Psychological Medicine (2009), **39**, 95–104. © 2008 Cambridge University Press
doi:10.1017/S0033291708003693 Printed in the United Kingdom

ORIGINAL ARTICLE

Decision making and problem solving in adolescents who deliberately self-harm

A. Oldershaw[1]*, E. Grima[1], F. Jollant[1,2], C. Richards[3], M. Simic[3], L. Taylor[3] and U. Schmidt[1]

[1] *King's College London, Institute of Psychiatry, London, UK*
[2] *Université Montpellier 1, France; Inserm U888, Montpellier, France; Department of Psychological Medicine and Psychiatry, Montpellier, France*
[3] *Croydon Child and Adolescent Mental Health Service, South London and Maudsley NHS Trust, UK*

Background. Healthy adolescents, and adults who engage in reward-driven, risky behaviours, demonstrate poor decision-making ability. Decision making in deliberate self-harm (DSH), a reward-driven, high-risk behaviour, has received little attention. This study assessed decision making and problem solving in adolescents with current or past SH.

Method. Decision making and problem solving were assessed using the Iowa Gambling Task (IGT) and the Means–Ends Problem-Solving Procedure (MEPS) respectively in 133 adolescents (57 healthy and 22 depressed controls with no SH history and 54 with SH history). A second analysis separated the SH group into current ($n=30$) and past ($n=24$) SH.

Results. The collective performance of adolescents with SH history did not differ from depressed or healthy adolescents on the IGT. However, current self-harming adolescents had a trend towards more high-risk choices ($p=0.06$) than those with previous SH history and were the only group not to significantly improve over time, persisting with high-risk strategy throughout. Those who no longer self-harmed learnt to use a low-risk strategy similar to healthy and depressed controls. Recency of last SH episode correlated with IGT performance. Depressed participants performed well on the IGT but poorly on the MEPS. By contrast, both collective and divided SH groups had comparable MEPS scores to healthy controls, all performing better than depressed participants.

Conclusions. Poor decision making is present in adolescents who currently self-harm but not in those with previous history; improvement in decision-making skills may therefore be linked to cessation of self-harm. Depressed adolescents who do and do not self-harm may have distinct characteristics.

Received 12 September 2007; Revised 17 April 2008; Accepted 17 April 2008; First published online 23 June 2008

Key words: Adolescent, decision making, Iowa Gambling Task, self-harm.

Introduction

Adolescence is a period of neural and physical development augmented by increased environmental demands. Behavioural changes characteristic of this period such as risk taking are linked to neural immaturity (Ernst *et al*. 2006), particularly in the prefrontal cortex, one of the last brain regions to mature (Casey *et al*. 2000). The triadic model of motivated behaviour seeks to explain the processes underlying risk taking and its emergence during adolescence (Ernst *et al*. 2006). The model proposes that decision-making behaviour is coordinated by the medial and ventral prefrontal cortices, which balances input from reward-seeking (ventral striatum) and harm-avoidant regions (amygdala circuits). During adolescence, prefrontal regulation is biased towards reward-seeking inputs, thus tipped towards choosing rewarding yet risky behaviours. In healthy adults, prefrontal regulation has developed such that reward-seeking and harm-avoidant 'behavioural brakes' are in balance. Thus, the triadic model suggests that a lack of prefrontal cortex maturity influences behaviour during adolescence, in particular risky, reward-driven decision making.

The reward-driven behaviour exhibited by adolescents takes many different forms and its nature and degree will be subject to individual differences. Because of its characteristics as a risky, reward-driven behaviour, heedless of long-term consequences, we conceptualize self-harm (SH) as occurring at the extreme end of this spectrum. Its specific link to adolescence, namely an increased prevalence and comparative low levels in adulthood (Hjelmeland &

* Address for correspondence: A. Oldershaw, M.Sc., P059, Institute of Psychiatry, De Crespigny Park, London SE5 8AF, UK.
(Email: anna.oldershaw@iop.kcl.ac.uk)

Groholt, 2005), further suggests that it could be linked to prefrontal cortex function and immaturity. A comparison of prefrontal cortex functioning in healthy and self-harming adolescents may therefore be important in understanding more about SH.

In the present study we used two measures to compare self-harming adolescents with healthy and depressed groups to test the hypothesis that SH behaviour may be associated with frontal lobe function. First, we used the Iowa Gambling Task (IGT), a decision-making test considered to be a measure of orbitofrontal cortex function, in particular the ventromedial prefrontal cortex (VMPFC). Lesion studies show that impaired performance on the IGT, characterized by persistent high-risk choices, is associated with damage to the VMPFC (Bechara *et al*. 1994, 1997, 1999). IGT results indicate that adolescents have poorer decision-making skills than adults (Overman *et al*. 2004) and performance steadily improves with development throughout teenage years, into adulthood (Crone & van der Molen, 2004; Hooper *et al*. 2004; Overman *et al*. 2004), thus the task appears to be sensitive to prefrontal cortex development. Decision-making deficits measured using the IGT have also been observed in adults who engage in reward-driven behaviours such as substance misuse (Grant *et al*. 2000), pathological gambling (Cavedini *et al*. 2002*a*), obsessive–compulsive disorder (Cavedini *et al*. 2002*b*), borderline personality disorders (Haaland & Landro, 2007) and eating disorders (Cavedini *et al*. 2004; Boeka & Lokken, 2006; Tchanturia *et al*. 2007). Poor decision making on the IGT has also been observed in adult suicide attempters, where it appears to be trait-like and stable even after recovery from depression (Jollant *et al*. 2005). We predicted that deficits on the IGT would also be observed in young people who have self-harmed.

Second, we assessed problem-solving skills using the Means–Ends Problem-Solving Procedure (MEPS). Decision making is a component of global problem-solving skills, defined by D'Zurilla & Goldfried (1971) in five stages: problem orientation, definition, generation of solutions, decision making, and solution implementation. The MEPS focuses on the initial steps of the problem-solving process (problem orientation/definition, solution generation) and includes no solution implementation. It assesses social problem solving, which is pertinent because people who SH indicate that interpersonal problems act as triggers (McLaughlin *et al*. 1996) and that they engage in SH 'to obtain relief' or 'to escape' (Boergers *et al*. 1998). Lesion studies suggest that performance on this type of problem-solving task is impaired following non-specific lesions to the frontal lobes, not necessarily including the orbital frontal cortex (Channon & Crawford, 1999). It has been demonstrated in one particular case study, with specific damage to the VMPFC, that MEPS ability is preserved, despite impaired performance on the IGT (Saver & Damasio, 1991). Previous studies using the MEPS with adults who have attempted suicide found impaired problem solving, and, as with the IGT, the deficit has been noted to persist even after an improvement in mood (Pollock & Williams, 2004). Only a few studies have used the MEPS in adolescent SH samples and the results are inconclusive: some report no differences from matched controls and those finding deficits tend to suggest that they are mediated by co-morbid depression or have not controlled for this (see Speckens & Hawton, 2005 for review). Thus, the existence of problem-solving deficits underpinning SH in adolescents remains somewhat uncertain and requires further investigation.

Both IGT and MEPS measures are objective and provide an indication of real-life behaviour rather than self-reported problem-solving ability, yet the MEPS taps into rather different aspects of problem solving to the IGT; it is not a measure of risky or reward-driven behaviour and may reflect performance of different brain regions. In light of previous research using the MEPS in SH populations, we predicted that performance on this task would be a function of depression rather than SH *per se*. Furthermore, if SH is uniquely linked to VMPFC-mediated decision making, this implies that depressed adolescents who self-harm will not be more impaired on the MEPS task than depressed adolescents with no SH history.

The present study investigated decision making and problem solving in adolescents who self-harm compared with a non-clinical healthy control group and a non-self-harming depressed control group. To assess whether performance on the tasks is consistent and trait-like, regardless of recovery from SH, secondary analyses compared the performance of adolescents currently self-harming to that of those who no longer self-harmed.

Method

Participants

One hundred and thirty-three participants aged between 12 and 18 years were recruited from a Community Child and Adolescent Mental Health Service (CAMHS) in London or through schools and contacts to form three groups: the SH group ($n=54$), a depressed group ($n=22$), and a healthy control group ($n=57$). Written informed consent was obtained prior to the study from all adolescents, and

from parents of those aged under 16 years. The study was approved by the Joint South London and Maudsley NHS Trust Research Ethics Committee.

Inclusion in the SH group required a history of SH and for CAMHS patients this had to be their presenting problem. Self-harm was defined as any self-injurious act purposefully carried out, regardless of underlying intent. Thus, suicidal and non-suicidal acts were included (Fortune & Hawton, 2005). Inclusion in the depressed control group required no history of SH, plus a primary clinical diagnosis of depression (if treated in the CAHMS) or a score above the clinical cut-off of 27 points recommended by the National Institute for Health and Clinical Excellence guidelines (NICE, 2005) on the Mood and Feelings Questionnaire (MFQ). Two participants included in the depressed group had diagnoses of depression from a CAMHS clinician but did not score in the clinical range on pure self-report. Exclusion criteria were IQ below 70, history of serious head injury, current use of medication affecting attention or primary psychiatric diagnosis other than depression or SH.

CAMHS participants were referred by clinicians and included in SH or depressed groups as appropriate. Participants recruited from schools/contacts local to the CAMHS team were screened using the MFQ and a Clinical and Demographic Questionnaire and subsequently assigned to the relevant group depending on disclosure of SH and MFQ score. All measures and tasks were completed in a random order in one 45-minute sitting, or screening was completed in one session and outstanding measures completed within 2 days. In case of distress resulting from disclosure, all participants were advised of a named counsellor and of contact details for a children's telephone counselling service.

A total of 224 participants were screened for participation. Of these, 15 were excluded for failure to complete assessments (due to school-imposed time restraints), IQ <70 or age >18 years. Seventy-five healthy participants were excluded after screening/assessment to match this sample closely to the SH group on gender and age.

Some adolescents had self-harmed in the past but reported that they no longer engaged in this behaviour. The distribution of SH behaviour indicated that 55% ($n=30$) of participants had experienced an SH episode within the previous 30 days and another 30% ($n=16$) had not self-harmed for 6 months or more, with the remainder falling in between. On the basis of this spread, it was decided to use a median split and take 30 days as a cut-off, creating two groups: Current Self-Harm (last SH episode $\leqslant 1$ month ago; $n=30$) and Past Self-Harm (last SH episode occurred >1 month ago; $n=24$). Four participants (all in the SH group: three current, one past) were taking antidepressants.

Measures

Background information and symptom assessment

Clinical and Demographic Questionnaire. This self-report questionnaire obtained basic background information and history of SH behaviours, such as frequency, duration and type of act(s).

Mood and Feelings Questionnaire, Child Report Version (*MFQ-C; Costello & Angold, 1988*). The MFQ-C (long version) is a self-report measure of depression designed for children and adolescents consisting of 33 items covering depressive symptoms and behaviour in the 2 weeks preceding assessment. The maximum score is 66. The accuracy of the MFQ in detecting cases meeting DSM-IV criteria for major depressive disorder in adolescents (Kent *et al*. 1997), high internal consistency (Cronbach's $\alpha=0.94$) and stable scores at retest (Wood *et al*. 1995) have been demonstrated. Guidelines from NICE (2005) conclude that the MFQ has good diagnostic validity with acceptable case detection of depression using a cut-off of 27 points or more.

Wechsler Abbreviated Scale of Intelligence (*WASI; Psychological Corporation, 1999*). This short measure of intelligence can be completed using four or two subtests to gain an estimate of Full-Scale IQ. The two-subtest version comprises vocabulary and matrix reasoning assessments and was considered appropriate for the current study, which needed a brief and efficient estimate of intelligence.

Problem-solving measures

Iowa Gambling Task (*IGT; Bechara et al. 1997*). The IGT is a computerized task played by selecting one card at a time from a choice of four decks displayed on the screen. With each selection, the participant wins some money, or wins then immediately loses. Participants are instructed to win as much money as possible and are told it is impossible to predict when a loss will occur. They do not know that two decks are disadvantageous because they are high-risk and result in overall net loss (big wins, but even more money lost; decks A and B), and two are advantageous low-risk decks leading to an overall net win (lower wins offset by even smaller losses; decks C and D).

Participants' progress is displayed during the task by a horizontal bar that changes length relative to the amount of money won or lost. Instructions in this study followed the format given by Bechara *et al*. (1999); participants were not told that the task would last 100 selections, but did know that it was not random and they would lose more on some decks than on others. Participants worked for points, not actual performance-dependent financial reward.

Participants' performance was measured using High-Risk Choices [mean number of 'high-risk' cards (decks A + B) chosen during the task] and Net Score {calculated by subtracting total number of high-risk cards chosen from the sum of low-risk card choices [decks (C + D) − (A + B)]}. Previous research in a similar population of adults with a history of suicide attempts (Jollant *et al*. 2005, 2007) and observations made by the task's developers (Bechara *et al*. 1997, 2005) suggest that choice 50 is the threshold between two different phases of the task: the average point where healthy controls switch from choosing equal numbers of high- and low-risk cards, to making more low-risk choices. Therefore, two Intermediate Net Scores (net scores for choices 1–50 and 51–100) were also calculated to investigate whether a change in strategy occurred.

The task is considered to be a good model of real life because it requires participants to apply decision making in the context of uncertainty; participants cannot predict degree or timing of punishment. This 'ecological validity' of the IGT has been demonstrated in a comparison of scores with real-life behaviour (Verdejo-Garcia *et al*. 2006).

Means–Ends Problem-Solving Procedure (*MEPS; Platt & Spivack, 1975*). This study used a modified version of the MEPS consisting of four stories told in the first person, each focusing on a different type of social relationship: current and prospective peer friendships, adult and partner. The original MEPS has been shortened in this way by several previous studies (e.g. Marx *et al*. 1992; Goddard *et al*. 1996; Sutherland & Bryant, 2008), including two that specifically adapted the task to include the same scenarios pertinent to SH used in the present study (Linehan *et al*. 1987; Hawton *et al*. 1999).

For each scenario, the participant was given the beginning and end of the story and told to fill out the middle part by giving the ideal solution that would connect them. For example, 'You love your boyfriend/girlfriend very much, but you have many arguments and one day (s)he leaves you. The story ends with everything being fine between you and your boyfriend/girlfriend. You begin where your boyfriend/girlfriend has just left you.'

Participants had a paper copy of the stories presented randomly. Each one was read aloud by the researcher immediately prior to the answer being given. Answers were given verbally, audiotaped and later transcribed to eliminate effects of problems such as dyslexia.

MEPS stories were scored according to the number of Relevant Means (RM) provided, defined as discrete steps taken from the beginning of the story that each bring the participant closer to the described end. Steps lacking detail, for example 'we sort things out' with no explanation of how things were resolved, were not considered to be RM. RM were broken down into those that were 'Active' (relied solely on actions of the participant) and those that were 'Passive' (someone else in the story completed a step or acted on the participant's behalf). An additional score of Effectiveness was rated on a five-point scale devised by the investigators based on the D'Zurilla & Goldfried (1971) definition of effective problem solving. A sum of scores across all stories for variables RM, means lacking detail, active means, passive means and effectiveness rating were calculated.

The MEPS was scored by two independent raters and inter-rater reliability was mostly excellent, with κ values ranging from 0.91 to 0.99. One MEPS variable (passivity) had a satisfactory reliability of 0.78.

Statistical analysis

Demographic variables were not normally distributed, thus Kruskal–Wallis tests were followed with Mann–Whitney *U* tests.

To assess the effect of age, level of depression and IQ on task performance, regression analyses were completed for IGT net score and intermediate net scores and for all MEPS variables. IQ was the only variable to significantly predict IGT scores (accounting for 4–4.5% of variance). MEPS performance on variables relevant means and effectiveness of solution were predicted by age (accounting for 3.8–4.3% of variance) and depression score predicted the passivity of answers (accounting for 3.4% of variance). Although all relationships were weak, we aimed to eliminate these potential confounds by including appropriate variables as covariates in subsequent analyses.

One-way analyses of covariance (ANCOVAs) were completed for IGT Net Scores and all MEPS variables, using relevant covariates, for two separate group comparisons: (1) main group comparison (SH, depressed controls, healthy controls) and (2) SH group comparison (current SH, past SH). Because of multiple MEPS variable comparisons, Bonferroni

Table 1. *Demographic characteristics of all participants*

	Healthy controls ($n=57$)	Depressed controls ($n=22$)	Total DSH ($n=54$)	Current DSH ($n=30$)	Past DSH ($n=24$)
Gender					
Female, *n* (%)	46 (80.7)	20 (90.9)	49 (90.7)	29 (96.7)	20 (83.3)
Male, *n* (%)	11 (19.3)	2 (9.1)	5 (9.3)	1 (3.3)	4 (16.7)
Recruitment					
CAMHS[a], *n* (%)	0 (0)	4 (18.2)	32 (59.3)	22 (73.3)	10 (41.7)
School/contacts, *n* (%)	57 (100)	18 (81.8)	22.3 (40.7)	8 (26.7)	14 (58.3)
Age[b], mean (S.D.)	15.8 (1.5)	15.7 (1.3)	15.8 (1.5)	15.2 (1.5)	16.4 (1.2)
Age range, mean	12–18	12–17	12–18	12–18	13–18
Mean IQ, mean (S.D.)	99.6 (14.3)	94.6 (9.7)	101.2 (12.5)	101.3[d] (12.3)	101.2 (12.9)
Mean MFQ[c], mean (S.D.)	10.9 (6.5)	33.5 (10.9)	32.7 (12.8)	35.7 (12.8)	29.0 (12.2)
MFQ range, mean	1–26	4–55	6–57	10–57	6–53
% per group reporting depression	0	91	69	80	54

DSH, Deliberate self-harm; CAMHS, Community Child and Adolescent Mental Health Service; MFQ, Mood and Feelings Questionnaire; S.D., standard deviation.

[a] Significantly more SH participants than depressed participants were recruited from a CAMHS ($U=350.0$, $p<0.01$).

[b] Past SH group significantly older than current SH group ($U=246.0$, $p<0.01$).

[c] Significant group difference on MFQ score ($\chi^2=72.8$, $p<0.001$): healthy controls less depressed than SH or depressed groups ($p<0.000$).

[d] Four scores missing.

corrections were applied and significance was set at $p<0.01$ ($p<0.05$/five variables).

As intermediate net scores and high-risk choices did not meet assumptions for parametric analysis, non-parametric within-group (Wilcoxon signed ranks test) and between-group analyses (Kruskal–Wallis tests/Mann–Whitney *U* tests) were used respectively. Bonferroni corrections for multiple within-group comparisons set significance for these analyses at $p<0.01$ ($p<0.05$/five analyses).

Correlation analyses used Pearson's correlation coefficient for normally distributed data and Spearman's correlation coefficient for non-normally distributed scores.

Results

Demographic and SH variables

Table 1 summarizes group demographic features. Groups had similar ages, gender ratios and IQs. There was a significant group difference on MFQ score ($\chi^2=72.8$, $p<0.001$); SH and depressed groups reported significantly higher levels of depression than healthy controls (p's <0.000). Significantly more SH participants than depressed participants were recruited from a CAMHS ($U=350.0$, $p<0.01$).

Direct comparison of current and past SH groups indicated statistically similar gender ratios, IQs and MFQ scores. However, participants who no longer self-harmed were significantly older than those currently self-harming ($U=246.0$, $p<0.01$).

Table 2 gives details of SH history. The current and past SH groups only differed in the recency of their SH episodes ($U=0.00$, $p<0.000$, $r=-0.8$).

Task performance

Table 3 summarizes performance on all tasks, adjusted to correct for confounding variables identified using regression. Figures 1 and 2 depict group performances on IGT and MEPS tasks.

SH participants versus *depressed participants* versus *healthy controls*

Net score. No group differences on overall net score were observed.

Change in card choices during the task. All groups significantly improved their scores over the course of the task (SH: $z=-2.6$, $p<0.01$, $r=-0.4$; depressed: $z=-2.9$, $p<0.01$, $r=-0.6$; healthy controls: $z=-3.1$, $p<0.01$, $r=-0.4$).

High-risk choices. No significant between group differences in the number of high-risk cards chosen were observed.

Table 2. *Self-harm history and characteristics*

	Total DSH[a] ($n=54$)	Current DSH ($n=30$)	Past DSH[a] ($n=24$)
Age at first time, mean (S.D.)	13.3 (1.5)	13.0 (1.4)	13.7 (1.5)
Total DSH episodes, mean (S.D.)	30.5 (59.2)	27.2 (52.2)	35.0 (68.7)
Days since last episode[b], mean (S.D.)	186.6 (337.8)	16.6 (10.4)	418.5 (423.5)
DSH type, *n* (%)			
Cutting	46 (85.0)	28 (93)	18 (75)
Banging	2 (3.7)	2 (7)	0 (0)
Overdose	2 (3.7)	0 (0)	2 (8.3)
Unspecified	4 (7.4)	0 (0)	4 (16.7)
>One method	10 (18.5)	5 (17)	5 (20.7)
Frequency when DSH present, *n* (%)			
>Once/week	7 (14)	4 (13.3)	3 (15)
Once/week	10 (20)	7 (23.3)	3 (15)
>Once/month but not every week	8 (16)	6 (20)	2 (10)
Once/month	5 (10)	4 (13.3)	1 (5)
Once every few months	12 (24)	6 (20)	6 (30)
Once/year	8 (16)	3 (10)	5 (25)
Number of episodes/year, mean (S.D.)	31.6 (34.7)	33.3 (33.8)	29.3 (37.8)
Suicide attempts, *n* (%)			
None	25 (48)	13 (43)	12 (55)
One or more	27 (52)	17 (57)	10 (45)
Therapy			
None	22 (42)	14 (48)	8 (36)
Psychological therapy/counselling, *n* (%)	30 (58)	16 (52)	14 (64)
Psychotropic medication[c], *n* (%)	4 (7)	3 (10)	1 (4)

DSH, Deliberate self-harm; S.D., standard deviation.

[a] Data for two participants missing on all variables; data for four participants missing on 'Frequency when DSH present' variables.

[b] Current and past SH groups only differed on duration since last SH episode ($U=0.00$, $p<0.000$, $r=-0.8$).

[c] Participants receiving psychotropic medication also had psychological treatment.

MEPS variables. The number of active means provided by participants showed significant group differences [$F(2,130)=4.2$, $p=0.01$, $r=0.25$)], the depressed group generated significantly fewer active means than other groups (p's <0.05). The overall effectiveness of solutions also differed between groups [$F(2,129)=4.3$, $p=0.01$], with the depressed group suggesting solutions that were significantly less effective than those of SH participants ($p<0.01$).

Current SH participants versus *past SH participants*

Net score. No significant group differences on overall net score were observed.

Change in card choices during the task. The performance of the past SH group significantly improved during the course of the task ($z=2.1$, $p<0.01$, $r=0.4$) but that of the current SH group did not.

High-risk choices. The current SH group showed a trend towards choosing more high-risk cards than the past group ($U=271.5$, $p=0.06$, $r=-0.2$).

MEPS variables. No significant differences on MEPS variables were found between SH groups.

Correlations and comparisons

IGT variables did not correlate with frequency of SH, total number of episodes or age at first episode. However, relationships with recency of SH were observed (net IGT score: $r_s=0.3$, $p<0.05$; high-risk

Table 3. *Summary of result on all problems-solving tasks*

	Healthy controls ($n=57$)	Depressed controls ($n=22$)	Total DSH ($n=54$)	Current DSH ($n=30$)	Past DSH ($n=24$)
IGT					
Overall net score	6.4 (18.4)	7.2 (18.6)	5.2 (18.4)	1.7 (20.1)	10.8 (20.5)
Intermediate net score: choices 1–50[a]	0.3 (6.4)	−0.4 (7.6)	0.5 (9.0)	−1.6 (6.7)	3.2 (10.8)
Intermediate net score: choices 51–100[a]	5.7 (13.1)	5.9 (13.5)	4.8 (14.7)	3.3 (15.0)	6.6 (15.0)
Total high-risk	47.1 (8.0)	47.2 (9.8)	46.8 (10.5)	49.1 (9.4)	44.6 (11.4)
MEPS					
Relevant means	13.2 (4.6)	10.2 (4.6)	13.3 (4.6)	14.7 (6.2)	12.8 (7.0)
Means lacking detail	1.2 (1.5)	1.1 (1.3)	1.4 (1.3)	1.4 (1.3)	1.4 (1.3)
Active means[b]	12.2 (4.8)	9.2 (3.7)	12.0 (4.3)	12.6 (4.3)	11.3 (4.3)
Passive means	0.9 (1.4)	1.1 (1.4)	1.2 (1.4)	1.2 (1.2)	1.2 (1.2)
Effectiveness[c]	13.1 (2.7)	11.6 (2.7)	13.5 (2.7)	13.6 (2.8)	13.5 (2.8)

DSH, Deliberate self-harm; IGT, Iowa Gambling Task; MEPS, Means–Ends Problem-Solving Procedure.

Values are given as mean (standard deviation).

[a] All groups significantly improved their score during the task (p's <0.01), except for the current SH group ($z=-1.9$, $p<0.01$).

[b] Significant group differences (on three-group comparison) [$F(2, 130)=4.2$, $p=0.01$]; depressed group significantly fewer active means than other groups (p's <0.05).

[c] Significant group differences (on three-group comparison) [$F(2, 129)=4.3$, $p=0.01$]; depressed group significantly fewer active means than SH group ($p<0.01$).

choices: $r_s=-0.3$, $p<0.05$), therefore scores improved as duration since last SH episode increased. MEPS variables did not correlate with any SH variable. MEPS and IGT variables did not correlate with one another.

Recruitment strategy, SH history or change in behaviour due to psychological intervention may have affected performance. However, no significant differences on either task were found when comparing clinical participants recruited from CAMHS *versus* those recruited from school ($n=36$ and $n=40$ respectively). Equally, SH participants who reported a history of suicidal act(s) were no different to those who did not ($n=28$ and $n=26$ respectively) and SH participants who had previously received psychological therapy ($n=30$) were similar to those who had not ($n=24$).

Discussion

This study examined decision-making and problem-solving skills in adolescents who self-harm as compared with depressed and healthy adolescent controls. It also directly compared those with current and past SH behaviour.

Key findings are that adolescents who have self-harmed, including current and past self-harming young people as a collective group, do not differ significantly from healthy controls or depressed controls in decision making on the IGT. However, when divided out, those who currently self-harm demonstrate poor decision-making skills, indicated by a greater attraction to short-term, high-reward solutions, and poorer adaptation of strategy to avoid long-term punishment, than individuals with a past history of SH. Those with a past history have decision-making skills comparable to those of healthy controls. Decision-making abilities appear to have a direct relationship with recency of SH episodes. By contrast, on the MEPS task, depressed adolescents who have a history of SH, whether current or past, are not impaired, whereas depressed adolescents with no SH history generate fewer and less effective solutions to problems.

Our findings support previous work indicating that the IGT can be used to detect poor decision making associated with risky behaviour in adolescents (Ernst *et al*. 2003). The majority of the SH participants in our community sample were self-cutters and female, which reflects previous demographic observations of this group (Hawton *et al*. 2002) and supports the notion that these findings may be generalized. Our study in part both supports and contrasts with that of Jollant *et al*. (2005), who found that adults who have attempted suicide are significantly poorer than healthy controls on IGT decision making even after recovery from suicidal ideation and axis I disorder. Although our results indicate

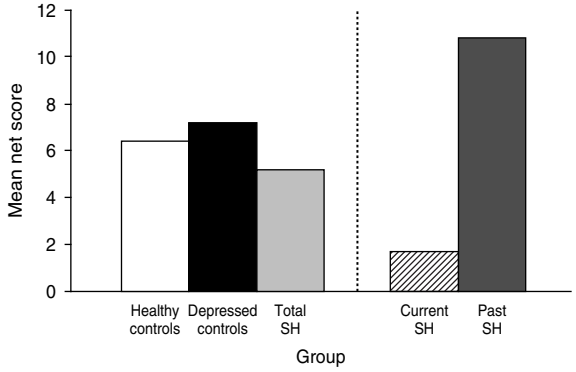

Fig. 1. Mean net scores on the gambling task for all five groups, after adjustment for IQ. SH, Self-harm.

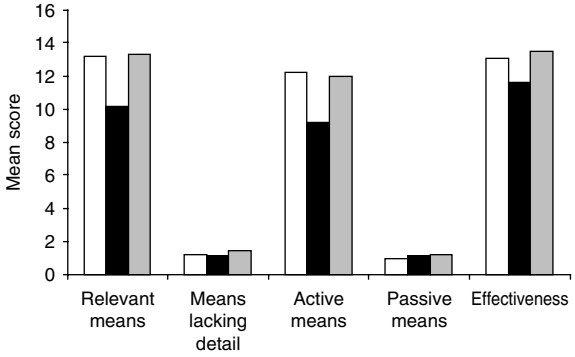

Fig. 2. Mean scores on Means–Ends Problem-Solving Procedure (MEPS) variables for three main comparison groups: Healthy Controls (□), Depressed Controls (■) and Self-Harm (SH; ▨) participants. MEPS variables were adjusted for age or Mood and Feelings Questionnaire (MFQ) score as appropriate following regression analyses. * Depressed participants produced significantly fewer active means than other groups [$F(2, 130) = 4.2$, $p = 0.01$, $r = 0.25$)]. ** Depressed participants produced significantly less effective means than SH participants [$F(2, 129) = 4.3$, $p = 0.01$].

that some deficits in decision making may exist in adolescents who SH, they appear to be state-like.

Prefrontal cortex development continues throughout adolescence (Casey *et al*. 2000) and poor, high-risk performance on the IGT is associated with prefrontal cortex deficits (Bechara *et al*. 1994). We may speculate that our findings suggest that decision making in the VMPFC of adolescents who self-harm is perhaps slightly less developed or deficient as compared with that of adolescents who have ceased SH behaviour. The performance of past SH participants might imply that 'recovery' from poor decision making is possible during this developmental stage. Indeed, this period of adolescence may be crucial for working to improve deficient decision making, as Jollant *et al*. (2005) suggest that once poor decision making continues into adulthood, this skills deficit becomes 'fixed' and trait-like, associated with vulnerability to adult suicide attempts.

Given the significant age difference between the current and past SH groups, it could be argued that results reflect developmental changes. Although a difference in maturity may well be a factor, both in these findings and in cessation of SH itself, there are several reasons to believe that age at least does not solely underlie these decision-making differences. First, age in the current SH group was not different to age of healthy controls and yet their decision-making scores were lower. Second, age did not correlate with or predict scores on the IGT, and third, current SH performance was similar across ages.

Decision-making deficits are not reflective of overall problem-solving capability. The present study supports the evidence that MEPS deficits may be mediated by underlying depression (Speckens & Hawton, 2005), and adds to it by demonstrating that, even after controlling for depression, adolescents with current and previous SH histories are significantly better than depressed adolescents at generating effective and active solutions to problems. It is possible that adolescents who self-harm and are depressed have different characteristics to depressed adolescents who do not self-harm; they are able to generate more solutions but are poorer at choosing or applying appropriate solutions in practice, opting for high-risk, 'quick-fix' answers.

Limitations

Improved understanding of the differences between the groups, by including wider assessment of prefrontal function, psychological or behavioural factors could have provided a clearer picture, indicating whether differential prefrontal cortex deficits were factors in the performance of these groups. Addition of skin conductance measures during the IGT could clarify emotional responses to reward and loss. Measures of impulsivity, novelty seeking, reward dependence and emotional tolerance could give insight into differing psychological factors. It has been proposed that decision making on the IGT is guided by emotional feedback (Dunn *et al*. 2006, for review) and the VMPFC is implicated in the regulation of emotion (Quirk & Beer, 2006). Therefore, it is uncertain whether some form of emotional dysfunction in adolescents who self-harm, such as intolerance of uncertainty, poor regulation or high emotional reward response, could have affected their ability to complete the IGT. By contrast, the MEPS relies on hypothetical situations that are not emotionally

charged; this could explain the comparably good performance of current SH participants during this task.

Although the comparison of current and past SH participants is robust, we cannot be certain of the decision-making abilities of the past SH group when their SH behaviour was present or whether the current SH group consists of subtly different or more severe cases. A clearer way of demonstrating that cessation of SH and improved decision making are linked would be with a longitudinal study, following the same participants through from current self-harm to cessation, and measuring within-group score changes.

Full diagnostic interviews were not completed with all participants. Therefore, the extent of co-morbidity including inattention due to attention deficit hyperactivity disorder (ADHD) or anxiety disorders cannot be confirmed. However, a recent IGT study on major depressive disorder found that anxiety scores did not correlate with or predict IGT performance (Must *et al*. 2006).

Furthermore, non-normal distribution of some scores indicates that the study would have benefited from greater participant numbers. Replication with larger numbers, particularly in the depressed group, and more closely age-matched participants is required.

Clinical implications

These findings have implications for the treatment of self-harm and suggest that work to improve decision-making skills in a clinical setting could help young people to move away from self-harm behaviour. Interventions focusing on decision-making development and learning the benefits of low-risk over high-risk solutions are indicated.

In conclusion, poor decision making is poorer in young people who currently self-harm than those with just past history. Deficits are unique to decision making and not reflective of overall problem-solving ability. Improvement of decision-making skills may be linked to recovery from self-harm and both may be mediated, in part, by prefrontal cortex development. The difficulties of adolescents who are depressed and self-harm appear to be distinct from those of depressed young people who do not self-harm.

Acknowledgements

We thank Professor Iain Campbell and Drs Kate Tchanturia, Helen Startup and Frederique Van den Eynde for their thoughtful reviews of early drafts. This study was funded by an Institute of Psychiatry Research and Development Grant.

Declaration of Interest

None.

References

Bechara A, Damasio AR, Damasio H, Anderson SW (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition* **50**, 7–15.

Bechara A, Damasio H, Damasio AR, Lee GP (1999). Different contribution of the human amygdala and ventromedial prefrontal cortex to decision-making. *Journal of Neuroscience* **19**, 5473–5481.

Bechara A, Damasio H, Tranel D, Damasio AR (1997). Deciding advantageously before knowing the advantageous strategy. *Science* **275**, 1293–1295.

Bechara A, Damasio H, Tranel D, Damasio AR (2005). The Iowa Gambling Task and the somatic marker hypothesis: some questions and some answers. *Trends in Cognitive Sciences* **9**, 159–162.

Boeka AB, Lokken LL (2006). The Iowa Gambling Task as a measure of decision making in women with bulimia nervosa. *Journal of the International Neuropsychological Society* **12**, 741–745.

Boergers J, Spirito A, Donaldson D (1998). Reasons for adolescent suicide attempts: associations with psychological functioning. *Journal of the American Academy of Child and Adolescent Psychiatry* **37**, 1287–1293.

Casey BJ, Giedd JN, Thomas KM (2000). Structural and functional brain development and its relation to cognitive development. *Biological Psychology* **54**, 241–257.

Cavedini P, Bassi T, Ubbiali A, Casolari A, Giordani S, Zorzi C, Bellodi L (2004). Neuropsychological investigation of decision-making in anorexia nervosa. *Psychiatry Research* **127**, 259–266.

Cavedini P, Riboldi G, D'Annucci A, Belotti P, Cisima M, Bellodi L (2002*b*). Decision-making heterogeneity in obsessive-compulsive disorder: ventromedial prefrontal cortex function predicts different treatment outcomes. *Neuropsychologia* **40**, 205–211.

Cavedini P, Riboldi G, Keller R, D'Annucci A, Bellodi L (2002*a*). Frontal lobe dysfunction in pathological gambling patients. *Biological Psychiatry* **51**, 334–341.

Channon S, Crawford S (1999). Problem-solving in real-life situations: the effects of anterior and posterior lesions on performance. *Neuropsychologia* **37**, 757–770.

Costello EJ, Angold A (1988). Scales to assess child and adolescent depression: checklists, screens, and nets. *Journal of the American Academy of Child and Adolescent Psychiatry* **27**, 726–737.

Crone EA, van der Molen MW (2004). Developmental changes in real life decision making: performance on a gambling task previously shown to depend on the ventromedial prefrontal cortex. *Developmental Neuropsychology* **25**, 251–279.

Dunn BD, Dalgleish T, Lawrence AD (2006). The somatic marker hypothesis: a critical evaluation. *Neuroscience and Biobehavioural Reviews* **30**, 239–271.

D'Zurilla TJ, Goldfried MR (1971). Problem solving and behaviour modification. *Journal of Abnormal Psychology* **78**, 107–126.

Ernst M, Grant SJ, London ED, Contoreggi CS, Kimes AS, Spurgeon L (2003). Decision making in adolescents with behaviour disorders and adults with substance abuse. *American Journal of Psychiatry* **160**, 33–40.

Ernst M, Pine DS, Hardin M (2006). Triadic model of the neurobiology of motivated behaviour in adolescence. *Psychological Medicine* **36**, 299–312.

Fortune SA, Hawton K (2005). Deliberate self-harm in children and adolescents: a research update. *Current Opinions in Psychiatry* **18**, 401–406.

Goddard L, Dritschel B, Burton A (1996). Role of autobiographical memory in social problem solving and depression. *Journal of Abnormal Psychology* **105**, 609–616.

Grant S, Contoreggi C, London ED (2000). Drug abusers show impaired performance on a laboratory test of decision making. *Neuropsychologia* **38**, 1180–1187.

Haaland VO, Landro NI (2007). Decision making as measured with the Iowa Gambling Task in patients with borderline personality disorder. *Journal of the International Neuropsychological Society* **13**, 699–703.

Hawton K, Kingsbury S, Steinhardt K, James A, Fagg J (1999). Repetition of deliberate self-harm by adolescents: the role of psychological factors. *Journal of Adolescence* **22**, 369–378.

Hawton K, Rodham K, Evans E, Weatherall R (2002). Deliberate self-harm in adolescents: self-report survey in schools in England. *British Medical Journal* **325**, 1207–1211.

Hjelmeland H, Groholt B (2005). A comparative study of young and adult deliberate self-harm patients. *Crisis* **26**, 64–72.

Hooper CJ, Luciana M, Conklin HM, Yarger RS (2004). Adolescents' performance on the Iowa Gambling Task: implications for the development of decision-making and ventromedial prefrontal cortex. *Developmental Psychology* **40**, 1148–1158.

Jollant F, Bellivier F, Leboyer M, Astruc B, Torres S, Verdier R, Castlenau D, Malafosse A, Courtet P (2005). Impaired decision making in suicide attempters. *American Journal of Psychiatry* **162**, 304–310.

Jollant F, Buresi C, Guillaume S, Jaussent I, Bellivier F, Leboyer M, Castelnau D, Malafosse A, Courtet P (2007). The influence of four serotonin-related genes on decision-making in suicide attempters. *American Journal of Medical Genetics* **5**, 615–624.

Kent L, Vostanis P, Feehan C (1997). Detection of major and minor depression in children and adolescents: evaluation of the Mood and Feelings Questionnaire. *Journal of Child Psychology and Psychiatry* **38**, 566–573.

Linehan MM, Camper P, Chiles JA, Strosahl K, Shearin E (1987). Interpersonal problem solving and parasuicide. *Cognitive Therapy and Research* **11**, 1–12.

Marx EM, Williams JMG, Claridge GC (1992). Depression and social problem solving. *Journal of Abnormal Psychology* **101**, 78–86.

McLaughlin J, Miller P, Warwick H (1996). Deliberate self-harm in adolescents: hopelessness, depression, problems and problem-solving. *Journal of Adolescence* **19**, 523–532.

Must A, Szabo Z, Bodi N, Szasz A, Janka Z, Keri S (2006). Sensitivity to reward and punishment and the prefrontal cortex in major depression. *Journal of Affective Disorders* **90**, 209–215.

NICE (2005). *Depression in Children and Young People*. Clinical Guideline 28. National Institute for Health and Clinical Excellence; British Psychological Society: London, UK.

Overman WH, Frassrand K, Ansel S, Trawalter S, Bies B, Redmond A (2004). Performance on the IOWA card task by adolescents and adults. *Neuropsychologia* **42**, 1838–1851.

Platt JJ, Spivack G (1975). *Manual for the Means–Ends Problem-Solving Procedure (MEPS): A Measure of Interpersonal Problem-Solving Skill*. Department of Mental Health Sciences, Hahnemann Medical College and Hospital: Philadelphia.

Pollock LR, Williams JMG (2004). Problem-solving in suicide attempters. *Psychological Medicine* **34**, 163–167.

Psychological Corporation (1999). *Wechsler Abbreviated Scale of Intelligence (WASI) manual*. San Antonio, TX.

Quirk GJ, Beer JS (2006). Prefrontal involvement in the regulation of emotion: convergence of rat and human studies. *Current Opinions in Neurobiology* **16**, 273–277.

Saver JL, Damasio AR (1991). Preserved access and processing of social knowledge in a patient with acquired sociopathy due to ventromedial frontal damage. *Neuropsychologia* **29**, 1241–1249.

Speckens AEM, Hawton K (2005). Social problem solving in adolescents with suicidal behaviour: a systematic review. *Suicide and Life-Threatening Behaviour* **35**, 365–386.

Sutherland K, Bryant RA (2008). Social problem solving and autobiographical memory in posttraumatic stress disorder. *Behaviour Research and Therapy* **46**, 154–161.

Tchanturia L, Liao P, Uher R, Lawrence N, Treasure J, Campbell I (2007). An investigation of decision-making in anorexia nervosa using the Iowa Gambling Task and skin conductance measurements. *Journal of the International Neuropsychological Society* **13**, 1–7.

Verdejo-Garcia A, Bechara A, Recknor EC, Perez-Garcia, M (2006). Decision-making and the Iowa Gambling Task: ecological validity in individuals with substance dependence. *Psychologica Belgica* **46**, 55–78.

Wood A, Kroll L, Moore A, Harrington R (1995). Properties of the Mood and Feelings Questionnaire in adolescent psychiatric outpatients: a research note. *Journal of Child Psychology and Psychiatry* **36**, 327–334.