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An investigation of decision making in anorexia nervosa using the Iowa Gambling Task and skin conductance measurements

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Abstract

The objective of this study is to determine (a) if decision making ability is impaired in patients with anorexia nervosa (AN) and in people with good recovery from AN and (b) whether any impairment in decision making is associated with alterations in skin conductance responses (SCR). Patients with AN ($n = 29$), healthy controls comparable in age and IQ (HC, $n = 29$), and women long term recovered from AN ($n = 14$), completed the Iowa Gambling Task (IGT) while their SCR were measured. AN patients performed poorly in the IGT compared to the HC and to the recovered AN participants. AN patients had decreased anticipatory SCR prior to choosing cards and reduced SCR after losses compared to HC. IGT performance and the SCR of recovered AN participants did not differ from the HC. Decision making ability is impaired in AN. It is associated with a significantly attenuated SCR. Neither of these features are found in recovered AN. The association between impaired decision making ability and a decreased autonomic response is consistent with the predictions of the Somatic Marker Hypothesis. (*JINS*, 2007, *13*, 635–641.)

Keywords: Eating disorders, Recovery, Neuropsychology, Biological markers, Iowa Gambling Task, Galvanic skin response

INTRODUCTION

Neuropsychological studies have reported small, but significant, impairments in cognitive function in anorexia nervosa (AN) (Green et al., 1996; Southgate et al., 2005; Tchanturia et al., 2004 Tchanturia et al., 2005). Furthermore, AN-like symptoms occur in association with damage to the frontal cortex (Uher & Treasure, 2005). Functional neuroimaging studies involving symptom provocation (e.g. exposure to food pictures) have reported abnormal activity in the ventromedial prefrontal cortex in patients with AN (Uher et al., 2003; Uher et al., 2004). These various studies suggest that in AN, there are changes in cognitive performance and associated alterations in prefrontal cortical function (Kaye et al., 1984; Kaye et al., 2000). It is still a matter of debate whether alterations in cognitive performance in AN are state or trait as some, but not all, studies have reported that impairments persist in recovered individuals (Roberts et al in press, Uher et al., 2003).

A neuropsychological investigation using the Iowa Gambling Task (IGT) reported that people with AN have poor decision making ability (Cavedini et al., 2004). The IGT was designed to capture the inability of individuals with damaged ventromedial prefrontal cortex to make adaptive decisions when presented with complex choices (Bechara et al., 1997; Bechara et al., 1999). One factor reported to distinguish people who perform well on the IGT from those who perform poorly is whether there is a rise in skin conductance prior to making high-risk decisions (Bechara et al., 1997). This relationship between the anticipatory skin conductance response and IGT performance provides support for the "Somatic Marker Hypothesis" (Damasio, 2004). This hypothesis postulates that adaptive decision making is influenced by emotional responses *via* feedback from autonomic somatic changes (somatic markers).

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Based on the various findings described previously, the present study tested the following hypotheses: (a) decision making ability (as measured by IGT performance) is impaired in patients currently ill with AN; (b) decision making ability is impaired in people who have recovered from AN (ANR); and (c) impaired decision making ability is associated with diminished anticipatory skin conductance responses (SCR) to high risk choices in the IGT.

METHOD

Participants

Twenty-nine women currently fulfilling the DSM-IV criteria for AN were recruited from the outpatient and inpatient services of the South London and Maudsley NHS Trust; 23 of these were of the restrictive subtype and 6 were of the binge-purge subtype. The diagnosis was established using the Structured Clinical Interview for DSM-IV (SCID) Axis I and II.

A group of women ($n = 14$) long recovered from AN (ANR), 11 restrictive and 3 binge purge subtype, were recruited from a volunteer database maintained by our Eating Disorders Research Unit. Body mass index (BMI), calculated as Weight in kg/[height in m]^2, was obtained on the test day from all participants. Criteria for recovery were, a BMI in the healthy range (20–25) and at least one year of regular menstruation. The mean duration of maintenance of normal weight in the ANR group was 6.3 years ($SD = 3.8$).

Healthy controls ($HC = 29$) were recruited by advertisement in local libraries, leisure centers, shops and newspapers. Exclusion criteria were, a history of head injury, epilepsy, or psychosis. For the *HC*, additional exclusion criteria were a family history of psychiatric conditions, current medication, low BMI (<20), positive answers to screening questions regarding strict dieting, over-exercising, bingeing, vomiting, or laxative abuse. Of the participants who responded to the invitation, 5 were excluded (two from the control and three from the recovered AN groups) because they did not meet the inclusion criteria. Participants were all women and native English speakers; 96% were white.

Ethical approval was obtained from the South London and Maudsley NHS Trust Research Ethics Committee. Following a full description of the study, written informed consent was obtained from all participants.

The Iowa Gambling Task

The Iowa Gambling Task (IGT) is a method of testing the ability to sacrifice immediate rewards in favor of long term gain (Bechara et al., 1997). Participants are required to choose from 4 decks of cards (100 cards in total) with the aim of achieving monetary gain. In each deck, there are the same proportions of losing and winning cards. Two decks are disadvantageous (high-risk, A and B): these give high rewards for the winning cards but very high losses for the losing ones; overall, losses outweigh gains. The other two decks are advantageous (low-risk, C and D): these give lower rewards and lower losses: overall gains are higher than losses. Healthy control participants are initially attracted by the rewards of the high-risk decks but over time learn to choose from the low risk decks. A computerized version of the IGT was used. The cumulative result was depicted by a growing/shrinking credit bar on the bottom of the screen. Participants selected cards using a computer mouse. Instructions for the task were identical to those used in the original study (Bechara et al., 1999): these were read out and included the information "You may find yourself losing money on all of the decks, but some decks will make you lose more than others. You can win if you stay away from the worst decks."

Skin Conductance Measurements

Recording of skin conductance was commenced at least 10 minutes before the start of the IGT and continued throughout. Two silver chloride disc electrodes (SLE Diagnostics, Surrey, UK) were attached to the palm surface of the second phalanx of the index and middle fingers of the nondominant hand using adhesive rings. A PSYLAB SC5 25-bit digital amplifier relayed the signal to a PSYLAB standalone-monitor (SAM) unit (Contact Precision Instruments UK, London) and a host PC running the PSYLAB7 software. To ensure adequate time for measurement of skin conductance responses (SCR), a minimum 6 second interstimulus interval was imposed between card picks, following the method of Bechara et al. (1999). This timing enables the SCR to be divided into a "response" and an "anticipatory" phase for each card selection, with the 5 second following each card pick constituting the response phase, and the remaining time (variable but at least 1 second) before the next card selection constituting the anticipatory phase. For each response SCR, all fluctuation amplitudes in the 5 seconds following a card pick were summed to give the total response amplitude for that card selection. For each anticipatory SCR, the largest fluctuation amplitude was taken as an index of the anticipatory SCR. Details of the analysis are reported elsewhere (Lawrence et al., 2006).

Additional Measures

The National Adult Reading Test (NART) (Nelson & Willison, 1992) was used to provide an estimate of IQ. In addition, the following self report instruments were administered to all participants: the eating disorder examination questionnaire (EDEQ) (Fairburn & Beglin, 1994); the Beck depression inventory (BDI) (Beck et al., 1961).

Data Analyses

All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 12 for

Windows. Demographic variables were compared using one-way analysis of variance (ANOVA).

For the IGT performance, the 100 card selections were divided into 5 blocks of 20, and the numbers of selections from disadvantageous and advantageous decks were counted for each block (Bechara et al., 1999). The net score for each of the five blocks was calculated as the difference in the number of cards selected from the advantageous and the disadvantageous decks [(C+D) − (A+B)]. A 5 × 3 repeated measures ANOVA was carried out with net scores from the five blocks as the repeated measures and three diagnostic groups (HC, AN, ANR) as the between subject variable.

Anticipatory SCRs were analyzed using repeated-measures ANOVA with deck (advantageous *vs*. disadvantageous) as within-subject, and group (AN, HC, ANR) as between-subject factors. Response SCRs were compared using repeated measures ANOVA with deck (advantageous *vs*. disadvantageous) and reinforcement (win *vs*. loss) as repeated measures, and group as between-group factors. Relationships between IGT performance, SCR, and aspects of psychopathology from self-report measures were explored using bivariate Pearson correlations.

RESULTS

Sample Characteristics

Demographic and clinical data are presented in Table 1. The three groups were matched for gender, age, education and estimated IQ (NART). Group differences in BMI were as expected (AN < ANR < HC). Illness duration was longer and lowest-ever BMI was lower in the AN patients than in the ANR group. Both AN and ANR groups were predominantly restrictive and the proportion of the binge purge subtype was small (20% in the AN and 21% in the ANR group). Demographic characteristics and clinical severity indicators did not differ between those with the restrictive and binge purge subtypes. In the AN group, 13 patients were on SSRI antidepressants (44%). None of the ANR group was on medication.

As expected, EDEQ scores were highest in the AN group; the ANR group did not significantly differ from the HC group. Scores of depressive symptoms measured by the BDI were highest in the AN group compared to both the HC and the ANR groups.

IGT Performance

Figure 1 shows the performance of the three groups on the IGT. Repeated measures ANOVA with block (5 levels) by group (3 levels) shows a main effect of block, [$F(1,69) = 12.2$; $p = .001$], meaning that overall, learning occurred during performance of the test. The main effect of group is significant [$F(2,69) = 3.16$; $p = .05$] and post-hoc LSD tests (exploring factors contributing to the main effect of groups) show that there is a significant difference between HC and AN groups ($p = .05$) and the ANR and AN groups ($p = .03$), but no difference between the HC and ANR groups ($p = .59$). There is no significant block × group interaction.

Skin Conductance Response

Anticipatory SCR—This data is represented in Figure 2. Repeated measures ANOVA with group (HC, AN, ANR) by decks (advantageous, disadvantageous) shows a main effect of group [$F(2,68) = 3.37$; $p = .04$] indicating that the groups were different in their SCR prior to choosing from the decks. The post-hoc LSD tests for group indicate that the AN group generated lower anticipatory SCR ($p = .02$) in comparison to the HC, but there is no difference between the AN and ANR groups ($p = .11$) or between the HC and ANR groups ($p = .72$). The main effect of deck and group by deck interaction were non-significant. Response SCR to win and loss-repeated measures ANOVA with within subject factors deck (advantageous, disadvantageous) and reinforcement (win, loss) and between subject factor group (HC, AN, ANR) shows significant main effects of deck (disadvantageous > advantageous $F(1,68) = 6.32$; $p = .01$), reinforcement (loss > reward $F(1,68) = 12.77$; $p = .001$), and group

Table 1. Demographic and clinical characteristics of study participants

Number of participants	AN ($N = 29$)	HC ($N = 29$)	ANR ($N = 14$)	F	p
Age	28.5 (9.17)	26.3 (7.9)	28.9 (7.4)	.708	.496
Years of education	15.3 (3.1)	16.3 (2.6)	16.2 (2.6)	.951	.391
IQ estimated	115.2 (5.5)	114.0 (9.3)	118.1 (5.7)	1.425	.248
BMI	15.5 (1.3)	22.1 (2.4)	20.3 (1.9)	87.874	.000
Duration of Illness (years)	8.2 (5.2)	N/A	5.0 (3.4)	35.977	.001
Lowest BMI	11.9 (1.3)	19.5 (2.5)	14.2 (2.2)	75.884	.000
EDEQ total	23.0 (8.6)	4.9 (4.8)	8.0 (5.8)	54.297	.000
Beck Depression Inventory (BDI)	28.6 (11.5)	5.0 (4.7)	9.7 (8.2)	58.17	.000

Female AN Patients Healthy Controls (HC) and long term recovered AN (ANR).
Means and standard deviations are provided. N, number of participants; BMI, body mass index; EDEQ, Eating Disorder Examination Questionnaire. Statistically significant differences are shown in bold under p values.

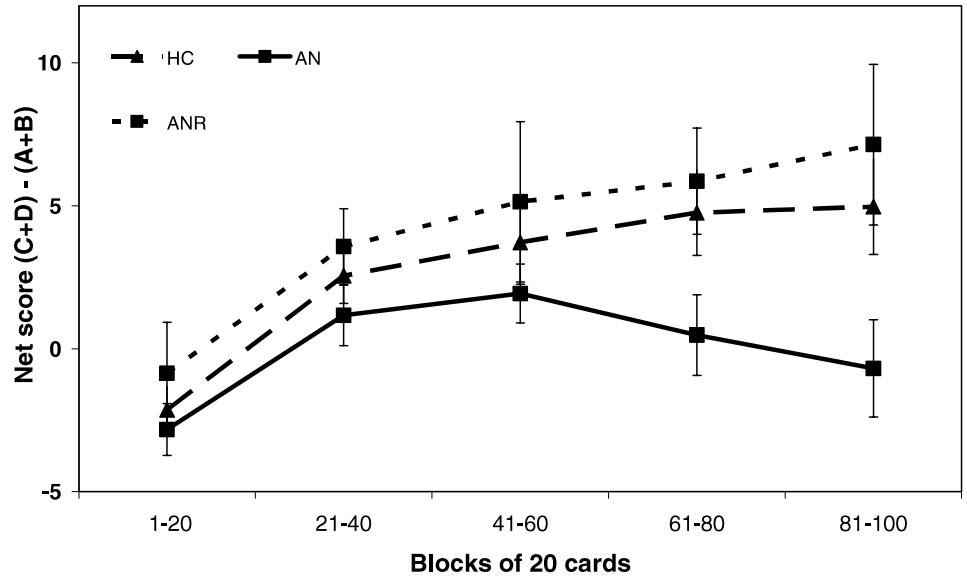

Fig. 1. IGT performance in HC, AN and long term ANR groups. The error bars represent one standard error of the mean.

($F(2,68) = 3.93$; $p = .02$). The LSD post-hoc tests for group show a significant difference between the HC and AN groups (HC > AN; $p = .01$), but no other group differences (ANR/AN; $p = .09$, HC/ANR; $p = .68$). The interaction between group, deck, and reinforcement was non significant $F(2,68) = 1.6$; $p = .21$). The interaction of group × reinforcement approached significance ($F(2, 68) = 2.93$; $p = .06$), suggesting the group membership differentially moderates the SCR to wins and losses. In particular, post hoc comparison showed that the AN group demon-

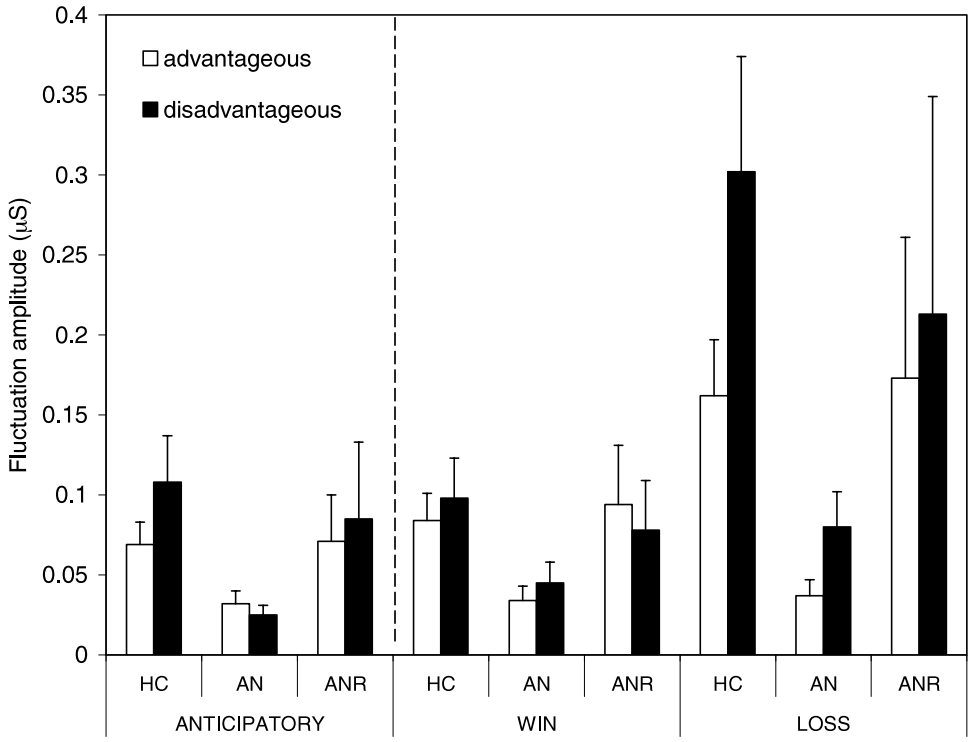

Fig. 2. Anticipatory skin conductance responses (ASCR) to advantageous (low risk) and disadvantageous (high risk) cards and skin conductance response to (win/loss) card selections from the advantageous (C+D) and disadvantageous (A+B) decks.

strated significantly lower SCR to losses compared with HC group ($p = .008$) in the disadvantageous and advantageous decks.

Correlation Analysis

To explore associations between IGT performance, SCR and depression, we conducted a two-tailed Pearson correlation analysis. Across all groups, the following SCR measures show a correlation with IGT performance: anticipatory SCR on advantageous decks ($r = .33$, $p = .004$), anticipatory SCR on disadvantageous decks ($r = .30$ $p = .01$), loss response SCRs in advantageous decks ($r = .27$, $p = .02$), and loss response SCRs in disadvantageous decks ($r = .26$, $p = .03$). SCRs in response to wins did not correlate with the IGT score.

Correlation analysis conducted across all groups show a significant negative association between Depression scores and IGT performance ($r = -.283$, $p = .02$).

Influence of Medication

Medicated and non-medicated AN patients were compared on the IGT and SCR. There were no significant differences between these groups on IGT performance ($F(1,27) = 0.142$, $p = .71$), anticipatory SCR ($F(1,27) = .042$, $p = .84$), or response SCR ($F(1,27) = .502$; $p = .49$).

DISCUSSION

Different profiles in IGT performance were found in the three groups: the HC and the ANR groups performed well and learned to avoid disadvantageous decks, whereas AN patients' performance did not improve over time. The data supports our first hypothesis that decision making ability (as measured by IGT performance) is impaired in patients with AN.

Our second hypothesis, namely, that decision making ability is impaired in people who have recovered from illness (ANR), was based on studies that have reported the persistence of psychological and neural abnormalities in recovered AN individuals (Roberts et al., in press; Tchanturia et al., 2005; Uher et al., 2003). The present data do not support this hypothesis as the ANR participants performed the decision making task as well as the HC group.

Our third hypothesis was that impaired decision making ability is associated with diminished anticipatory skin conductance responses to high-risk choices in the IGT.

People with AN demonstrated significantly lower anticipatory SCR to all choices (not only to the risky choices) and thus this hypothesis is partially supported.

Correlation analyses show that anticipatory SCRs prior to choosing high- and low-risk cards are associated with IGT score, and thus the overall reduction in anticipatory SCR in AN may be related to their poorer performance.

Most participants with current AN had clinically significant levels of depression and it is possible that impaired decision making and lower skin conductance responses are caused by the depression, rather than the eating disorder. We found a significant association between the level of depression and IGT performance. This may appear to be a plausible explanation of our data, because the emotional/autonomic responses to positive and negative stimuli are reduced in depression (e.g., Davidson et al., 2002; Rottenberg et al., 2005). However, study by Dalgleish and colleagues (2004) has demonstrated that people with unipolar depression perform at the same level as control participants in the IGT. Furthermore, Garon et al. (2006) have shown that the levels of depression are not associated with IGT performance in other neuropsychiatric disorders. Given that depression, like low BMI, is a core component of AN (Blinder et al., 2006), it is not possible to separate the relative contributions of affective and eating disorder symptomatology.

The data from this study are consistent with the literature suggesting that there is insensitivity to somatic signals in AN (Halmi & Sunday, 1991; Papezova et al., 2005). According to the Somatic Marker Hypothesis (Damasio, 2004), it can be argued that the impaired decision making is a consequence of a lack of sensitivity to and/or a failure to generate peripheral bodily alarm signals. However, the directionality of this relationship has not been established.

The fact that poor decision-making is only present in currently ill patients raises the possibility that it is associated with starvation. If this is so, the intact performance in the ANR group suggests that malnutrition does not have a permanent scarring effect on frontal lobe function. This is important, because there is concern about the potential long-term effects of this chronic illness, especially in young women. It should be noted however, that the ANR group had a shorter duration of AN and on the basis of lowest ever BMI, may not have been as severely ill. To provide definitive information on this state/trait issue, a longitudinal study will be required.

Impaired performance on the IGT has been observed in drug or alcohol abusers, people with obsessive-compulsive disorder, borderline personality disorder, and in suicide attempters (Cavedini et al., 2002; Fein et al., 2004; Jollant et al., 2005), suggesting that it is associated with a broad range of psychopathology characterized by compulsive and self-destructive behavior.

A study involving manipulation of amino acid intake, suggested that decision-making depends on the dopaminergic (DA) system (Scarna et al., 2005). This is of interest because polymorphisms in DA receptors have been reported to be associated with AN (Bergen et al., 2005) . Impaired IGT performance in AN could be a consequence of starvation, mediated by the alterations in the intake of amino acid precursors of neurotransmitters (e.g., DA), and resulting changes in central reward pathways. This would provide an explanation for the relatively normal performance seen in the recovered group of participants.

Alternative models of decision making have been developed (Maia & McClelland, 2004; Tomb et al., 2002). Rolls

and colleagues (Hornak et al., 2004; Rolls, 1996) have proposed that emotional responses in anticipation of an action may be absent in some patient groups. According to their model, the AN patients would have an impaired association between the reinforcement properties of the stimulus and their action in the IGT. In this framework the apparent insensitivity to noxious stimuli (e.g. high thresholds for pain, hunger, health hazards) in AN can be explained as a centrally mediated low sensitivity to punishment. The decreases seen in both anticipatory and response to loss SCR in AN patients is also consistent with this explanation. Overall, impaired IGT performance and altered anticipatory/loss SCR is an association only and causality should not be inferred from the present data.

One limitation of our study was that the sample size was insufficient to separately examine the AN diagnostic subgroups (restrictive and binge purge). A further limitation was that a measure of attention was not included and, therefore we were not able to explore associations between IGT performance and attention. Finally AN patients exhibit a number of physiological differences from healthy individuals which may affect the validity of the SCR measurement: for example, they show a general decrease in autonomic nervous system function and also have dry thin skin with poor peripheral circulation. However, it has been found that SCR is a sensitive measure of reaction to standard stimuli in underweight patients with AN (e.g., Lattimore et al., 2000). For such reasons, some care should be exercised when drawing conclusions from skin conductance data.

From a therapeutic standpoint, it is possible that giving patients personalized performance profile feedback from this task may help engagement and motivation for treatment.

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