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Body weight and its association with impulsivity in middle and old age individuals

Marilena Aiello[a,*], Elisabetta Ambron[b], Roberta Situlin[c], Francesco Foroni[d], Gianni Biolo[c], Raffaella I. Rumiati[a,e]

[a] Area of Neuroscience, SISSA, Trieste, Italy
[b] Laboratory for Cognition and Neural Stimulation, Dept. of Neurology, Perelman School of Medicine at the University of Pennsylvania, United States
[c] Department of Medical, Surgical and Health Sciences, Clinica Medica AOUTS, University of Trieste, Trieste, Italy
[d] School of Psychology, Australian Catholic University, Strathfield, NSW, Australia
[e] ANVUR, Roma, Italy

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ABSTRACT

Impulsivity, conceptualized as impulsive personality trait, poor inhibitory control and enhanced reward sensitivity, has been strongly linked to obesity. In particular, a disequilibrium between cognitive control and reward sensitivity has been observed in obese individuals in both behavioural and imaging studies. While this issue has been widely investigated in children and adults, it has received little attention in older adults. Here, obese and non-obese participants aged between 40 and 70 years completed the Barratt Impulsiveness scale (assessing motor, non-planning and attentional impulsiveness), a Go/no-go task with foods and non-foods (assessing inhibitory control) and a reward sensitivity battery with high and low caloric foods (assessing liking, wanting, tastiness and frequency of consumption). We observed that participants with higher BMI reported increased wanting for high calorie foods, but did not show poorer inhibitory control. Interestingly, participants who scored lower on the MMSE reported to consume high calorie more than low calorie foods. Finally, those who presented low scores on non-planning and motor impulsiveness subscales reported higher tastiness ratings for low calorie foods. These results show that increased reward sensitivity but not reduced inhibitory control may characterize higher BMI during aging. Importantly, they also highlight new findings concerning food preferences among older adults.

1. Introduction

Obesity is one of the greatest health challenges of this century, as it increases significantly the risk of chronic diseases, impairs and reduces quality of life. According to the latest European health interview survey (EHIS), conducted between 2013 and 2015, 1 in every 6 persons aged 18 or over in the EU was obese in 2014, proportions that seem to increase with age.

Eating behaviours and the ability to maintain a healthy diet and weight are influenced not only by metabolic, but also by non-metabolic factors such as cognition and motivation (Berthoud, 2011). Impulsivity, in particular, has received a lot of attention by neuroscientists. Impulsivity encompasses several aspects that have been divided into three categories (Guerrieri et al., 2007). First, impulsiveness may represent a personality trait. For instance, individuals scoring high on the Barratt Impulsiveness Scale tend to act without thinking (motor impulsiveness), fail to plan ahead (non-planning impulsiveness) and are not able to focus attention or to concentrate (attentional impulsiveness) (Fossati, Di Ceglie, Acquarini, & Barratt, 2001; Patton et al., 1995). Second, impulsivity may be conceptualized as a deficit in inhibitory control, consisting in the ability to supress prepotent actions in order to achieve a goal, typically assessed with go/no-go or stop-signal tasks (Bari & Robbins 2013). Finally, impulsivity may also be conceptualized as higher reward sensitivity. Reward sensitivity includes both liking (or consummatory pleasure) and wanting (or anticipatory pleasure). While liking refers to the pleasure associated with food consumption, wanting represents the motivational drive toward food (Berridge, Robinson, & Aldridge, 2009).

Obesity has been strongly linked to impulsivity (Lavagnino, Arnone, Cao, Soares, & Selvaraj, 2016; Bartholdy, Dalton, O'Daly, Campbell, & Schmidt, 2016). Obese individuals are impaired at performing tasks that assess inhibitory control (Lavagnino et al., 2016), tend to exhibit a higher food wanting than normal weight individuals (or a reduced food liking) (for a review see Ziauddeen, Farooqi, & Fletcher, 2012), and

* Corresponding author.
E-mail address: maiello@sissa.it (M. Aiello).

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score higher on self-report instruments assessing trait impulsivity (Meule & Blechert, 2016). The hypothesis that obesity may be characterized by a disequilibrium between cognitive control and reward sensitivity, which in turn produces impulsive food decisions, has also been supported by neuroimaging studies. Indeed, beyond brain circuits regulating hunger and satiety, different brain areas are involved in food consumption (Ziauddeen, Alonso-Alonso, Hill, Kelley, & Khan, 2015). Food activates brain reward circuitry including several limbic and cortical brain regions: among the others, the striatum, which is involved in food motivation, the amygdala, which processes the attentional salience of food, the orbitofrontal cortex and the anterior cingulate cortex, which represent the reward value of food (Chen, Papies, & Barsalou, 2016; Rolls, 2015). Moreover, food also activates several neurotransmitter systems, in particular the dopamine system, which modulates natural and artificial rewards and which has been associated with 'wanting' of food as opposed to 'liking' of food (Volkow, Wang, & Baler, 2011). Different brain regions involved in executive functions and cognitive control suppress the rewarding effects of food and are considered central for regulating unhealthy eating impulse (Chen et al., 2016). The dorsolateral prefrontal cortex, for instance, has been implicated in the control over food choices (see Hare, Camerer, & Rangel, 2009; Mengotti, Aiello, Terenzi, Miniussi, & Rumiati, 2018) and the "top down" cognitive influence on satiation (Thomas et al., 2015).

For what concerns obesity, neuroimaging studies report that, compared to lean individuals, obese show increased response in reward regions such as the striatum but decreased activation in areas involved in cognitive control including the dorsolateral prefrontal cortex (for recent studies see, Brook , Cedernaes, J., & Schiöth, 2013; Balodis et al., 2013; Opel et al., 2015). Importantly to note, decreased reward activation has also been reported and interpreted in favour of the reward deficiency hypothesis, according to which the reduced sensitivity toward food rewards may be compensated in obese individuals by overeating (Volkov et al., 2011). It has been proposed that this last aspect may characterize obesity when binge eating is present (Balodis et al., 2013).

While in recent years the relationship between BMI and impulsivity has been widely investigated in children and adults, this aspect has received little attention with regard to the middle or old age individuals (van Meer, Charbonnier, & Smeets, 2016).

Several studies have explored the association between executive functions and BMI in elderly. These studies have shown, however, conflicting results, with some reporting reduced executive functions in obese and other showing opposite effects (for a reviews see Smith, Hay, Campbell, & Trollor, 2011; Dahl and Hassing, 2012). Moreover, amongst these studies, only three have specifically evaluated aspects of inhibitory control trough the *Stroop Colour and Word test* or the *Wisconsin Card Sorting test*, showing that elderly with higher BMI exhibit a lower performance at these tasks compared to those with lower BMI (Waldstein & Katzel, 2006; Gunstad et al., 2007; Walther, Birdsill, Glisky, & Ryan, 2010).

Given the neurocognitive literature reviewed so far, and the cited studies on elderly, we may hypothesized that the same pattern, i.e. increased reward sensitivity and reduced cognitive control may characterize also older obese. At the same time, reduced striatal activity during the anticipation and processing of rewards has been observed during aging (see for instance Eppinger, Nystrom, & Cohen, 2012), together with a decline of inhibitory control (Sebastian et al., 2013). These changes may affect reward sensitivity and inhibitory control toward food in this age group, and we may expect to see an increased inhibitory control deficits and a reduced reward sensitivity toward foods in those with obesity.

To investigate this issue, we assessed the relationship between BMI and impulsivity (conceptualized as a personality trait, poor inhibitory control and higher reward sensitivity) in obese and non-obese participants aged between 40 and 70 years. Here, we excluded participants over 70 because this age range is often characterized by body weight loss and sensorial disturbances that are likely to influence eating behaviours (Alibhai, Greenwood, & Payette, 2005). Since the number of obese individuals is likely to increase with aging, many health problems associated with obesity, such as diabetes, cognitive decline, and cardiovascular disease are also expected to increase. Therefore, a better comprehension of mechanisms related to body weight in these individuals is crucial.

2. Methods

2.1. Participants

Thirty participants took part in the study. The mean age was 58.43 (SD 9.52), range 42–70, while the mean BMI was 31.94 kg/m^2 (SD 8.05), range 21.91–49.50. Specifically, 8 participants were categorized as normal weight (BMI 18.5–24.9), 6 as overweight (BMI 25–29.9), and 16 as obese (BMI ≥ 30). All participants had a normal cognitive status (MMSE mean 29.33 SD 0.99 range 26–30) and were also screened for major depression (BDI mean 5.60 SD 5.98 range 0–21). Exclusion criteria for all participants were the presence of clinical history of neurological/psychiatric disorders, history of alcohol and/or drug abuse, and diabetes. Table 1 summarizes participants' demographic and clinical information. Obese participants, recruited in collaboration with the 'Clinica Medica Ospedale Riuniti di Trieste', were assessed before beginning the nutritional treatment to control body weight. The SISSA Ethical Committee approved the study and all participants provided written informed consent.

2.2. Procedure

The participants in this study were tested in a state of satiation. They were instructed to eat before the participation in the experiment. Upon arriving, after providing informed consent, they rated their current state of hunger on a seven-point Likert scale, in order to confirm they were in a satiated state. Participants then underwent the Mini Mental State Examination (MMSE, Measso et al., 1993) and they filled in the Beck Depression Inventory (BDI, Beck, 1967). Afterwards, they completed the following questionnaires and tasks:

The Barratt Impulsiveness Scale (BIS-11; Fossati et al., 2001). The BIS-11 contains 30 items and has three subscales: attentional impulsiveness (AI, i.e., a tendency to rapid shifts in attention), motor impulsiveness (MI, i.e., a tendency to rash, immediate actions), and non-planning impulsiveness (NP-I, i.e., a tendency to not plan ahead and to ignore long-term consequences of one's actions). Higher scores represent higher impulsivity.

Go/no-go task (Aiello, Eleopra, Foroni, Rinaldo, & Rumiati, 2017). The target stimuli ("go stimuli") appeared in 75% of the trials, and nontargets ("no-go stimuli") appeared 25% of the times. Participants were asked to press the spacebar as fast as they could without making

Table 1
Demographical and clinical data.

	Mean	*sd*	*Range*
Age	58.43	*9.53*	42–70
Education	11.27	*3.02*	8–18
MMSE	29.33	*0.99*	26–30
BMI	31.94	*8.05*	21.9–49.5
BDI	5.60	*5.98*	0–21
BIS	62.37	*12.33*	40–85
Attentional (AI)	16.57	*3.63*	10–24
Motor (MI)	20.17	*3.29*	15–28
Non Planning (NP-I)	24.93	*4.00*	18–36

Note. MMSE = Mini Mental State Examination; BMI = Body Mass Index; BDI = Beck Depression Inventory; BIS = Barratt Impulsiveness scale; AI = Attentional impulsiveness; MI = Motor impulsiveness; NP-I = Non-planning Impulsiveness. In italics, standard deviations (sd) and ranges for each variable.