Psychiatry Research 177 (2010) 1–11

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Review article

Sensitivity to reward and punishment in eating disorders

Amy Harrison *, Niamh O'Brien, Carolina Lopez, Janet Treasure

Institute of Psychiatry, Kings College London, UK

ARTICLE INFO

Article history:
Received 16 January 2008
Received in revised form 8 June 2009
Accepted 11 June 2009

Keywords:
Systematic review
Reward
Punishment
Personality
Novelty seeking
Harm avoidance

ABSTRACT

The aim of this review was to collate and summarise the self-report data regarding anomalies in sensitivity to reward and punishment in eating disorders (ED) with use of a meta-analysis where possible. Electronic databases were searched to December 2008. Studies were required to have a non-eating disorder healthy control group and include at least one self-report measure of sensitivity to reward or punishment in an eating disorder population. Findings were very heterogeneous and inconsistencies between studies and measures were highlighted. In general, patients with anorexia nervosa (restricting type) were less sensitive to reward than healthy controls, whereas patients with bulimia nervosa and anorexia nervosa (binge/purge) type were more sensitive. All ED groups report higher sensitivity to punishment than healthy controls. Individuals with eating disorders differ from healthy controls in measures of reward and punishment sensitivity as measured using the Temperament and Character Inventory, Tridimensional Personality Questionnaire and BIS/BAS scales, but further work is required as there is some heterogeneity in the data. Generating more research using behavioural measures may increase understanding of the findings.

Contents

1. Introduction

The role of the reward system in driving eating behaviour has become the subject of much investigation in light of the increasing prevalence of obesity in the western world (Lowe and Levine, 2005). Many studies have followed Gray's (1970) seminal theory of personality:

* Corresponding author. Eating Disorders Research Unit, Department of Academic Psychiatry, King's College London, 5th Floor Bermondsey Wing, Guy's Hospital, London, SE1 9RT, UK. Tel.: +44 20718 80168; fax: +44 20718 80167.
E-mail address: amy.harrison@iop.kcl.ac.uk (A. Harrison).

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doi:10.1016/j.psychres.2009.06.010

reinforcement sensitivity theory (RST), which involves reward sensitivity, thought to be related to behavioural activation and punishment sensitivity, thought to be related to behavioural inhibition.

Animal studies suggest that reward systems in the brain can become dysregulated by starvation and intermittent access to high palatability food, some of the key symptoms in eating disorders (Avena et al., 2008; Carr, 2007). Studies in humans have found that binge-eating and purging behaviours are associated with higher sensitivity to reward (Loxton and Dawe, 2001; Farmer et al., 2001). High reward sensitivity has also been associated with greater activation to food cues in functional magnetic resonance imaging (fMRI) studies (Beaver et al., 2006).

There has, however, been little direct research on measures of sensitivity to reward and punishment in people with eating disorders. Relatively few studies have addressed these constructs using behavioural tasks (Bruce et al., 2003, 2004; Cavedini et al., 2006; Rosval et al., 2006; Tchanturia et al., 2007). Studies in anorexia nervosa (AN) using the Iowa Gambling Task have shown that this group tends to perform poorly on these tasks compared to healthy controls, indicating lower sensitivity to reward in the acute state but this effect seems to reverse after recovery (Cavedini et al., 2006; Tchanturia et al., 2007). Four studies have examined behavioural disinhibition in ED compared to healthy controls using the Go No/Go task and have found that people with binge/purge form of the illness are more disinhibited when faced with punishment than controls (Bruce et al., 2003, 2004; Rosval et al., 2006) or when targets are food related (Mobbs et al., 2008). More work has been done to explore these concepts through self-report measures and these data may help to clarify these tendencies.

Due to the scarcity of behavioural studies, it was decided to concentrate on self-report measures in this review and return to the literature on experimental tasks at a later date when more published studies are available.

Understanding how anomalies in the reward and punishment systems might act to cause or maintain eating disorders may lead to more successful interventions for this vulnerable group.

The aim of this systematic review was therefore to collate and analyse the literature on self-reported sensitivity to reward and punishment in people with broad and narrow categories of eating disorders.

2. Methods

The "QUOROM statement" for a systematic review and meta-analyses was followed (Moher et al., 1999), using its guidelines to structure and guide the review (see Fig. 1).

2.1. Searching

Articles were located using the electronic databases PsycInfo, Medline and Web of Science, by additional hand searches through reference lists and specialist eating disorder journals, and through direct contact with academic institutions with an interest in this area. Search keyword terms were: REWARD, PUNISHMENT, REINFORCEMENT, CONTINGENCY, PREDICTION ERROR, BIS, BAS, PROBABLISTIC, DECISION, APPROACH, AVOIDANCE, PERSONALITY, TEMPERAMENT, CHARACTER, NOVELTY SEEKING, EATING DISORDER, ANOREXIA NERVOSA, BINGE and BULIMIA NERVOSA. No date restrictions were applied to the selection of literature, and articles were searched up to December 2008.

Any studies including self-report measures of reward or punishment sensitivity in an eating disorder population (excluding studies in the obese population but including current and recovered ED) were eligible for inclusion.

2.1.1. Selection

To be included, studies were required to compare results of an eating disorder (ED) group to a non-eating disorder healthy control group and be written in English. The following flow chart details the number of studies found at each stage of the search and the final number of studies included in the review.

2.1.2. Data extraction

Descriptive statistics (mean, S.D., and sample size) for eating disorder and healthy control groups were extracted. Missing data were requested from the author where necessary. Data from one study (Bloks et al., 2004; Cavedini et al., 2006) included repeated measures from the same population. These longitudinal data have not been included in the review.

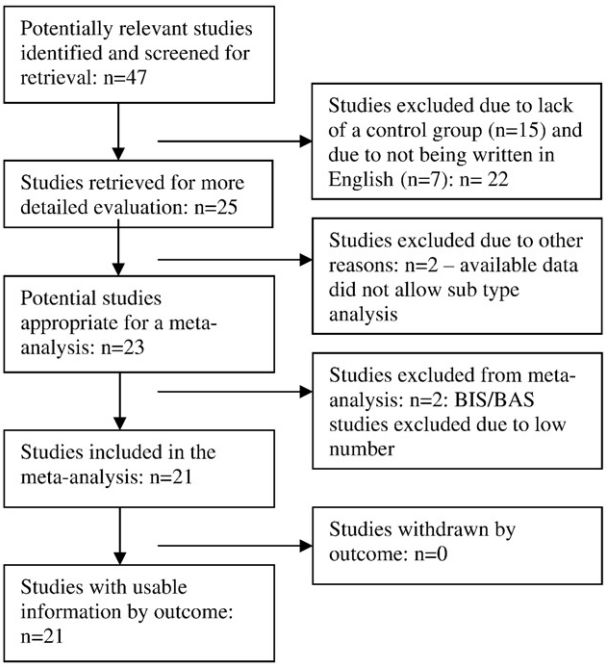

Fig. 1. Flowchart.

2.2. Quantitative data synthesis

Where sample size allowed, results for each of the measures were summarized by a meta-analysis. Analyses were carried out in Stata 9.1 using the user-contributed commands for meta-analyses: *metan* (Bradburn et al., 1998) and *metabias* (Steichen, 1998). *Cohen's d* effect sizes were calculated for each study using an effect size calculator (Wilson, 2001). Cohen's effect sizes (d) are understood as *negligible* ($=0$ and <0.15), *small* ($>=0.15$ and <0.40), *medium* ($>=0.40$ and <0.75), *large* $>=0.75$ and <1.10), *very large* ($>=1.10$ and <1.45) and *huge* (>1.45).

In *metan* (Bradburn et al., 1998) the standard error of each study's standardized effect size was used. This was calculated from the estimated effect and group sizes following Cooper and Hedges (1994). Random-effect models were used throughout (Everitt, 2003). The assumption of homogeneity of true effect sizes was evaluated using Cochran's Q test for homogeneity. Due to the small sample sizes a measure of inconsistency I^2 ($(Q-df)/Q$) was calculated (Higgins et al., 2003).

The presence of publication bias was assessed by visual inspection of funnel plots and corroborated by Egger's (Egger et al., 1997) and Begg's adjusted rank test (Begg and Mazumdar, 1994) and implemented in *metabias*. Forest plots display the results of the meta-analyses in graphical format.

A forest plot "provides a simple visual representation of the amount of variation between the results of the studies, as well as an estimate of the overall result of all the studies together with all the independent data available for each measure" (Lewis and Clarke, 2001, p. 1479). Each line in the forest plot represents an individual study/comparison. The position of the square in relation to the vertical axis, represents the point estimate of the results of a particular study; specifically it shows how the effect size of the study varies from zero. The size of the square shows the weighed individual contribution of the study to the meta-analysis and it is proportional to the sample size of the study. The horizontal line through the square represents the 95% confidence interval (CI) of the effect size. The overall estimate from the meta-analysis and its CI are displayed at the bottom of the plot represented as a diamond.

2.3. Study characteristics

All of the 25 studies used an experimental cross-sectional design. Eighteen studies included either an anorexia nervosa (AN) or a bulimia nervosa (BN) sample; 10 studies specified subtypes (anorexia nervosa restricting type (RAN) and anorexia nervosa binge/purge type (BPAN)). Five studies included recovered patients in their samples: (O'Dwyer et al., 1996; Ward et al., 1998; Bailer et al., 2004; Klump et al., 2004; Wagner et al., 2006; Tchanturia et al., 2007). It was decided to include recovered participants because due to the chronic nature of eating disorders, it is of interest to the field to understand whether reported behaviour or characteristic is a trait present in people who have a lifetime history of an eating disorder, or whether the behaviour or characteristic is a state characteristic of a currently ill person. The participants in most of the studies were between the ages of 20 and 30 years, however four studies (O'Dwyer et al., 1996; Kane et al., 2004; Rybakowski et al., 2004; Monteleone et al., 2006) included younger participants. Very little information was reported about co-morbid disorders. Ten studies reported elevated levels of depression in the patient