	1.587	0.460
T Anxiety	1	4.22	1.937	0.646

Note. Age is expressed in months. Education is expressed in academic years. SDQ = Strengths and difficulties questionnaire, M Edu = mothers' educational level, F Edu = fathers' educational level, zBMI = standardized body mass index, Attitudes = weight-based attitudes, POTs = perception of teasing scale, BD = body dissatisfaction, N-back 0 = working memory level 0, N-back 1 = working memory level 1, N-back 2 = working memory level 2, PLT AB = probabilistic learning task for couple ab, PLT CD = probabilistic learning task for couple cd, Tot Anxiety = total anxiety, AR Anxiety= arousal activation, T Anxiety = negative thoughts.

The relation between body weight and cognitive performance: Testing the role of Stereotype threat

Correlational analyses show that zBMI has a negative relation with working memory performance at N-back level 2, *r* (176) = -.185, *p* =.014, whereas a non significant bivariate relation emerged between zBMI and N-back level 0, *r* (176) = -.066, *p* = .328, and between zBMI and N-back level 1, *r* (176) = -.145, *p* = .056, despite the relation's direction is negative.

SPSS PROCESS macro was used to test the hypothesis that stereotype salience moderates the relation between body weight and working memory performance. We used the model 1 to verify the validity of the model by adopting body weight as predictor, the experimental condition as moderator, and the working memory performance as outcome. We repeated the analyses for each n-back level, and for the performance on the filler task (i.e., probabilistic learning).

Table 4

Bivariate Correlations between the explored variables

	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1.zBMI	.052	-373**	.034	.487**	.114	-.054	.189*	-.157*	-.191*	-.007	.069	.158*	-.012	-.066	-.145	-.185*
2.Age	-	.139	.169	-.014	-.112	-.049	.042	-.068	-.023	-.010	.043	0.113	0.086	0.128	0.133	.225**
3.POTs	-	-	.008	.502**	.270**	.117	.316**	-.223**	-.161*	.069	.146	.250**	.021	-.033	-.078	-.105
4.Attitudes	-	-	-	-.039	-.030	-.010	-.044	-.104	.034	.089	.177*	.102	.054	.095	-.091	.071
5.BD	-	-	-	-	.066	-.041	.118	-.057	-.087	.083	-.009	.219**	-.031	-.160*	-.183*	-.191*
6.Tot Anxiety	-	-	-	-	-	.770**	.921**	-.115	-.053	.059	.008	.099	-.095	-.063	-.036	-.013
7.AR Anxiety	-	-	-	-	-	-	.471**	-.002	-.012	.071	-.050	.100	.033	.014	-.063	-.028
8.T Anxiety	-	-	-	-	-	-	-	-.147	-.065	.037	.040	.068	-.160*	-.113	-.018	.002
9.M Edu	-	-	-	-	-	-	-	-	.436**	-.253**	-.147	0.052	0.036	0.01	0.05	0.062
10.F Edu	-	-	-	-	-	-	-	-	-	-.184*	-.042	0.136	0.064	0.021	0.062	.164*
11.Health Status	-	-	-	-	-	-	-	-	-	-	.373**	-0.006	-0.023	-0.076	-.256**	-0.127
12.SDQ	-	-	-	-	-	-	-	-	-	-	-	0.024	-0.002	-.309**	-.349**	-.302**
13.PLT AB	-	-	-	-	-	-	-	-	-	-	-	-	.671**	.046	.004	.048
14.PLT CD	-	-	-	-	-	-	-	-	-	-	-	-	-	.098	.035	-.070
15.N-back 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.469**	.315**
16.N-back 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.653**
17.N-back 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note. * Significant at the level of 0.05 (2-tails) ** Significant at the level of 0.01 (2-tails). SDQ = Strengths and difficulties questionnaire, M Edu = mothers' educational level, F Edu = fathers' educational level, zBMI = standardized body mass index, Attitudes = weight-based attitudes, POTs = perception of teasing scale, BD = body dissatisfaction, N-back 0 = working memory level 0, N-back 1 = working memory level 1, N-back 2 = working memory level 2, PLT AB = probabilistic learning task for couple ab, PLT CD = probabilistic learning task for couple cd, Tot Anxiety = total anxiety, AR Anxiety= arousal activation, T Anxiety = negative thoughts.

The main outcome of interest was children's performance at the level 2 of the N-back task (see Figure 2), as this was the task requiring the highest level of executive control.

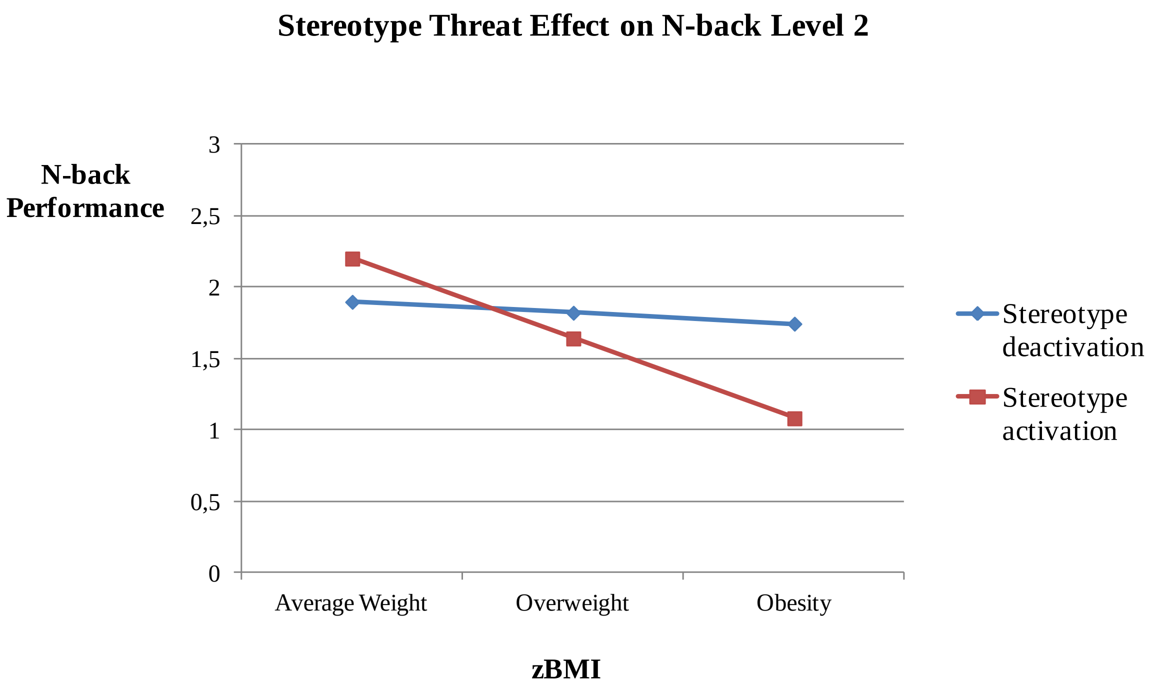


Figure 2. Simple slopes analyses showing Stereotype Threat effect on working memory in N-back level 2.

Results reveal that zBMI is not a significant predictor of the level 2 N-back score, *B* = -.073, *SE* = .159, *p* = .645, 95 % CIs= -.388, .241, as well as experimental condition, *B* = .503, *SE* = .419, *p* = .231, 95 % CIs= -.324, 1.331. Instead, as hypothesized (H1), we have found a significant zBMI x Condition interaction, *B* = -.463, *SE* = .232, *p* = .048, 95 % CIs= -.922, -.003. Simple slopes analyses indicate that zBMI have a negative impact on working memory performance in the stereotype activation condition, *B* = -.536, *SE* = .169, *p* = .001, 95 % CIs= -.871, -.201, but not in stereotype deactivation condition, *B* = -.073, *SE* = .159, *p* = .645, 95 % CIs= -.388, .241. As the significant interaction term indicates, the present slopes significantly differ from each other.

The results are confirmed when parents' level of education and health status are included as covariates in the model too. According to the analyses, mother's level of education *B* = -.001, *SE* = .004, *p* = .967, 95 % CIs= -.088, .085, father's level of education *B* = .061, *SE* = .043, *p* = .157, 95 % CIs= -.024, .147, and children's health status *B* = -.165, *SE* = .121, *p* = .175, 95 % CIs= -.405, .074, have not a significant impact on working memory performance. However, the interaction term zBMI x Condition is still significant, *B* = -.523, *SE* = .262, *p* = .047, 95 % CIs= -1.042, -.005, and simple slopes indicated that zBMI negatively affects working memory performance in stereotype activation condition, *B* = -.580, *SE* = .192, *p* = .003, 95 % CIs= -.960, -.199, but not in stereotype deactivation condition, *B* = -.056, *SE* = .180, *p* = .755, 95 % CIs= -.412, .299. A detailed representation of these results is reported in Table 7.

In addition, we performed a Johnson-Neymar post-hoc analysis to determine the level of zBMI at which the performance deficit in the ST condition, as compared to the NST condition, becomes significant, i.e., stereotype threat effect begins to affect children's working memory performance. Results (see Table 5) revealed that the interactional effect zBMI x condition attains significance when children's zBMI is equal or higher than 2.62.

Table 5

Johnson-Neymar post-hoc analysis for working memory level 2

zBMI	*B*	*SE*	*t*	*p*	LLCI	ULCI
-0.739	0.845	0.568	1.486	.139	-0.277	1.968
-0.481	0.726	0.515	1.409	.160	-0.290	1.742
-0.222	0.606	0.462	1.310	.191	-0.307	1.519
0.036	0.486	0.412	1.179	.240	-0.328	1.301
0.294	0.366	0.365	1.003	.317	-0.354	1.088
0.553	0.247	0.322	0.765	.445	-0.390	0.884
0.811	0.127	0.286	0.444	.657	-0.438	0.692
1.070	0.007	0.259	0.029	.976	-0.504	0.519
1.329	-0.112	0.243	-0.460	.646	-0.593	0.369
1.587	-0.232	0.242	-0.954	.341	-0.711	0.247
1.846	-0.351	0.256	-1.371	.172	-0.858	0.154
2.104	-0.471	0.282	-1.668	.097	-1.029	0.086
2.363	-0.591	0.318	-1.859	.064	-1.218	0.036
2.619	-0.709	0.359	-1.973	.050	-1.419	0
2.622	-0.711	0.360	-1.974	.049*	-1.421	-0.00
2.880	-0.830	0.406	-2.042	.042*	-1.633	-0.028
3.139	-0.950	0.456	-2.082	.038*	-1.851	-0.049
3.397	-1.070	0.508	-2.104	.036*	-2.073	-0.066
3.656	-1.190	0.562	-2.116	.035*	-2.299	-0.080
3.914	-1.309	0.617	-2.122	.035*	-2.527	-0.091
4.173	-1.429	0.672	-2.124	.035*	-2.757	-0.101
4.432	-1.549	0.729	-2.124	.035*	-2.988	-0.109

Note. * Significant at the level of 0.05 (2-tails) ** Significant at the level of 0.01 (2-tails).

Regards N-back level 0 (see Figure 3), our analyses highlight that zBMI has not a significant impact on working memory performance, *B* = .147, *SE* = .141, *p* = .297, 95 % CIs= -.130, .425, whereas experimental condition has, *B* = .917, *SE* = .371, *p* = .014, 95 % CIs= .185, 1.650. However, the interaction zBMI x experimental condition on working memory is significant, *B* = -.507, *SE* = .205, *p* = .014, 95 % CIs =-.913, -.101. Specifically, simple slopes show a negative effect of zBMI on cognitive task in the stereotype activation condition, *B* = -.359, *SE* = .149, *p* = .017, 95 % CIs = -.655, -.064, and a non significant effect in the stereotype deactivation condition, *B* = .147, *SE* = .141, *p* = .297, 95 % CIs = -.130, .425. Results do not change when covariates (parents' level of education and health status) were added in the model (see Table 7).

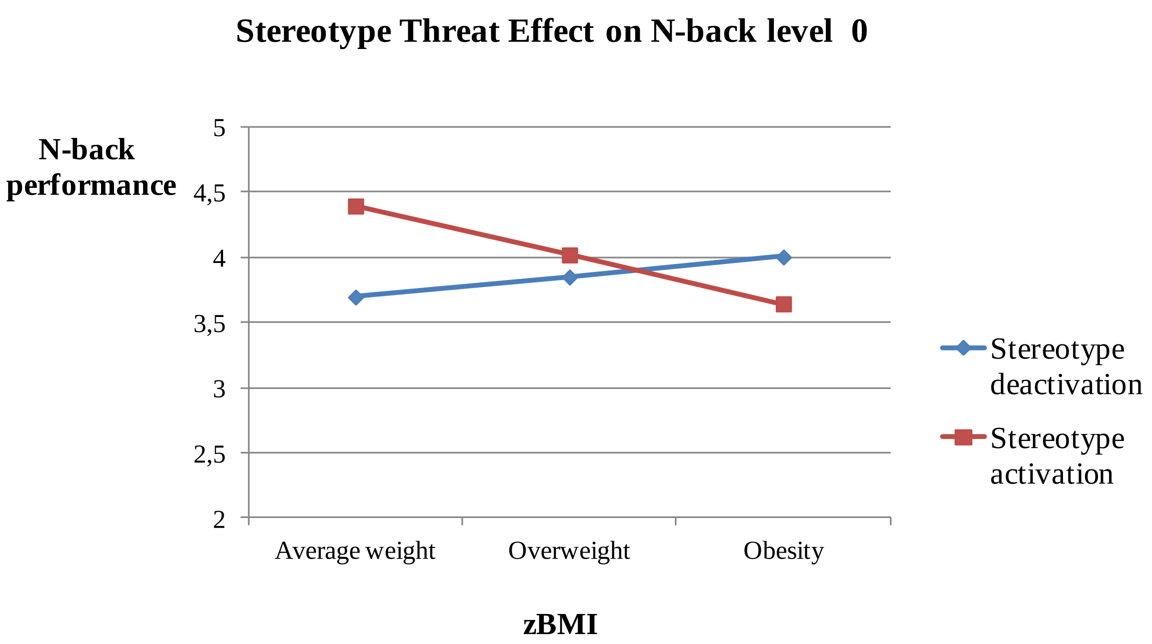


Figure 3. Simple slopes analyses showing Stereotype Threat effect on working memory in N-back level 0.

By repeating the same analyses with zBMI as moderator and experimental condition as predictor, we found that body weight X condition interaction is significant with a zBMI lower than .811, and higher than zBMI of 4.173 (see Table 6).

Concerning working memory level 1 (see Figure 4), we found that zBMI, *B* = -.120, *SE* = .172, *p* = .486, 95 % CIs= -.460, .220, and experimental condition, *B* = .288, *SE* = .453, *p* = .525, 95 % CIs= -.606, 1.183, have not a significant impact on working memory performance. Furthermore, despite simple slopes show that body weight has a negative impact in stereotype activation condition, *B* = -.379, *SE* = .183, *p* = .040, 95 % CIs= -.740, -.017, and no effect on the stereotype deactivation condition, *B* = -.12, *SE* = .172, *p* = .486, 95 % CIs= -.460, .220, the interaction zBMI x Conditions on working memory level 1 is not significant, *B* = -.259, *SE* = .251, *p* = .184, 95 % CIs= -.755, .237. Results are basically the same also including in the model parents' level of education and health status as covariates (see Table 7).

Table 6

Johnson-Neymar post-hoc analysis for working memory level 0

zBMI	*B*	*SE*	t	*p*	LLCI	ULCI
-0.739	1.293	0.503	2.569	.011*	0.299	2.286
-0.481	1.161	0.455	2.550	.011*	0.262	2.061
-0.222	1.030	0.409	2.517	.012*	0.222	1.838
0.036	0.899	0.365	2.464	.014*	0.179	1.620
0.294	0.768	0.323	2.376	.018*	0.130	1.406
0.553	0.637	0.285	2.231	.027*	0.073	1.201
0.811	0.506	0.253	1.997	.047*	0.005	1.006
0.832	0.495	0.251	1.973	.050	0	0.991
1.070	0.374	0.229	1.635	.103	-0.077	0.827
1.329	0.243	0.215	1.130	.260	-0.182	0.669
1.587	0.112	0.214	0.523	.601	-0.311	0.536
1.846	-0.018	0.226	-0.081	.934	-0.466	0.429
2.104	-0.149	0.249	-0.599	.549	-0.643	0.343
2.363	-0.280	0.281	-0.998	.319	-0.836	0.274
2.622	-0.412	0.318	-1.294	.197	-1.040	0.216
2.880	-0.543	0.359	-1.510	.132	-1.253	0.166
3.139	-0.674	0.403	-1.670	.096	-1.471	0.122
3.397	-0.805	0.449	-1.791	.075	-1.693	0.082
3.656	-0.936	0.497	-1.883	.061	-1.918	0.044
3.914	-1.067	0.545	-1.956	.052	-2.145	0.009
3.986	-1.104	0.559	-1.973	.050	-2.208	0
4.173	-1.199	0.595	-2.014	.045*	-2.373	-0.024
4.432	-1.330	0.645	-2.062	.040*	-2.603	-0.056

Note. * Significant at the level of 0.05 (2-tails) ** Significant at the level of 0.01 (2-tails).

Because in each working memory level covariates did not change the outcomes, we have not included these variables in the following analyses.

Then, we performed the same types of analyses to test the effect of stereotype salience on probabilistic learning task. Total score is calculated by considering task's performance on each couple of the probabilistic selection test. Thus, we performed two different analyses for each probabilistic learning couple (one without and one with covariates), and results reveal no significant effects (all *ps* > .208, see Table 8).

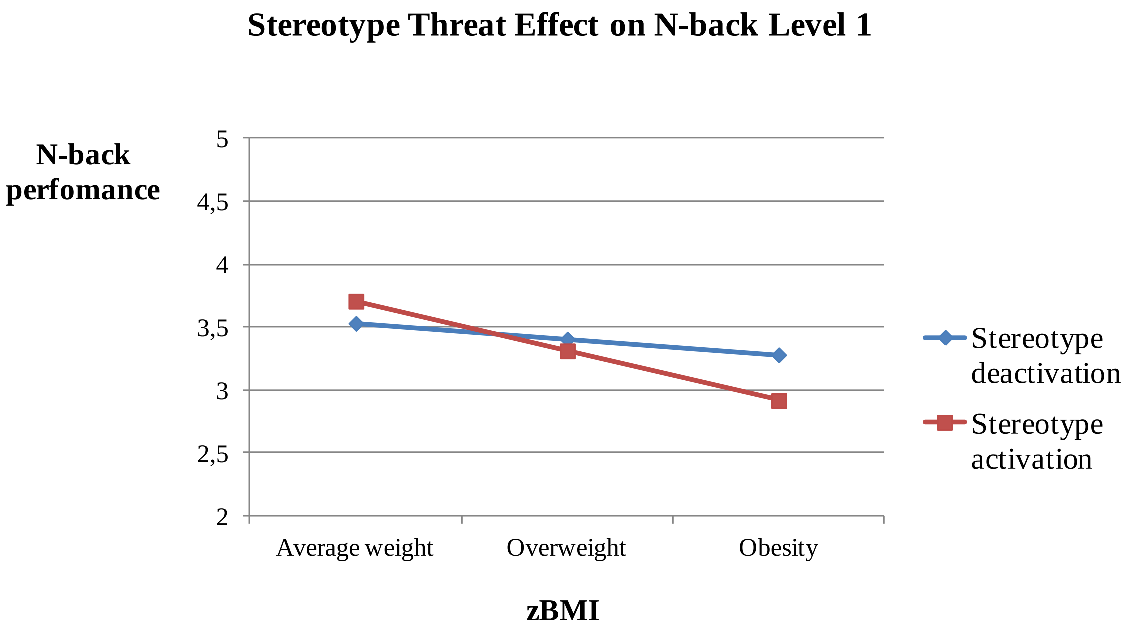


Figure 4. Simple slopes analyses showing Stereotype Threat effect on working memory in N-back level 1.

Anxiety as a mediator

We tested the role of anxiety as a mediator of the relation between body weight and working memory deficits in a stereotype-threatening situation. Based on previous analyses, we used the SPSS macro Process to test two moderated mediational models with working memory in n-back level 0 and n-back level 2 as the outcomes, respectively, zBMI as the main predictor, anxiety as the mediator, and experimental condition as the moderator.

Results reveal that the effect of zBMI on global anxiety, *B* = .072, *SE* = .048, *p* = .509, 95 % CIs= -.085, .419, the effect of condition on global anxiety, *B* = .167, *SE* = .127, *p* = .193, 95 % CIs= -.024, .168, and the interaction zBMI x experimental condition on global anxiety, *B* = -.046, *SE* = .071, *p* = .509, 95 % CIs= -.187, .093, are not significant. Regarding working memory level 2, results showed that global anxiety has not a significant impact on

Table 7

Summary of results of the moderation analyses on working memory

	Overall model					Simple Slopes			
						Stereotype Activation		Stereotype Deactivation	
	B	*SE*	*t*	*p*	95% CIs	*B*	*SE*	*B*	*SE*
Working Memory Level 2									
zBMI	-0.073	0.159	-0.460	.645	-0.388, 0.241	-0.536*	0.169	-0.073	0.159
Condition	0.503	0.419	0.231	.231	-0.324, 1.331				
zBMI x Condition	-0.463	0.232	-1.990	.048	-0.922, -0.003				
Working Memory Level 2 (with covariates)									
M Edu	-0.001	0.004	-0.041	.967	-0.088, 0.085	-0.580*	0.192	-0.056	0.180
F Edu	0.061	0.043	1.420	.157	-0.024, 0.147				
Health Status	-0.165	0.121	-1.361	.175	-0.405, 0.074				
zBMI	-0.523	0.180	-0.312	.755	-0.412, 0.299				
Condition	0.483	0.473	1.020	.309	-0.452,1.420				
zBMI x Condition	-0.523	0.262	-1.997	.003	1.042, -0.005				
Working Memory Level 0									
zBMI	0.147	0.141	1.044	.295	-0.130, 0.425	-0.359*	0.149	0.147	0.141
Condition	0.917	0.371	2.473	.014	0.185, 1.650				
zBMI x Condition	-0.507	0.205	-2.464	.014	-0.913, -0.101				
Working Memory Level 0 (with covariates)									
M Edu	0.009	0.040	0.237	.812	-0.070, 0.090	-0.423*	0.178	0.190	0.167
F Edu	-0.011	0.040	-0.292	.770	-0.091, 0.068				
Health Status	-0.068	0.112	-0.605	.545	-0.290,0 .154				
zBMI	0.190	0.167	1.142	.255	-0.139, 0.520				
Condition	1.107	0.439	2.522	.012	0.239, 1.975				
zBMI x Condition	-0.613	0.243	-2.525	.012	-1.094, -0.133				
Working Memory Level 1									
zBMI	-0.120	0.172	-0.697	.486	-0.460, 0.220	-0.379*	0.183	-0.120	0.173
Condition	0.288	0.453	0.636	.525	-0.606, 1.183				
zBMI x Condition	-0.259	0.251	-1.030	.304	-0.755, 0.237				
Working Memory Level 1 (with covariates)									
M Edu	0.008	0.046	0.185	.855	-0.083, 0.100	-0.520*	0.204	-0.128	0.191
F Edu	-0.009	0.046	-0.195	.845	-0.100, 0.082				
Health Status	-0.427	0.128	-3.320	.001	-0.681, -0.172				
zBMI	-0.128	0.191	-0.674	.501	-0.506, 0.248				
Condition	0.553	0.502	1.101	.272	-0.439, 1.546				
zBMI x Condition	-0.392	0.278	-1.409	.160	-0.941, 0.157				

Note. Bolded names in the first column are outcomes; all others are predictors. *p < 0.05, **p < 0.01, ***p < 0.001. M Edu = mothers' educational level, F Edu = fathers' educational level, zBMI = standardized body mass index.

Table 8

Results of the moderation analyses on probabilistic learning task

	Overall model					Simple Slopes			
	B	*SE*	*t*	*p*	95% CIs	Stereotype Activation		Stereotype Deactivation	
						B	*SE*	*B*	*SE*
Probabilistic learning AB									
zBMI	4.459	2.213	0.202	.840	-3.92, 4.814	9.636	2.359	4.459	2.213
Condition	3.332	5.846	0.569	.569	-8.21, 1.487				
zBMIxCondition	5.177	3.235	0.160	.873	-5.87 6.903				
Probabilistic learning AB (with covariates)									
M Edu	-5.43	5.970	-0.091	.927	-1.23, 1.126	2.133	2.609	2.279	2.436
F Edu	7.452	5.894	1.264	.208	-4.20, 1.910				
Health Status	5.128	1.643	0.312	.755	-2.74, 3.761				
zBMI	2.279	2.436	0.935	.351	-2.54, 7.096				
Condition	5.913	6.432	0.919	.359	-6.80, 1.863				
zBMIxCondition	-1.46	3.552	-0.041	.967	-7.17, 6.876				
Probabilistic learning CD									
zBMI	-4.820	2.339	-0.206	.836	-5.100, 4.134	-3.360	2.493	-4.82	2.339
Condition	3.638	6.178	0.058	.953	-1.180, 1.256				
zBMIxCondition	4.488	3.418	0.131	.895	-6.300, 7.190				
Probabilistic learning CD (with covariates)									
M Edu	-4.69	6.246	-0.075	.940	-1.28, 1.188	5.666	2.730	8.991	2.549
F Edu	2.306	6.167	0.374	.709	-9.88, 1.450				
Health Status	-2.820	1.719	-0.016	.986	-3.43, 3.371				
zBMI	8.991	2.549	0.353	.724	-4.14, 5.938				
Condition	4.915	6.730	0.730	.466	-8.39, 1.822				
zBMIxCondition	-3.320	3.717	-0.090	.928	-7.68, 7.015				

Note. Bolded names in the first column are outcomes; all others are predictors. *p < 0.05, **p < 0.01, ***p < 0.001. M Edu = mothers' educational level, F Edu = fathers' educational level, zBMI = standardized body mass index.

effect of zBMI on working memory performance though the total anxiety is not significant (mean = .0006; 95%CI: -.031/.035), as zero is included in the confidence interval.

In addition, we have found that global anxiety is not a significant predictor of the task performance also in the level 0 working memory task, *B* = -.196, *SE* = .222, *p* = .377, 95 % CIs= -.635, .242, and that it has no mediating role in the relation between body weight and working memory (mean = -.009; 95%CI: -.057/.004) in the threatening (vs. non threatening) working memory, B = .011, SE = .255, p = .963, 95 % CIs= -.492, .516, and that the indirect condition. The same results were confirmed also when we considered the two anxiety subscales separately.

Regarding negative thoughts, we have found that zBMI, *B* = .107, *SE* = .064, *p* = .089, 95 % CIs= -.020, .235, condition, *B* = .069, *SE* = .169, *p* = .681, 95 % CIs= -.265, .404, as well as the zBMI x condition, *B* = .012, *SE* = .094, *p* = .897, 95 % CIs= -.173, .197, have not a significant impact on negative thoughts. Furthermore, negative thoughts are not significant predictor of level 2 working memory performance score, *B* = .103, *SE* = .192, *p* = .590, 95 % CIs= -.276, .483, and the indirect effect of zBMI (through negative thoughts) on working memory level 2 is not significant (mean = .011; 95%CI: -.023/.065). Similarly, results indicate that negative thoughts do not significantly predict working memory performance on level 0, *B* = -.219, *SE* = .167, *p* = .191, 95 % CIs= -.549, .110, and that the indirect effect of zBMI through negative thoughts on working memory level 0 is not significant (mean = -.024; 95%CI: -.101/.005).

Concerning arousal reactions, we have found that condition, *B* = .262, *SE* = .119, *p* = .030, 95 % CIs= .025, .498, is a significant predictor of arousal reaction, but zBMI, *B* = .017, *SE* = .045, *p* = .709, 95 % CIs= -.072, .106, and the interaction zBMI x condition, *B* = -.093, *SE* = .066, *p* = .161, 95 % CIs= -.224, .037, are not. Furthermore, our analyses indicate that arousal activation is not a significant predictor of working memory performance on level 2, *B* = -.175, *SE* = .267, *p* = .513, 95 % CIs= -.703, .353, and the indirect effect of zBMI on working memory performance through arousal reaction is not significant (mean = .004; 95%CI: -.007/.044). As well as on working memory level 2, the effect of arousal reaction on working memory level 0 is not significant, *B* = -.055, *SE* = .237, *p* = .816, 95 % CIs= .816, -.523, and it has not a significant impact on working memory when it is considered in the relation body weight/ working memory/stereotype salience (mean = .001; 95%CI: -.010/.032)

Moderated moderation analyses

Model 3 in SPSS Process was adopted to test whether experiences of weight-based teasing, negative weight-based attitudes, or body weight dissatisfaction strengthen the effect of stereotype threat on working memory performance. By adopting zBMI as predictor, working memory as outcome, and experimental condition as the main moderator, experiences of weight-based discrimination, weight based attitudes, and body weight dissatisfaction as were separately entered as second-order moderators.

Experiences of weight-based discrimination

Regarding working memory level 2, when experiences of weight-based discrimination are entered in the model as second moderator, the predictivity of the model does not change significantly, R^2 change = .000, *F* (1,165) = .021, *p* = .884. In addition, experiences of weight-related teasing have not a significant impact on working memory performance, *B* = -.031, *SE* = .128, *p* = .803, 95 % CIs= -.284, .221, and the interaction effect zBMI x experimental condition x weight-related teasing is not significant as well, *B* = .010, *SE* = .072, *p* = .884, 95 % CIs= -1.132, .153.

As regards working memory level 0, we also found that experiences of weight-related teasing do not further moderate the explored model, R^2 change = .000, *F* (1,165) = .154, p = .695. Experience of weight related teasing have not a significant impact on working memory, *B* = .038, *SE* = .121, *p* = .731, 95 % CIs= -.181, .257, as well as the interaction zBMI x Condition x Experience of weight-related teasing, *B* = .024, *SE* = .062, *p* = .695, 95 % CIs= -.099, .149.

Weight-related attitudes

Adding weight-related attitudes as moderator does not change significantly the explanatory power of the explored model, both on working memory level 2, R^2 change = .001, *F* (1,158) = .292, *p* = .589, and on working memory level 0, R^2 change = .004, *F* (1,158) = .725, *p* = .395.

In addition, our analyses show that the impact of weight-based attitudes on working memory level 2, *B* = .005, *SE* = .127, *p* =.965, 95 % CIs = -.246, .257, as well as the interaction body weight x condition x weight-based attitudes, *B* = -.0746, *SE* = .137, *p* =.589, CIs= -.346, .197, are not significant.

We have found the same results considering working memory 0 as outcome. Weight-based attitudes are significant predictor, *B* = .109, *SE* = .111, *p* =.326, CIs= -.110, .328, and the interaction body weight x condition x weight-based attitudes, *B* = .102, *SE* = .119, *p* =.395, CIs= -.134, .338, has not a significant effect.

Body dissatisfaction

The hypothesis of a moderated moderation model was also not supported with regard to body dissatisfaction for both working memory level 2, R^2 change = .005, *F* (1,158) = .902, *p* = .343, and working memory level 0, R^2 change = .000, *F* (1,158) = .004, *p* = .946.

Results show that the effect of body dissatisfaction on working memory level 2 is not significant, *B* = -.019, *SE* = .244, *p* =.937, CIs = -.502, .463, and that the interaction body weight x experimental condition x body dissatisfaction does not attain significance as well, *B* = .170, *SE* = .179, *p* =.343, CIs= -.184, .525.

In addition, body dissatisfaction is not a significant predictor on working memory level 0, *B* = .364, *SE* = .192, *p* =.059, CIs= .996, -.418, and the interaction body weight x experimental condition x body dissatisfaction is not significant, *B* = -.010, *SE* = .155, *p* =.946, CIs= .946, -.316.

III.5.3. Discussion

Study 1 explored whether stereotype threat effects may affect working memory performance in children with obesity, and whether this effect may be mediated by anxiety and moderated by the experiences of weight-based stigmatization. Our analyses not only confirm results previous are in line with past literature regarding other stigmatized groups, but they also offer new results and new considerations. In detail, we demonstrated that stereotype salience has a negative impact on children with obesity by disrupting their working memory proficiency, even though children with obesity do not report to experience anxiety in the testing situations. Moreover, the disruptive impact of stereotype threat operates regardless of children's prior experiences of weight-based discrimination and internalization of negative attitudes toward weight.

In general, descriptive and correlational analyses confirm that excess weight is a highly stigmatizing condition for young children, A positive relation emerges between body weight and experiences of weight-based discrimination (Haines et al., 2008; McCormack et al., 2011; Van den Berg, et al., 2008; Van Geel et al., 2014), as previously demonstrated in the literature, and a negative relation also emerges between body weight and body dissatisfaction (Evans et al., 2013; Weinberger et al., 2016). Importantly, and in line with previous findings, negative weight-based attitudes appear to be endorsed by children with excess weight as well as those with average weight (Marini et al., 2013; Kornilaki, 2014; Schwartz et al., 2006).

More relevant to our research purposes, our findings confirm the existence of a negative relation between body weight and working memory performance, as repeatedly reported in literature (for a review, see Barkin, 2013). However, as hypothesized, this relation only appears in the stereotype-threatening situation, i.e., when children with obesity are exposed to a contest that is explicitly labelled as diagnostic of their cognitive proficiency.

Consistent with the predictions of the stereotype threat models, we found that being tested in a context that exposes the individual to the risk of confirming a negative stereotype attached to his/her group causes an undue burden on working memory.

Furthermore, our results show that the interaction between body weight and experimental condition negatively affect working memory performance in the most difficult levels of working memory test. This evidence is consistent with previous work concerning stereotype threat effect, as the hampering effects of stereotype-threatening contexts is particularly evident in high difficult tasks, such as highly difficult math problems and complex word problems, which recruit a higher amount of executive resources (Spencer et al., 1999; Quinn & Spencer, 2001).

Moreover, our results reveal that stereotype threat effects especially concerns children with severe obesity. Despite this outcome might suggest that cognitive impairment is related with health condition, and depend on emerging pathologies that do actually interfere with cognitive functioning, this result does not change when children's health status is added in the model as covariate. Rather, it is plausible that the identification with the group of people with excess weight does not correspond to the biological definition of excess weight. Thus, despite according the World Health Organization a child is with obesity when its standardized BMI is higher than 2.00 (Onis et al., 2007), children could begin to perceive themselves as in obesity status only when the standardized body weight is higher. In fact, identifying in the group represent one of the main components to trigger the stereotype threat effect in individuals belonging to that group (Schmader et al., 2008). Studies about stereotypes threat in children showed that children develop the identification in the gender or race category when they are 3-to-4-year-olds (Martin & Ruble, 2010; Quintana, 1998), but it is possible that body weight identification, due to the body changing and the different salience, occurs later in individuals' life.

By repeating the same kind of analyses for the other n-back levels and for the control task, we have found that the interaction body weight and experimental condition is significant only on the n-back level 0. Specifically, we found that the significant interaction is valid for people with a low body weight or with an extremely severe obesity condition: Children with low body mass index increase their performance, whereas children with extremely severe obesity (over 4 standard deviation) decrease their performance. Thus, this effect does not seem to be related to obesity group identity. In detail, it is plausible that on an easier working memory task (as the level 0 N-back is) children belonging to not-stigmatized group were motivated to put more effort in the task, in order to confirm their expected advantage. This is known as stereotype lift effect (Walton & Cohen, 2003), i.e., the benefit that members of an advantaged groups receive when assessed on a task on which members of a negatively stereotyped outgroup are expected to fail.

The second hypothesis was not confirmed. Anxiety, assessed as global anxiety, arousal reaction, and negative thoughts, does not mediate the relation between body weight and working memory. We could hypothesize that other mechanisms concur in the explanation of the observed negative impact of the stereotype-threatening situation on the relation between body weight and working memory (e.g., monitoring or suppression processes), but we can also contend that by using other kinds of instruments we could obtain different results. In fact, anxiety was explored by means of a self-report questionnaire, which could be limited by social desirability bias (Grimm, 2010). Using physiological measure of anxiety or adding some scales of observation of not-verbal behaviour during task performance could give another prospective and open to new considerations.

The third hypothesis was disconfirmed as well: Weight-based teasing does not moderate the relation between body weight and working memory in stereotype (vs. no stereotype) condition. Possible reasons for the obtained results could be the chronicity of experiences of discriminations that reduce the sensibility to stereotype threat situation, but also, on the contrary, chronic experiences of weight-based teasing could be internalized by children. In this last case, the best way to learn about the effect of external factors is the investigation of internalized weight-based stigma (Pearl & Puhl, 2016). Another possible explanation is the absence of questions about relational forms of discrimination in children’s questionnaire, particularly common especially among girls (Tang-Péronard & Heitmann, 2008). Future research to better disentangling the risks factors affecting the vulnerability of children with excess weight to stereotype threatening environments is needed.

A limitation of this research is the lack of more geographical variability in the sample, which restricts generalizability of the findings. In fact, participants come from schools located in the north and centre of Italy, but we do not know the situation in the other Italian regions, in which there are different rates of overweight and obesity (Centro Nazionale di Epidemiologia, Sorveglianza e Promozione della Salute [CNESPS], 2014), and possibly different weight-based attitudes. Generalization of our findings is also limited in part by the small size of our sample, and the unequal number of males and females. In this studies we did not explore gender hypotheses, but Azarbad and Gonder-Frederick (2010) underlined that woman and younger people are more susceptible to weight-bias stigma than man and older, and it is possible that including more girls than boys could give another result. Other limits of the present study could be found in the choice of some instruments, for example physiological measure of anxiety, which could have offered a better evaluation of the anxiety level during the task performance, rather than the self-questionnaire.

A strength of this study is the novelty in the explanation of observed cognitive deficits in children with obesity. In fact, these findings represent the first evidence of stereotype threat effect in children with obesity, and suggest that executive functions may not be hampered if children with obesity were tested in non-threatening environments. Thus, we could offer some theoretical contributions to two lines of research. Concerning the relation *weight status/cognitive performance*, to date only the study by Krukowski et al. (2009) examined the association from a psychosocial point of view. As compared to their work, we replaced the record of academic performance with a direct assessment of basic cognitive abilities, and a correlational design with a stronger experimental paradigm. We also included a possible mediator (anxiety) or moderator (stigma experiences), based on the Integrated Process Model of Stereotype Threat (Schmader et al., 2008). Until now, research about stereotype threat had explored stigmatization associated to obesity only in a preliminary way, and never with a children population, despite the role of stereotypes in the detriment of cognitive performance in children had been previously confirmed (Ambady et al., 2001; Galdi et al., 2014; Neuville & Croizet, 2007; Tomasetto et al., 2011). Finally, we may contribute to research concerning *weight-based stigma* during childhood, that despite the evidence that even young children endorse negative weight-based stereotypes and experiences several weight-based discrimination’s experiences (for a review, see Puhl & Latner, 2007), is still in its infancy.

III.5.4. Conclusion

This study represents the first investigation of stereotype threat effect in children with obesity, and the first evidence of its effect in this population. We demonstrated that body weight status negatively relates with working memory performance, and that this negative relation became stronger in stereotype threat condition, i.e., when we introduced the computer game as an intelligence test rather than a computer game for children, especially in children with severe obesity. We also found that anxiety does not mediate this relation, as well as experiences of weight-based discrimination do not moderate the relation between body weight and working memory proficiency.

Study 2 is aimed at verifying whether the same pattern of results also hold in an adult population.

6. STUDY 2

In Study 2, we have explored whether stereotype threat may have derailing impact on working memory efficiency also on adults with obesity. To date, the literature presents only one study about the role of weight-related stereotypes on cognitive functioning in adults (Major et al., 2012). The authors asked women with obesity to give a speech about “why they would make a good dating partner”, while they have videotaped or audiotaped (i.e., high vs. low threat condition due to appearance-related concerns). Then, participants performed a Stroop color-naming task to evaluate their executive resources, in particularly their attention inhibition ability. Consistent with the hypotheses, women with obesity obtained lower performance in the Stroop color-naming task than woman with average weight, but only in the videotaped (i.e., stereotype-threatening) condition. These findings represent the first evidence of stereotype threat effects hampering cognitive performance in people with obesity. Nevertheless, only one specific component of executive functions has been studied, identity threat was induced by focusing on physical appearance concerns and the related fear of not appearing attractive enough, rather than on concerns pertaining to cognitive proficiency. It would be therefore important to deepen this area of investigation by exploring the effect of stereotype threat induced by the risk of not being perceived as sufficiently intelligent, as well as by focusing on performance deficits in working memory, i.e., the executive function that in at the core process of stereotype threat process.

Consistent with past literature, we hypothesized that working memory performance decreases in participants with higher body mass index (H1). However, based on our theoretical account, we also hypothesized that this effect was exacerbated when weight stigma is made salient in the testing situation (i.e., stereotype threat condition) (H2). As in study 1, in order to rule out the possibility that performance differences may arise merely from reduced motivation and effort in individuals with obesity (or by increased effort in participants with average weight), and not from increased working memory load under stereotype threat, we included a filler task tapping in probabilistic learning, on which we did not expect any systematic performance decrease in participants under stereotype threat (H2a) Furthermore, we supposed that past experiences with weight-related stigma moderate the relation between weight status and working memory performance, by making individuals with obesity more vulnerable to stereotype-threatening environments (H3). We also investigated the role of weight-related attitudes (H4a) and body dissatisfaction (H4b), and we hypothesized that they could act as further moderators of the relation between body weight and working memory deficits under stereotype threat. Finally, because self-perception of one's attainments is lower in members of stigmatized groups (Steele & Aronson, 1995; Forbes et al., 2014), we hypothesized that not only the actual test performance, but also the subjective perception of one's performance is lower in people with obesity, especially in a stereotype threat condition (H5).

III.6.1. Method

Participants

Participants were 137 adults ranging from 18 to 67 years of age from different areas of Italy. Participants were adults hanging out in the Cesena's site of University of Bologna (students, personnel, parents of children accessing clinical services, etc.), voluntaries of local associations, and patients of clinicians in the Cesena area who contributed to advertise our research. We recruited men and women of diverse body weight categories, because of our interest in targeting the effects of stereotype threat in people with obesity (vs. people with average weight), Retained participants were assigned to one of three experimental conditions (Stereotype Threat, ST; Stereotype de-activation, NST; Neutral, N) according to a predefined random sequence.

Procedure

After the approval of the Ethical Committee of the University of Bologna and upon participants' signed informal consent, we set data collection in a quiet room located at either a clinical centre, a cultural association, or a University laboratory, depending on participants' availability. We presented participants with a questionnaire assessing their educational level, health status, experiences of weight-based discrimination, weight-related attitudes, and body dissatisfaction, and we subsequently measured participants' weight and height to compute BMI. Following, participants were randomly assigned to one of the three experimental conditions before completing two computer tasks assessing working memory and probabilistic learning. Finally, after completing a final questionnaire assessing their performance appraisal (self-perception and errors estimation), participants were fully debriefed, thanked, and dismissed.

Experimental Manipulation. We manipulated the diagnosticity of the context, with regard to the negative stereotypes associated with obesity, by presenting the cognitive tasks in three different ways. In the ST condition (47 participants), the tasks were presented as very sensitive tests to assess intelligence and cognitive proficiency. In the NST condition (44 participants), participants were invited to perform some distraction tests before attending an alleged final, more relevant test. In the C condition (40 participants), we provided participants with the standard instructions for each of the two tasks, labelled as a working memory and a probabilistic learning task, respectively. No differences emerged in participants' body weight by conditions.

Measures

Level of education. We asked participants to indicate their educational level, and we operationalized this answer in term of school years: Primary school correspond to 5 point, middle school to 8, high school to 13, bachelor degree to 16, master degree to 18, and doctoral degree to 21 years of school education.

Health Status. Health status condition was investigated by presenting a list of 5 health conditions (type II diabetes, arterial hypertension, cardiovascular system, sleep disorder, other chronic diseases) with the question "Have you been diagnosed with any of these health problems?" Each reported pathology was scored with 1 point, and the sum of all the marked answers was used as the individuals' health status score.

Weight-based discrimination. We used the Everyday Discrimination Scale, by replacing the items pertaining to other experiences of discrimination (e.g., racial, or sexual) with items related with negative experiences associated with body weight (Williams, Yu, Jackson, & Anderson, 1997; Jackson, Steptoe, Beeken, Croker, & Wardle, 2014). The instrument is composed by 9 statements with a 6-point Likert scale, with an α value equal to .905 in the present sample.

Weight-based attitudes. The Fat Phobia Scale (Bacon et al., 2001) was used to assess participants' weight-related attitudes. The instrument is a 5-point semantic differential scale composed by 14 pairs of adjectives (α = .860), in which participants have to answer according their personal opinion.

Body dissatisfaction. To assess body weight dissatisfaction, participants competed the body weight identification and satisfaction scale by Pulvers et al. (2004). Their aim was to observe 9 pictures with a growing weight status, and to indicate both the image that currently looks like them, and the image which they would like to resemble. Subtracting the second answer to the first one (i.e., actual – ideal discrepancy) we obtained the body weight dissatisfaction's score.

Working memory. The Automatic Operation Span Test (OSPAN; Unsworth, Heitz, Schrock, & Engle, 2005) was used to assess working memory. In this task, participants have to solve a math problem while memorizing a series of letters. The test includes 5 series of math operations and letters (from 3 to 7 of length), each randomly presented for three times. The score corresponds to the sum of all correctly recalled sets: This means that if an individual recall correctly 3 letters in a set size of 3, and 3 in a set of 4, the OSPAN value corresponds to 3 (3+0).

Probabilistic Learning. We used the same Probabilistic Selection Task (Frank et al., 2004) that we adopted in Study 1 with only two differences: Symbols were hiragana characters instead of aliens, and there was an extra couple of symbols. Thus, we presented 3 symbol pairings (AB, CD, EF), and participants had to pick the "winning symbol" of each pair. The win-probabilities of each symbol changes for each couple: A wins over B in 80% of the times, C wins over D in 70% of the times, and E wins over F in 60% of the times. Couples were presented for 60 times, and we considered the proportion of correct (vs. incorrect) answers.

Self-perception. Participants filled out a questionnaire to assess the participants' self-perception after the task performance. The scale (same used by Forbes et al., 2014) is a 5 point Likert scale composed by 6 items (e.g., doubtful, foolish, insecure).

Errors estimation. Participants were also asked to estimate the percentage of errors that they supposed to have done in the tasks.

Statistical Analyses

We computed descriptive statistics and correlations among the main variables. We also computed the ANOVA values to know about differences in body weight status in term of educational level, health status, experiences of weight-based discrimination, body weight-attitudes, body weight dissatisfaction, working memory performance, and probabilistic learning task.

Then, to test our first hypothesis, we used the SPSS Macro PROCESS (Hayes, 2013). Specifically, we selected model 1 with the muticategorical option for the moderator (i.e., experimental condition), BMI as predictor, and the AOSPAN score as the dependent variable. By means of the multicategorical option, the Process macro automatically converted the 3-level variable describing experimental conditions into three dummy-coded binary variables, each one comparing one condition to another. In detail, Contrast 1 opposed the stereotype deactivation to the neutral condition, Contrast 2 opposed the stereotype activation to the stereotype deactivation condition, and Contrast 3 opposed the stereotype activation to the neutral condition. We performed the same analysis also with the filler task (i.e., the implicit learning task) as the outcome. Finally, we repeated all the analyses by including level of education and health status as covariates.

To test the role of experiences of discrimination, of weight-based attitudes, and of body dissatisfaction as moderator, we performed hierarchical regression analyses with working memory as the outcome. With this purpose, we performed three separate models, I which the candidate second-order moderator variables (i.e., experiences of discrimination, weight-based attitudes, and body dissatisfaction) were added to the baseline model with BMI as the predictor, and condition as the main moderator. In a subsequent step, also the 2- and 3-way interactions terms between BMI, condition, and the second-order moderators were further added to the models.

Finally, we have also verified whether self-perception and errors' estimation changed according to body weight and experimental conditions. With this purpose and by using SPSS Macro PROCESS (Hayes, 2013), we performed Model 1, by entering body weight as independent variable, condition as moderator, and self-perception and error estimation as the outcomes. Furthermore, we have considered working memory score and probabilistic learning score as covariates, to adjust for actual performance.

III.6.2. Results

Sample characteristics

From the recruited participants, six were excluded because the performance during the computer task was inadvertently interrupted. The remaining 131 participants (33 men and 98 women) were aged from 20 to 67 (M_{age} = 41.43, *SD* = 11.23), and they had a mean BMI equal to 34.006 Kg/m^2 (*SD* = 10.729). Specifically, according to the Health World

Organization criteria, 74 were with obesity (a BMI equal to or higher than 30), 18 participants were with overweight (BMI between 25 and 29.9 kg/m^2), and 39 participants were in a average body weight status (BMI between 18.50 and 24.99 kg/m^2). The mean value for the education level corresponds to 12.632 school years (*SD* = 3.199), whereas, concerning the main professions, 8.4% were housewives, 8.4% were unemployed, 13.7% were office workers, 8.4% were merchants, 7.6% were workmen, and 9.9% were students.

Means and standard deviation for all variables are described in Table 9. Bivariate correlations are reported in Table 11.

Table 9

Means and standard deviation of variables

Variables	Min	Max	*M*	SD
Age	20	67	41.43	11.213
BMI	17.85	62.43	34.006	10.729
Health Status	0	5	0.511	0.888
Level of Education	5	18	12.632	3.199
Weigh-based attitudes	1.14	4.43	3.055	0.690
Weight-related discrimination	9	44	15.815	8.725
Body dissatisfaction	-2	6	2.491	1.824
Probabilistic Learning AB	0	1	0.641	0.213
Probabilistic Learning CD	0.25	1	0.609	0.191
Probabilistic Learning EF	0.10	1	0.574	0.196
Working Memory	0	61	14.356	13.701
Self-evaluation	1	7	3.595	1.444
Errors perception	11.67	94.33	50.288	18.465

Descriptive analyses

ANOVA analyses (see Table 10) show differences related with body weight groups (average weight, overweight, obesity) regarding level of education, F (2,125) = 10.034, p = .000, and health status, F (2, 128) = 3.730, p = .027, but also in body dissatisfaction, F (2, 117) = 77.172, p = .000, and experiences of weight-based discrimination, F (2, 127) = 15.205, p = .000. No differences emerged in terms of weight-based attitudes, F (2, 111) = .039, p = .961.

Table 10

Descriptive data for variables (means and standard deviation) per participants' body weight

	Average weight	Overweight	Obesity
Age	41.21 (12.93)	42.39 (9.11)	41.32 (10.82)
Health Status	0.20 (.46)	0.50 (.78)	0.67 (1.03)
Educational Level	14.25 (3.18)	13.11 (2.37)	11.61 (3.02)
Weigh-based attitudes	3.06 (.70)	3.09 (.51)	3.04 (.73)
Weight-related discrimination	10.92 (9.83)	12.61 (5.12)	19.10 (9.83)
Body dissatisfaction	0.62 (1.13)	1.93 (.99)	3.65 (1.28)
Probabilistic Learning AB	0.63 (.23)	0.66 (.19)	0.64 (.21)
Probabilistic Learning CD	0.62 (.18)	0.67 (.17)	0.58 (.19)
Probabilistic Learning EF	0.57 (.20)	0.60 (.17)	0.56 (.20)
Working Memory	17.41 (15.05)	21.50 (12.36)	10.91 (12.26)
Self-evaluation	3.74 (1.48)	3.20 (1.23)	3.60 (1.46)
Errors perception	49.21 (17.75)	47.54 (18.72)	51.80 (19.01)

Stereotype Threat effects on working memory

Bivariate correlational analyses (see Table 11) showed a negative relation between body weight and working memory performance, r (131) = -.246, p = .001, as expected (H1). By using SPSS Macro Process, Model 1, we explored the role of stereotype salience as a moderator of this negative relation (see Figure 5).

Results highlighted that body weight has a significant negative impact on working memory performance, B = -.524, SE = .176, p = .003, 95 % CIs= 19.84, 45.01, as well as the contrasts between stereotype activation vs. deactivation condition (contrast 2), B = -19.158, SE = 8.934, p = .034, 95 % CIs= -36.838, - 1.468, and between neutral vs. stereotype deactivation condition (contrast 1), B = 18.206, SE = 9.628, p = .061, 95 % CIs= -.852, 37.264. More importantly, the interaction body weight x contrast 2, B = -.524, SE = .176, p = .003, 95 % CIs= 19.84, 45.01, as well as the interaction body weight x contrast 1, B = -.6461, SE = .272, p = .019, 95 % CIs= -1.184, -.107, attained significance, thus suggesting that the relation between body weight and working memory efficiency varies according to task diagnosticity (H2). No differences were found between stereotype activation and neutral condition (contrast 3), B = -.947, SE = 9.680, p = .922, 95 % CIs= -20.109, 18.213, and the interaction between body weight x contrast 3 was also not significant, B = -.040, SE = .272, p

Table 11

Bivariate Correlations between the covariates and main variables

	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13
1.Age	-.094	.298**	-.166	-.269**	.155	-.174	-.047	-.066	.041	-.209*	.277*	.199*
2.BMI	-	.165	-.316**	.440*	-.101	.759**	.005	-.183*	-.001	-.256**	-.062	.068
3.Health Status	-	-	-.212*	-.035	.103	.113	.058	-.029	.055	-.095	-.018	.041
4.Educational Level	-	-	-	.035	.112	-.258**	.044	.108	.099	.364**	-.067	-.140
5.Discrimination	-	-	-	-	.094	.500**	.025	-.030	.104	-.135	.003	.086
6.Weight-based attitudes	-	-	-	-	-	-.005	-.087	-.023	.100	-.127	.058	.225*
7.Body dissatisfaction	-	-	-	-	-	-	-.032	-.064	-.071	-.142	-.042	.148
8.Probabilistic Learning AB	-	-	-	-	-	-	-	.155	.082	.100	-.079	.022
9.Probabilistic Learning CD	-	-	-	-	-	-	-	-	.227**	.189*	-.006	-.145
10.Probabilistic Learning EF	-	-	-	-	-	-	-	-	-	.016	-.097	-.182
11.Working Memory	-	-	-	-	-	-	-	-	-	-	-.285**	-.373**
12.Self-evaluation	-	-	-	-	-	-	-	-	-	-	-	.371**
13.Errors perception	-	-	-	-	-	-	-	-	-	-	-	-

Note. * Significant at the level of 0.05 (2-tails) ** Significant at the level of 0.01 (2-tails).

= .882, 95 % CIs= -.578, .498. Specifically, simple slopes analyses underline that the negative link between body weight and working memory is significant in the stereotype activation condition, B = -.524, SE = .176, p = .003, 95 % CIs= -.872, -.175, as well as in the neutral condition, B = -.564, SE = .207, p = .007, 95 % CIs= -.974, -.153, whereas the relation becomes non significant in the stereotype deactivation condition, B = .081, SE = .176, p = .643, 95 % CIs= -.266, .430.

In addition, we separately added educational level and health status as covariates. According to correlational analyses, educational level negatively relates with body weight, r (128) = -.316, p = .000, and positively relates with working memory performance, r (128) = -.368, p = .000. Instead, health status condition does not show a significant relation with body weight, r (131) = -.368, p = .059, and working memory performance, r (131) = -.111, p = .209.

Regression analyses showed that health status does not change the models' results, whereas, when educational level is entered in the model, the main effect of neutral condition of working memory performance disappears (see Table 12). However, the significance of all the interaction terms remains unchanged compared to the previous analysis.

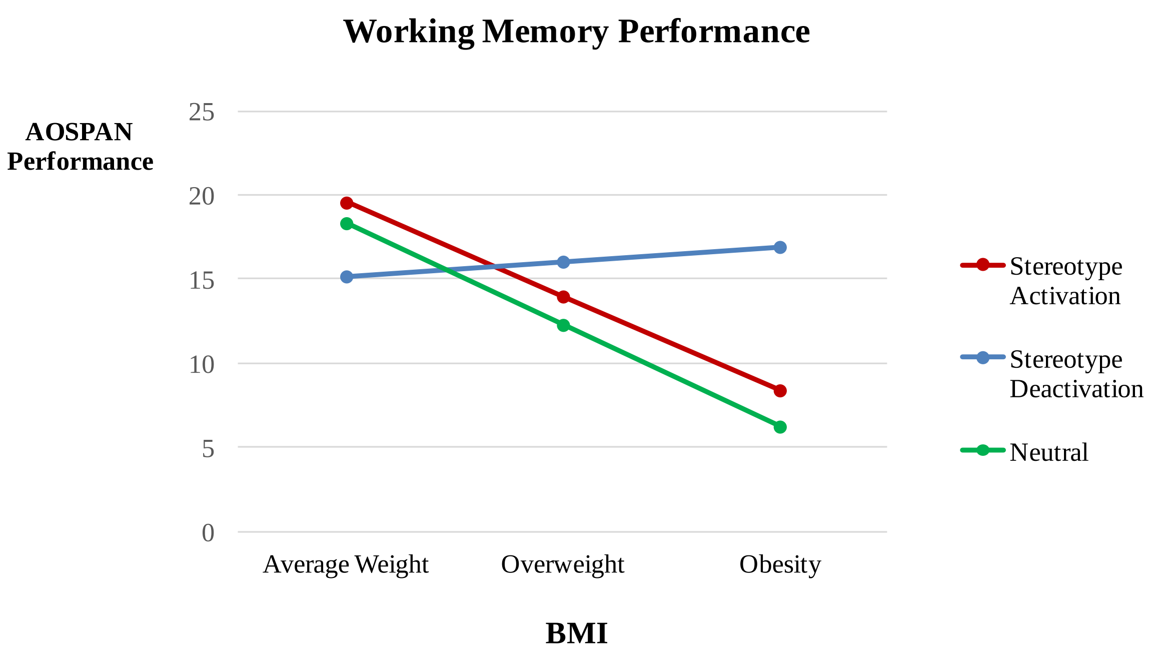


Figure 5. Simple slopes analyses showing Stereotype Threat effect on working memory.

Table 12

Moderation analyses on working memory performance

	Overall model					Simple Slopes					
	B	*SE*	*t*	*p*	95% CIs	Stereotype Activation		Stereotype Deactivation		Neutral Condition	
						B	*SE*	*B*	*SE*	*B*	*SE*
Working Memory											
BMI	-0.524	0.176	-2.975	.003	-0.872, -0.175	-0.524*	0.176	0.081	0.176	-0.564*	0.207
N vs NST (Contrast 1)	18.206	9.628	1.890	.061	-0.852, 37.264						
ST vs. NST (Contrast 2)	-19.153	8.93	-2.143	.034	-36.839, -1.468						
ST vs N (Contrast 3)	-0.947	9.680	-0.097	.922	18.213, -20.109						
BMI x Contrast 1	-0.646	0.272	-2.37	.019	-1.184, -0.107						
BMI x Contrast 2	0.605	0.249	2.432	.016	0.112, 1.098						
BMI x Contrast 3	-0.040	0.272	-0.148	.882	-0.578, 0.498						
Working Memory (with covariates)											
BMI	-0.455	0.169	-2.681	.008	-0.791, -0.119	-0.455*	0.169	0.164	0.170	-0.245	0.216
Educational Level	1.436	0.379	3.787	.000	0.685, 2.188						
N vs NST (Contrast 1)	9.517	-9.529	0.998	.319	9.349, 28.383						
ST vs. NST (Contrast 2)	-18.450	8.570	-2.152	.033	-35.417, -1.483						
ST vs N (Contrast 3)	-8.933	9.553	-0.935	.351	-27.847, 9.981						
BMI x Contrast 1	-0.410	0.269	-1.521	.130	-0.943, 0.123						
BMI x Contrast 2	0.620	0.238	2.595	.010	0.147, 1.093						
BMI x Contrast 3	0.210	0.270	0.777	.438	-0.324, 0.745						

Table 12 (*continued*)

	Overall model					Simple Slopes					
	B	*SE*	*t*	*p*	95% CIs	Stereotype Activation		Stereotype Deactivation		Neutral Condition	
						B	*SE*	*B*	*SE*	*B*	*SE*
Working Memory (with covariates)											
BMI	-0.492	0.178	-2.760	.006	-0.846, -0.139	-0.492**	0.178	0.105	0.178	-0.566*	0.207
Health Status	-1.312	1.323	-0.992	.323	-3.931, 1.306						
N vs NST (Contrast 1)	19.088	9.686	1.970	.051	-0.083, 38.260						
ST vs. NST (Contrast 2)	-18.031	8.943	-2.016	.045	-35.734, -0.329						
ST vs N (Contrast 3)	1.056	9.767	0.108	.914	-18.276, 20.389						
BMI x Contrast 1	-0.671	0.273	-2.454	.015	-1.213, -0.130						
BMI x Contrast 2	0.597	0.249	2.397	.018	0.104, 1.091						
BMI x Contrast 3	-0.074	0.274	-0.269	.787	-0.616, 0.468						
Probabilistic Learning Task AB											
BMI	0.002	0.003	0.947	.346	-0.003, 0.008	0.003	0.003	0.001	0.003	-0.005	0.003
N vs NST (Contrast 1)	0.213	0.156	1.365	.175	-0.096, 0.522						
ST vs. NST (Contrast 2)	-0.027	0.145	-0.188	.851	-0.314, 0.259						
ST vs N (Contrast 3)	0.185	0.157	1.184	.239	-0.125, 0.496						
BMI x Contrast 1	-0.006	0.004	-1.398	.165	-0.015, 0.003						
BMI x Contrast 2	-0.001	0.004	-0.415	.679	0.010, 0.006						
BMI x Contrast 3	-0.008	0.004	-1.778	.078	-0.017, 0.001						

Table 12 (*continued*)

	Overall model					Simple Slopes					
	B	*SE*	*t*	*p*	95% CIs	Stereotype Activation		Stereotype Deactivation		Neutral Condition	
						B	*SE*	*B*	*SE*	*B*	*SE*
Probabilistic Learning Task CD											
BMI	-0.004	0.003	-1.359	.177	-0.009, 0.002	-0.004	0.003	-0.003	0.003	-0.004	0.003
N vs NST (Contrast 1)	-0.044	0.140	-0.314	.754	-0.321, 0.233						
ST vs. NST (Contrast 2)	-0.001	0.130	-0.004	.997	-0.258, 0.257						
ST vs N (Contrast 3)	-0.045	0.141	-0.316	.753	-0.323, 0.234						
BMI x Contrast 1	-0.001	0.004	-0.194	.846	-0.009, 0.007						
BMI x Contrast 2	0.001	0.004	0.187	.852	-0.007, 0.008						
BMI x Contrast 3	0.000	0.004	-0.023	.982	-0.008, 0.008						
Probabilistic Learning Task EF											
BMI	0.000	0.003	-0.087	.931	-0.006, 0.005	0.000	0.003	-0.001	0.003	0.002	0.003
N vs NST (Contrast 1)	-0.162	0.150	-1.076	.284	-0.459, 0.136						
ST vs. NST (Contrast 2)	-0.021	0.136	-0.158	.875	-0.290, 0.247						
ST vs N (Contrast 3)	-0.132	0.147	-0.899	.370	-0.423, 0.159						
BMI x Contrast 1	0.004	0.004	0.847	.399	-0.005, 0.012						
BMI x Contrast 2	-0.001	0.004	-0.240	.811	-0.008, 0.007						
BMI x Contrast 3	0.002	0.004	0.431	.668	-0.006, 0.010						

Note. Bolded names in the first column are outcomes; all others are predictors. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. BMI = body mass index; ST = Stereotype Threat; NST = Stereotype de-activation; N = Neutral Condition.

To ensure that the effect of stereotype salience was limited to the working memory task only, we repeated the same set of analyses by using the probabilistic learning performance as the outcome. Results highlighted that body weight has not a significant impact on probabilistic learning task, regardless of the experimental conditions (all *p*s > .78, see Table 12).

Moderated moderation models

Three different hierarchical regression analyses were performed to test the role of experiences of weight-based discrimination, weight-related attitudes, and body dissatisfaction as moderators of the relation body weight x experimental condition on working memory performance.

Experiences of weight-related discrimination

Results did not support the hypothesis for a moderated moderation model with body weight x experimental condition as predictors, and experiences of weight-related discrimination as a second-order moderator. In fact, hierarchical analysis showed that the R^2 value did not improve significantly when experiences of weight-based discrimination are entered in the model, R^2 change = .016, *F* (2,120) = 1.108, *p* = .334. Furthermore, analyses reveal that experiences of weight-related discrimination have not a significant impact on working memory performance, *B* = -1.031, *SE* = .950, *p* = .280, and that the interaction terms between body weight x weight-based discrimination x contrast 2, *B* = -.049, *SE* = .032, *p* = .130, and body weight x weight-based discrimination x contrast 3, *B* = .014, *SE* = .039, *p* = .719, are not significant as well.

Weigh-based attitudes

Similar results were found for weight-based attitudes. In fact, hierarchical regression analyses showed that R^2 of the model do not significantly change when weight-based attitudes are included in the model to test the moderated moderation model, R^2 change = .006, *F* (2,104) = .391, *p* = .441. In addition, we have found that weight-based attitudes, *B* = -.072, *SE* = 9.140, *p* = .719, the interaction between body weight x weight-based attitudes x contrast 2, *B* = -.092, *SE* = .416, *p* = .825, and the interaction between body weight x weight-based attitudes x contrast 3, *B* = -.238, *SE* = .499, *p* = .635, are not significant predictors of working memory performance.

Body weight dissatisfaction

In lined with previous results, when body weight as included in the analyses to test the moderated moderation model, results do not confirm the hypothesis, R^2 change = .933, *F* (2,107) = .933, *p* = .397. Moreover, body weight dissatisfaction do not significantly predict working memory performance, *B* = 3.440, *SE* = 3.742, *p* = .360, as well as the interaction body weight x body dissatisfaction x contrast 2, *B* = .013, *SE* = .173, *p* = .938, and the interaction between body weight x body weight dissatisfaction x contrast 3, *B* = .236, *SE* = .190, *p* = .219, on working memory are not significant predictors of working memory performance.

Self-perception and errors estimation

By performing with SPSS macro process' model 1 (Hayes, 2013), results reveal that working memory actual performance is the only predictor of performance self-perception, *B* = -.033, *SE* = .0095, *p* = .0008, 95 % CIs= -.051, -.014, and that neither body weight, *B* = -.008, *SE* = .0192, *p* = .6472, 95 % CIs= -.0467,.0291, or experimental conditions, contrast 2: *B* = .8406, *SE*= .9513, *p* = .3787, 95 % CIs=-1.043, 2.724, contrast 3: *B* = -.662, *SE*= 1.0381, *p* = .524, 95 % CIs=-2.718, 1.393, or the interaction body weight x experimental conditions, BMI x Contrast 2: *B* = -.026, *SE*= .026, *p* = .328, 95 % CIs= -.079, .026, BMI x contrast 3: *B* = .023, *SE*= .029, *p* = .936, 95 % CIs= -.055, .059, have a significant impact on the outcome.

We found the same result, when considering errors estimation as the outcome. Also in this case, working memory performance was the only significant predictor, *B* = -.033, *SE* = .0095, *p* = .0008, 95 % CIs= -.051, -.014. None of the other predictors attained a significant effect.

III.6.3. Discussion

This study examined the impact of stereotype threat phenomena on working memory efficiency in individuals with excess weight. Furthermore, we have also explored the moderating role of experiences of weight-based discrimination, weight-related attitudes, and body weight dissatisfaction as possible moderators of the relation between body weight and working memory performance under stereotype threat. Finally, we also tested the impact of stereotype threat on individual appraisal of their performance, by assessing their self-worth and errors' perception.

Results suggest that the negative relation between excess body weight and the proficiency of executive functions should may be more thoroughly understood by taking into account the potential derailing effects exerted by weight-based stigmatization. In fact, consistent with our prediction, we found that the salience of the assessment diagnosticity of the, with regard to an ability for which individuals with obesity are negatively stereotyped (i.e., intelligence and cognitive proficiency), significantly changes this relation. In detail, we found that the well-established decrease in working memory efficiency at increasing levels of body weight only manifests when the working memory task is presented as diagnostic of intelligence (i.e., stereotype threat cognition), or as diagnostic of memory (i.e., control condition with standard assessment instructions). In contrast, no relation between body weight and working memory appeared when the task was labelled as not diagnostic of cognitive abilities.

These findings expand previous literature under different respects. First, by exploring the impact of weight-based stigma on working memory, we demonstrated that negative stereotypes associated to obesity do actually cause deficits in an executive function that is at core of a variety of complex abilities that are essential to individuals' accomplishments in daily life. Second, by using three different experimental conditions, we have had the possibility to demonstrate that stereotype effects not only occur when stereotype-related diagnosticity is forcedly underlined, as it commonly is in stereotype threat research, but also in a neutral condition strictly modelled upon current procedures in cognitive assessment. Specifically, we found that working memory performance in the stereotype activation condition does not significantly differ from performance in the neutral control condition. This evidence lead us to argue that for individuals with obesity, ordinary testing situations could be perceived as threatening as those in which weight-related stereotypes are purposely made salient. This pattern of findings is also consistent with seminal studies on gender or ethnic differences in math or in cognitive assessment (e.g., Steele & Aronson, 1995; Spencer et al., 1999), in which it appeared that it was sufficient to label the task as a "math" or a "cognitive" assessment, with no further reference to negatively stereotyped group membership, to induce performance derailments. Referred with past studies on cognitive deficits in obesity, these findings suggest that part of the detriment in executive functions demonstrated in the literature (e.g., Prickett et al., 2015; Smith et al., 2011) could be explained also by the mere fact that participants with obesity may have experienced the situation of cognitive assessment as threatening, thus performing at a lower-than-optimal level. In lines with the stereotype threat model (Schmader et al., 2008; Steele & Aronson, 1995), the increased performance of participants with obesity in the stereotype deactivation condition may be explained by the absence of negative thoughts, suppression and monitoring efforts, and arousal, that could have increased the availability of working memory resources. Contrary to stressing situations that could trigger avoidance-goals strategies and worry about performance and consequently reduce the task performance (Brodish & Devine, 2009), a deactivation condition could therefore lead to the opposite direction. The fact that stereotypes could lead to inefficacy behaviour's strategy seems to be in lines with previous studies concerning health life style, which showed, for example, that messages including weight-based stereotypes lead people with overweight to eat more caloric foods and to have a lower perception of self-efficacy control (Major et al., 2014).

However, when educational level is included in the model, data analyses showed that only stereotype threat activation prompts a significant negative relation between body weight and working memory efficiency, whereas the relation becomes non significant in the neutral condition, i.e., when standard test instructions are provided. It is possible that participants with high level of education are more accomplished with testing situation, and that the standard instructions used for the task presentation in this condition represent something more familiar – and therefore less threatening - to them. However, researches also showed that educational level may represent a cognitive reserve that could have a significant role in the relation between obesity and cognitive functioning (Davis et al., 2010; Kirton & Dotson, 2016; Wit et al., 2016). Anyway, because educational level weakens the relation between body weight and cognitive proficiency only in the neutral condition, but not in the condition of stereotype activation, these results further highlight that also highly educated individuals with obesity may underperform in assessment situations, when environmental cues remind them of the negative stereotypes associated with cognitive. However, future studies should provide further support for this contention

Our results also highlighted that weight-based experiences of discrimination do not moderate the vulnerability to stereotype threat. One possible reason for this null finding may be that people with obesity may actually report difficulties in episodic memory abilities (Cheke, Simons, & Clayton, 2016). This cognitive complication could therefore make self-report answers less close to the genuine people with obesity's experiences, thus reducing the reliability of the measures adopted to assess stigma experiences. However, as well as in the study with children, chronicity of experiences of discriminations could make people less sensible to stereotype threat cue. In fact, during time, they could have developed copying strategies or strengthen personal resilience, thus buffering the effect of experience of weight stigma, even though they continue to experience discriminatory episodes in their life. In addition, recent investigations show that experiences of weight based discrimination have not as much impact as the interiorized weight-based stigma (e.g., Puhl, Quinn, Weisz, & Suh, 2017). Thus, applying weight-based stereotypes to themselves may make people with obesity more sensitive to stereotype identity activation, as compared to experiencing stigmatization from others. However, in our study we demonstrated that neither endorsing negative weight-based attitudes, nor manifesting high body dissatisfaction, increases the vulnerability of working memory efficiency to stereotype-threatening situations. Indeed, our results may actually suggest that stereotype threat vulnerability in individuals with obesity is genuinely independent from both subjective experiences of weight-based stigmatization, and personal attitudes toward excess weight.

Finally, our results reveal that actual working memory performance has a negative impact on error perception and individuals' self-doubt, whereas the self and errors perception on the probabilistic learning task are not predicted by task performance, or the experimental condition, or the body weight, and or the interaction body weight x condition. In any case, body weight and experimental condition did not affect neither self-perception nor error-estimation. These findings are in contrast with Forbes et al.'s (2014) results, which suggested that minority group members rate their performance as lower, regardless of their actual error rate on a probabilistic learning task. A possible explanation of our findings is that participants have a clearer awareness of their performance in working memory task than in the probabilistic learning task, and therefore use this cue as a reliable reference point for their self-evaluation.

Several limitations of the current research are important to note. First, the sample is mainly composed by females and by people born in Italy, despite the country is by now a multi-ethnic nation. Individuals from different cultures may indeed endorse different attitudes and stereotypes toward obesity, and may be differently vulnerable to stereotype threat. Furthermore, the body weight distribution of our sample does not respond to the national body weight distribution (the majority of people were with obesity, whereas the Italian prevalence of obesity corresponds to 21.5%). These peculiarities could limit the generalizability of the results to the overall population. In addition, we have investigated experiences of weight stigma and weight-related attitudes, but we have not assessed neither the body weigh identification nor weight-based stereotypes application to the self.

Despite these limitations, study finding add to the incomplete understanding of factors associated with the low cognitive performance in people with obesity (for a review, see Prickett et al., 2015). Till now, literature explored only the role of physiological mechanisms and health status or educational level (e.g., Alchanatis et al., 2004; Cottrell et al., 2007; El-Ad & Lavie, 2005; McCarthy et al. 2002; Spruyt & Gozal, 2012; Vitelli et al., 2015; Wang et al., 2016), without considering the impact of socio-psychological factors. This study explored this dimension by testing the role of weight-related stereotype threat effect on executive functions. In particular, by focusing on working memory, we expanded the findings by Major et al. (2012), who tested the stereotype threat model in this population for the first time. Thus, the current research offers a contribution to both the research concerning cognitive functioning in the population with obesity, as well as to stereotype threat research. In addition, from a methodological point of view, the present research is an experimental study in which we included a control condition modelled upon standard procedures for cognitive assessment, thus providing a more compelling evidence of stereotype threat generalizability in ecological contexts.

III.6.4. Conclusion

In conclusion, the current results may be compared with findings from other stigmatized populations (e.g., women and math performance or ethnicity minority), in which the stereotype threat effect was previously demonstrated as a negative predicament affecting individuals' cognitive proficiency, regardless of their actual cognitive capacities. Stereotype salience emerged as a powerful factor that reduces the working memory proficiency in people with excess body weight, regardless of their personal experiences of weight-based discrimination, internalized weight-related attitudes, or manifest dissatisfaction for their body size.

IV. GENERAL DISCUSSION

Study 1 with children and Study 2 with adults explored whether stereotype threat effects may deplete working memory resources in individuals with obesity (as compared to those with average-weight), and whether this effect may be moderated by the experiences of weight-based stigmatization, weight-related attitudes, and body weight dissatisfaction.

Primarily, we should note that both studies confirm past findings by confirming that a negative relation exists between body weight and working memory performance in children as well as in adults. Furthermore, body weight positively relates with body dissatisfaction and experiences of weight-related discrimination, while no differences on weight-related attitudes were found according to the individuals' body mass index, this suggesting that either individuals with average weight or with excess weight are equally likely to internalize negative biases toward obesity.

However, the main contribution of the present study is to demonstrate that the reduced cognitive proficiency associated with increasing body weight only appears when the assessment is perceived by participants as diagnostic of cognitive efficiency, both in children and in adults. As regards children, our study represents the first evidence of weight-based stereotype threat vulnerability in a paediatric population, a phenomenon that was never explored and tested in the literature. Concerning Study 2, our findings with adults are in line with those from Major et al.'s (2012) study, and provide further evidence for the stereotype threat interference on cognitive efficiency in individuals with obesity. Specifically, the current study explored the effect of stereotype threat on working memory, i.e., the executive process at the core of the stereotype threat model. Each of the two studies offers a contribution to the literature concerning the relation body weight and cognitive function, as well as to the literature on stereotype threat.

Both study 1 and study 2 showed that experiences of weight-related discrimination, weight-related attitudes, and body dissatisfaction are not significant moderator of the relation body weight and working memory performance under stereotype threat. As previously discussed, it is possible that the impact of experience of weight-based discrimination, weight-related attitudes, and body dissatisfaction on individual's life changes according to other variables. For example, people that have developed efficient copying strategies to contrast weight-based discrimination are not affected by negative weight-related episodes. Similarly, people could endorse negative weight-based stereotypes, but not apply these negative attitudes to themselves. Also, individuals could recognise themselves as heavier than their ideal body weight, but could consider this dimension as not important in their identity definition, thus resulting less sensitive to stereotype threat effect. Future studies should take in consideration these results, and include these unexplored dimensions as control variables. For example, it could be appropriate to assess weight bias internalization via an Implicit Association Task (Greenwald et al., 1998), in order to determine whether people with obesity apply negative weight-based stereotypes on themselves at the implicit (and not necessary at the explicit) level. Adding specific measures to investigate copying strategies, level of resilience, body-weight self-esteem, and importance attributed to body weight, could add other important elements for further investigations. It might also be important to investigate the role of time spent in an excess-weight status: More time with obesity could mean more repeated experiences of weight-based discrimination, and also a higher sensibility to stereotype-threatening cues. Furthermore, it could be useful to investigate the effect of indirect sources of stigmatization on individual cognitive abilities: For example, what is the role of media messages? Could negative tv images associated with weight-based stereotypes have a deleterious impact on people cognitive abilities?

We have also explored, in Study 1, the role of anxiety as a mediator of the relation between body weight/ and working memory performance under stereotype threat, without finding support for its significant role. It is possible that this outcome is related to the low reliability of the instrument adopted for the anxiety assessment. Possibly, by using physiological measures of anxiety (e.g., cortisol level or skin conductance), we could obtain a different outcome. Further studies in this direction could be useful, in order to determine the role of test anxiety in the impairment of cognitive function. For example, past evidence suggests that the physiological stress responses (increasing of blood pressure, variability on heartbeat's frequency, index of galvanic skin reflex or cortisol level), that occur under stereotype threat (Schmader et al., 2008), are also evident in individuals with obesity exposed to stressful stigma-related experienced (Schvey et al., 2014; Tomiyama et al., 2014). Cortisol, for example, has a high concentration in hippocampus and prefrontal cortex (Blair, 2006; Metcalfe & Jacobs, 1998), two brain areas that may be involved both in the appraisal of stressful situations, and in the execution of tasks requiring executive control. In fact, hippocampus is related to spatial memory (e.g., Payne, Nadel, Allen, Thomas, & Jacob, 2002; Revelle & Loftus, 1990), a specific facet of performance intelligence that is damaged in individuals with obesity (e.g., Xiang & An, 2015; Li et al., 2008; Yu et al., 2010). Similarly, prefrontal cortex is associated to executive functions that are impaired in individuals with excess weight (Braet et al., 2007; Cserjési et al., 2007; Guxens et al., 2009; Miller et al., 2006; Smith et al., 2011; Prickett et al., 2015). Thus, future works could also investigate the pattern of physiological activation in individuals with excess weight who undergo a cognitive examination at different levels of stereotype salience. Alternatively, we could assess the anxiety level during the task performance by assessing the not-verbal behaviour (e.g., Bosson, Haymovitz, and Pinel, 2013).

Furthermore, future studies could explore also other dimensions related with weight-related stereotype threat, both as outcome and as control variables. Regarding possible moderators, future investigation may deal with depression. Depression has a high comorbidity with obesity (De Wit et al., 2010), and it has a negative impact on cognitive proficiency as well (Opel et al., 2015). Thus, we could hypothesize that people with depression could be more sensitive to negative environmental cues (Duque & Vázquez, 2015), and that weight-related stereotypes that remind of a negative evaluation about the self, could have a heightened impact on working memory performance. Another possible moderator is the participants' gender. Previous studies have showed that weight-based stereotypes are more easily attributed to women than to man (Azarbad & Gonder-Frederick, 2010). Our sample have a heterogenic distribution of males and females. Specifically, the study with children have more males with obesity than girls with obesity, whereas the study with adults involved more woman than men. However, in both studies, stereotype threat effect was significant. Future studies with more balanced samples may hopefully test the hypothesis that girls and women with obesity are more vulnerable to stereotype-threatening cues than men.

Furthermore, with the present studies we tested the effect of stereotype threat on working memory, but other investigation could also expand the applicability of the Stereotype Threat Model to a broader array of cognitive examinations, in particular to tasks that are more explicitly related to the measurement of "Intelligence", as intelligence is a key domain to which negative stereotypes about obesity apply. Furthermore, future studies may deepen the role of cognitive impairments observed under stereotype on the ability of individuals with obesity to plan and manage dieting and exercise behaviours. Previous studies have indeed demonstrated that stereotype threat reduces the ability of individuals with excess weight to exert control in these domains (Major et al., 2014; Pearl et al., 2015; Shentow-Bewsh et al., 2016). However, no cognitive aspects were considered in previous studies, and future studies could fill this gap. Finally, the link between reduced cognitive proficiency and reduced educational attainments in children and adults with obesity could be another focus for future studies. Literature shows that people with obesity have lower educational attainments, more frequent early interruption of their studies, and are also less encouraged to go on with studies. What is the role of stereotype threat in this direction? Because Major et al. (2014) showed that stereotypes could reduce the self-efficacy in observing a diet, future studies could test the hypothesis that stereotyped situation reduce the individuals' self-efficacy perception in reaching educational attainment. Future studies may deepen this area of investigation. Finally, we have explored the role of stereotype threat in children and adults, but we do not know what happens with adolescents, for whom body weight, relationships with peer, and engagement in the academic domain could have all a heightened importance.

These findings could have implications for clinical and educational practice. For example, in the treatment obesity programs could be useful to train people to develop the ability to manage weight-related stigmatization experiences. These interventions could deal with improving copying strategies in front of episodes of weight-based discrimination (for a review of coping strategies see, Li & Rukavin, 2009), or with strengthening self-esteem, self-efficacy, and individual's resilience. Furthermore, to buffer the negative impact of stereotype threat on working memory abilities, it could be useful to conduct a cognitive training to reinforce executive functions. This could have not only a positive impact on executive functioning, and consequently on the execution of complex social and cognitive tasks, but also on health status (e.g., Verbeken, Braet, Goossens, & Van der Oord, 2013), as past studies showed that lower executive control predicts weight-gain the following year (Groppe & Elsner, 2015). Educational interventions could be addressed to both adults and children in the overall population, in order to prevent and reduce negative stereotypes associated with obesity in the society at large.

In conclusion, the main findings from these studies suggest that the negative relation between excess obesity and cognitive functioning may be more complex than it appears, and that social-cognitive processes may inflating the gap in cognitive proficiency associated with excess weight. Also, individuals' actual experiences of weight-based discrimination, weight related attitudes, body dissatisfaction, as well as their level of anxiety when performing the tasks (limited to children), do not appear to play a relevant role, thus suggesting that all individuals with excess weight may be equally vulnerable to the hampering effects of negative stereotypes attached to their social group. These findings raise several queries for future investigations, to deepen our understanding of a variety of other consequences of weight-based stigma. These and other studies could indeed offer a strong empirical base for educational interventions addressing negative weight-based stereotypes and stigmatization against adults and children with excess weight.

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