Decisional Impulsivity in Obesity

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Abstract

Introduction: Elevations in impulsivity have been clearly shown in various psychiatric conditions, especially in those of addiction. Evidence does suggest some overlap between the pathological use of food and drugs but no clear evidence to date has been made available with regards to obesity. In this study we hypothesize that obese subjects would have relatively more impulsive profiles when compared to healthy volunteers.

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Method: Delayed discounting is also studied by means of the Monetary Choice Questionnaire, also hypothesizing impairments in this subtype of impulsivity.

Results: Obese subjects sought less evidence prior to making a decision when compared to healthy controls. Greater delayed discounting was also evident in this cohort of subjects as compared to healthy ones. Premature responding was not shown to occur in the obese subjects.

Conclusion: Obesity is therefore characterized by impaired reflection impulsivity and greater delayed discounting. Both suggest a deficit in deciding on the basis of future outcomes that are more difficult to represent. This evidence could suggest possible therapeutic domains which need targeted interventions on the aspects of decision making deficits.

Key words
Impulsivity, Obesity, Addiction

Introduction

Obesity is a major international public health issue. The mechanism underlying obesity is complex and heterogenous, including, but not limited to, metabolic, genetic, inflammatory and neurocognitive contributions. The question of self-control, or the ability to control our impulses is highly relevant to pathological eating behaviours. Impulsivity is a heterogeneous construct with discrete but overlapping neural substrates.[1] Impulsivity can be divided into decisional and motor subtypes. Decisional impulsivity is further divided into reflection impulsivity (the amount of information gathered before taking a decision) and delay discounting (a measure of subjective discounting of a delayed reward). Motor impulsivity divides into motor response inhibition and premature or anticipatory responding.[2]

Here we focus on assessing impulsivity in an adult population in Malta, a country highlighted as having one of the most obese populations

worldwide. In the 2009 Eurostat statistics, among the 19 European Union Member States for which data are available, the proportion of obese people in the adult population varied in 2008/9 between 8.0% (Romania) and 23.9% (UK) for women and between 7.6% (Romania) and 24.7% (Malta) for men.[3]

Converging studies have linked obesity with impaired delay discounting. Overweight and obese participants exhibited higher temporal discounting rates than underweight and healthy weight participants. A higher body mass index (BMI) was also strongly correlated with greater delay discounting.[4] Delay discounting is also correlated with clinical severity of BMI and depression, with greater discounting related to both disorders specifically for choices of comfort foods (i.e., the dessert and fried food).[5] Moreover, a higher discount rate is also predictive of higher calorie intake in obese women and children, and poorer treatment outcomes with less weight loss following intervention. Changing this concern with immediate reward into a more future-oriented outlook could therefore be useful in order to promote the choice of healthy foods and thereby facilitate a healthy weight. Behavioural interventions such as episodic future thinking rather than focusing on the immediate reward has been shown to reduce discount rates in obesity.[6]

In contrast, to delay discounting, only one study has investigated reflection impulsivity in obesity. Obese subjects with and without binge eating disorder (BED) were tested on the Information Sampling Task (CANTAB) with obese subjects without BED showing impairments in integration of available information in the cost condition.[7] Here we intend to use the Beads Task to test reflection impulsivity in obesity and has been shown to differ from the Information Sampling Task.[8] In the task, subjects sequentially view beads selected from jars with differing proportions of red and blue beads which has been shown to be associated with greater reflection impulsivity in substance use disorders, pathological gamblers[9] and binge drinkers.[8]

We have previously shown that neither obese subjects with or without BED were impaired in waiting impulsivity tested on the 4-Choice Serial Reaction Time task, whereas subjects with substance use disorders (abstinent alcohol and methamphetamine dependence, current cannabis and nicotine users, and binge drinkers) showed greater waiting impulsivity relative to healthy controls.[2] As this previous study assessed subjects with lower BMIs ; 34.68 and obese BED and 32.72 in Obese control, we sought to assess this measure in a group with higher BMIs. We hypothesized that obese subjects would have greater decisional impulsivity with higher delay discounting and greater reflection impulsivity relative to healthy controls.

Methods
Recruitment

Subjects with BMI of 30 or higher were recruited in Malta from an eating disorders unit ('Fondazzjoni Kenn Ghal Sahhtek'). Obese subjects were also screened for BED using the DSM-V criteria for BED. Age- and gender-matched healthy volunteers with a BMI of 26 or less were recruited via local advertisement.

The inclusion criteria included subjects who were either male or female English speakers, aged between 18-75 years. They also had to be deemed capable of giving a written informed consent. The exclusion criteria included, subjects with a history of severe neurological deficit or head injury. A clinical diagnosis of a significant DSM Axis one mental disorder, (e.g. schizophrenia, bipolar disorder, substance dependence) was also excluded. Subjects with a current major depression of moderate severity were excluded.

The study was approved by both the Cambridge Research Ethics Committee and the Malta Health Ethics committee. Written informed consent was obtained from all participants and reimbursement was given for their participation.

Questionnaires and tasks

Subjects completed the Alcohol Use Disorders identification test (AUDIT)[10] and Beck Depression Inventory.[11] Trait impulsivity was measured by the UPPS-P Impulsive Behaviour Scale[12] and the Spielberger State and Trait Anxiety Inventory.[13] Impulsive choice was assessed using the Monetary Choice Questionnaire[14] and reflection impulsivity was assessed using the beads task. Premature responding or "waiting impulsivity" was investigated by the 4 choice serial reaction time task. The latter is a novel translation of the task, based on the rodent 5-choice serial reaction time task, testing premature responding in disorders of

drug and natural food rewards.[2]

Beads task

Subjects were shown two jars on the computer screen with opposite ratios of red and blue beads (Jar 1: $P=0.80$ red; $P=0.20$ blue/Jar 2: $P=0.80$ blue; $P=0.20$ red) (Fig. 1). They were informed of the bead ratio and were told that beads from one of the jars would be presented one at a time in the centre of the screen. The subjects' goal was to infer whether the beads were drawn from Jar 1 or Jar 2. The subjects were free to view as many beads as they wanted to a maximum of 20 beads before committing to their decision. The decision was followed by a confidence rating in which subjects used a mouse to indicate the degree of confidence that their answer was correct, on a line anchored at 'Not confident' to 'Very confident'. Subjects were then informed that the next block would start. There was no feedback. The task was controlled for working memory by showing the coloured beads drawn across two rows at the top of the screen. There was no time limit to the task. The primary outcome measure was the number of beads drawn prior to a decision. There were three blocks of trials with the same bead order used in a previous study.[15]

Figure 1:

Beads task. Subjects viewed two jars with opposite ratios of red and blue beads (Jar 1: P=0.80 red; P=0.20 blue/Jar 2: P=0.80 blue; P=0.20 red). Beads selected from a single jar were sequentially shown to the participants. The goal was to infer from which jar the beads were being selected. After each bead was drawn, participants either chose to draw another bead or to make a decision. The drawn beads remained on display at the top of the screen. (Banca et al., 2015)
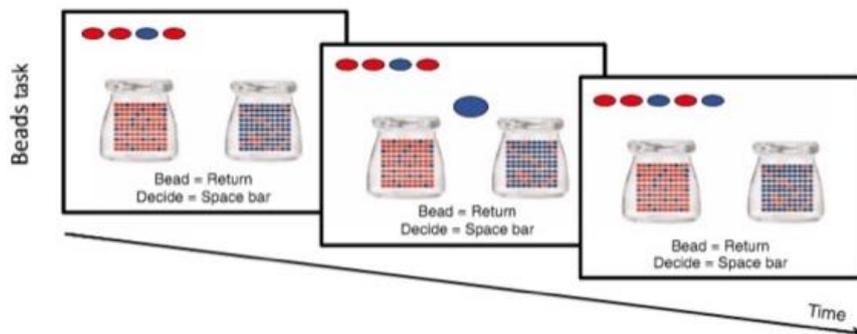
Delay discounting task

Delay discounting was measured using the Monetary Choice Questionnaire[14], composed of 27 items, in which participants choose between a small immediate reward and a larger delayed reward. The primary outcome measure was the discount parameter K.

Premature or Anticipatory Responding

Subjects were seated in front of a touch screen (a Paceblade Tablet personal computer; Paceblade Technology, Amersfoort, the Netherlands). When four boxes appeared on the screen, the subject pressed and held down the space bar on the keyboard with their dominant index finger.

The space bar press indicated the "cue onset" time. After a specified period (cue-target interval), a green circle target appeared briefly and randomly in one of the four boxes. Subjects released the space bar and touched the box on the screen in which the target had appeared. The primary outcome measure was premature release of the space bar before target onset.

The block order was as follows: Baseline block 1; Test block 1; Baseline block 2; Test blocks 2–4. Baseline blocks without monetary feedback were used to individualize monetary feedback amounts for subsequent blocks on the basis of the mean fastest reaction time (RT) and SD of the individual. The four Test blocks with monetary feedback were optimized to increase premature responding and varied by duration and variability of the cue-target interval and the presence of distractors. *It was programmed in Visual Basic with Visual Studio 2005 and Microsoft .NET Framework 2.0 (Microsoft, Redmond, Washington) with the Euro currency for testing in Malta. Total task duration was 20 min.[2]*

Premature responding task. (A) Task. Subjects press and hold down the space bar when they see four empty boxes (Cue) on the touch screen. After a green circle (Target) appears in one of the boxes, the subject releases the space bar and touches the box in which the target had appeared. The main outcome measure, premature responding, is measured as release of the space bar before target onset. (B) Feedback for the Test blocks is individualized on the basis of the mean fastest reaction time (RT) and SD obtained in the Baseline block (Voon et al., 2014)
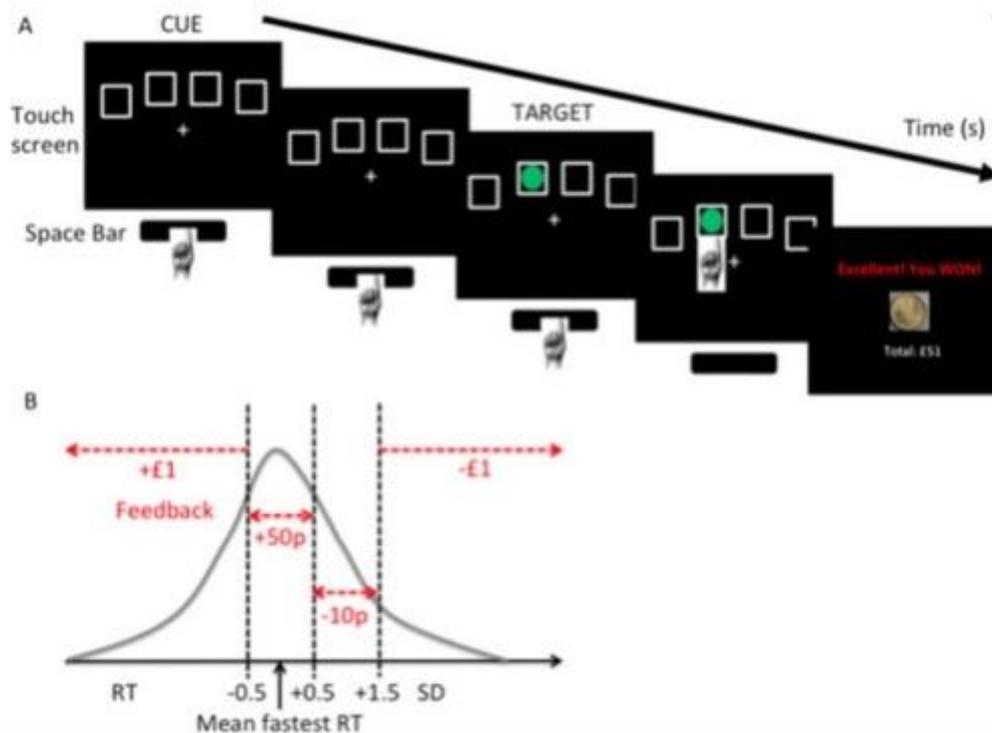
Statistical analysis of behavioral outcomes

The data were inspected for outliers (>3 SD from group mean) and for normality (Shapiro-Wilkes test $p>0.05$). As all the primary outcome measures were not normally distributed, they were analyzed using non-parametric independent samples Mann-Whitney U tests.

Results

Thirty obese subjects (age 36.46, SD=10.13) and 30 age- and gender-matched healthy volunteers (age 34.66, SD=9.39, t=.71, p=.47) were included in this study. Individuals with obesity had a mean BMI of 49.06 (SD=11.67) and HVs of 21.86 (SD=4.72, t=11.82, $p<.0001$). The male to female ratio was that of 8:22 for each group.

14 out of 30 obese subjects fulfilled criteria for BED. Compared to HVs, obese subjects reported significantly higher scores on depression

(t=4.53, $p<.0001$), anxiety (t=3.49, p=.001), binge eating (t=6.08, $p=<.0001$) and impulsivity (t=3.06, p=.003). There were also statistically significant differences in binge eating disorder traits (t=6.08, $p=<.001$). However, no statically significant differences were notes with regards to drinking habits (t=-.74, p=.46) and obsessive compulsive disorder (t=1.78, p=.07).

Jumping to conclusions

Obese subjects required fewer beads prior to decision (greater impulsivity or lower evidence accumulation) (p=0.047) (Figure 3). There were no differences in the objective probability at the time of decision (Obese: 0.82 (SD 0.20); HV: 0.83 (SD 0.18), p=0.641) or in subjective confidence (Obese: 385.15 (SD 116.60); HV: 394.73 (SD 135.29), p=0.605).

Table 1: *shows the descriptive data and t-test differences for the obese and healthy subjects included in the study.*

|	Obese (N=30)	HVs (N=30)	T test	P value
Age	36.46 (10.13)	34.66 (9.39)	.71	.47
Males:females	8:22	8:22		
BMI	49.06 (11.67)	21.86 (4.72)	11.82	<.0001
BDI	20.26 (11.47)	7.73 (9.88)	4.53	<.0001
SSAI	51.30 (13.21)	39.93 (11.93)	3.49	.001
BES	20.96 (10.48)	6.83 (7.21)	6.08	<.0001
AUDIT	3.50 (4.50)	4.33 (4.19)	-.74	.46
OCI-R	23.40 (11.37)	18.30 (10.70)	1.78	.07
UPPS total	137.93 (20.09)	121.65 (20.66)	3.06	.003

Figure 3*: Jumping to conclusions*
The graph shows the primary outcome measure, the number of beads viewed prior to decision in Obese subjects and matched healthy volunteers (HV)
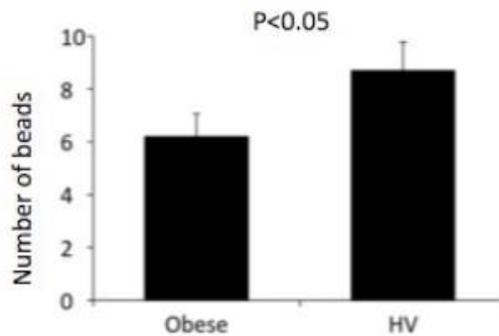
Figure 4: Delay discounting and premature responding
The left graph shows the primary outcomes of the delay discounting task and right shows the 4-Choice Serial Reaction Time task (4-CSRT).
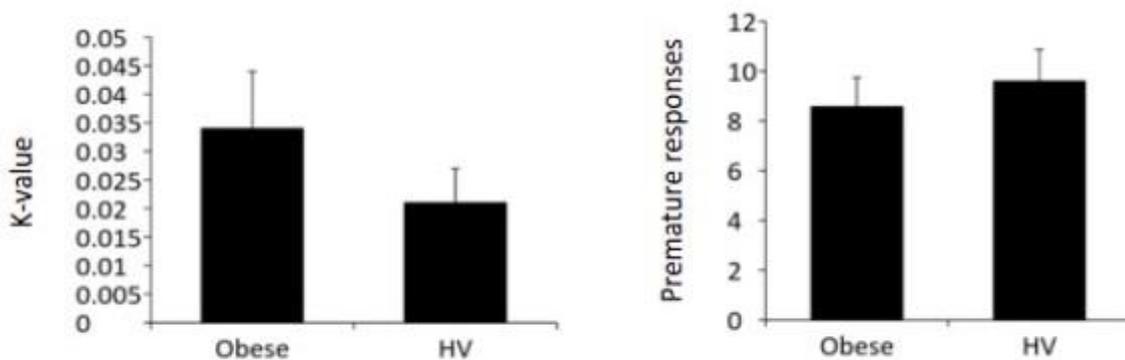
Delay discounting

There was a trend towards greater discounting of delayed rewards or greater impulsivity in obese subjects compared to HV (Obese: 0.034 (SD 0.057); HV 0.021 (SD 0.034), *p*=0.054) (Figure 4). Data from 3 Obese subjects and 4 HV were removed as outliers (>3 SD from group mean).

Premature responding

There were no group differences between Obese subjects and HV in premature responding (Obese: 8.86 (SD 6.23); HV: 9.60 (SD 6.93), *p*=0.691) (Figure 4). Data from 2 Obese subjects were removed as outliers (>3 SD from group mean).

Discussion

We show that obese subjects relative to non-obese controls accumulate less evidence prior to decision making along with a trend towards enhanced delay discounting. No differences were observed between groups in waiting impulsivity. These findings emphasize impairments in decisional impulsivity and confirm previous findings of a lack of a difference in waiting impulsivity despite testing a population with higher BMIs in this current study[2]

In this study we show using the Beads task that obese subjects demonstrate a reduced tendency towards collecting salient information from the external environment before making a decision. In a previous study, obese subjects with or without BED tested using the Information Sampling Task (IST) did not show any differences in the amount of evidence sampled. Obese subjects without BED did show impaired integration of information to optimize outcomes over later trials within a cost condition.[7] The divergent findings between the two tasks highlight differences between the tasks or may reflect the higher BMI in the current group under study.

The IST and beads task test similar concepts. However, dissociation of results given by both tests may occur. A similar dissociation has been shown in studies in schizophrenia as subjects showed consistent impairment in the beads task while no differences between first episode psychosis patients and healthy volunteers were shown on the IST.[16] The disparity is likely to be a function of task differences. The IST presents information in a very explicit manner as it makes use of a 5x5 grid showing the total amount of information available to be sampled as a constant reminder. The latter may possibly act as an explicit external relative anchor and encouraging 'thinking ahead' of all possibilities, thus giving an overall representation of the task. In contrast, in the beads task subjects are not explicitly reminded that they can only choose 20 beads as this is only mentioned in the instruction phase. This makes the information less visually explicit. This makes it possible that individuals are less likely to always consider all options and thus may result in more impulsive decisions. Therefore, although the IST maybe more transparent and reduce uncertainty of the end point or total available information, the beads task maybe more ecologically valid as the total information available is not always explicitly known to the subject user.[8]

Secondly, in the beads task, bead sequences are generated from jars of known probabilities whereas in the IST, the generative probability distribution from which colored boxes are sampled is unknown. Thus, evidence is sampled from differing known probabilities. It may soon become apparent to participants that this generative probability is close to 50:50, pushing them towards caution. This may lead to subjects having an easier probability structure but more vague task structure which in return increases sensitivity to impulsive decisions. Thirdly, differences in monetary rewards are unlikely to explain different task results. In the fixed win condition, the IST is associated with winning points if correct while the beads task offers no explicit reward.[8]

In this study we find a trend supporting previous findings that obese subjects are more likely to choose the immediate, yet smaller reward.[4] Using the monetary choice questionnaire we show that obese subjects have a trend towards higher temporal discounting rates than healthy volunteers. Together this suggests the need to develop effective therapeutic interventions aimed at training individuals in the consideration of the future consequences.

We did not show differences in waiting impulsivity or premature responding in the obese subjects consistent with our previous study[2] suggesting that differences in BMI were unlikely to account for the lack of difference in this measure.

We show that decisional impulsivity is impaired in obesity. These two tasks might be

linked by impairments in the ability to link action with future outcomes in the face of uncertainty. These findings highlight a critical role for decisional impulsivity in obesity. Future work on the role of reflection impulsivity as a predictor for treatment outcome and as a target for therapeutic modulation are indicated.

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