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journal homepage: [www.elsevier.com/locate/psychres](http://www.elsevier.com/locate/psychres)

## An investigation of habit learning in Anorexia Nervosa



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## ARTICLE INFO

## Article history:

Received 2 November 2015

Received in revised form

14 June 2016

Accepted 21 July 2016

Available online 26 July 2016

## Keywords:

Anorexia Nervosa

Habit formation

Compulsivity

Goal-directed learning

Eating disorders

## ABSTRACT

Anorexia Nervosa (AN) is a disorder characterised by compulsive behaviour, such as self-starvation and excessive exercise, which develop in the pursuit of weight-loss. Recent theory suggests that once established, compulsive weight-loss behaviours in AN may become habitual. In two parallel studies, we measured whether individuals with AN showed a bias toward habits using two outcome-devaluation tasks. In Study 1, 23 women with AN (restrictive and binge/purge subtypes), and 18 healthy controls (HC) completed the slips-of-action paradigm, designed to assess reward-based habits. In Study 2, 13 women with restrictive AN, 14 women recovered from restrictive AN, and 17 female HC participants completed the slips-of-action paradigm, and an avoidance paradigm, designed to assess aversive habits. AN participants showed no deficit relative to HCs in the ability to use feedback to respond correctly to stimuli. Following devaluation of outcomes, all groups in both studies were equally able to withhold inappropriate responses, suggesting no deficit in the balance between goal-directed and habitual control of behaviour in these tasks in AN. These results suggest that individuals with AN do not show a generalised tendency to rely on habits in two outcome-devaluation tasks. Future research is needed to investigate the potential role of disorder-specific habits in the maintenance of behaviour in AN.

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## 1. Introduction

Anorexia nervosa (AN) is a severely debilitating psychiatric disorder characterised by an intense fear of weight gain or becoming fat, despite significantly low body weight (American Psychiatric Association, 2013). Individuals with AN place extreme over-importance on the control of weight and shape, and often have disturbed body image perception (Fairburn et al., 2003). These distorted beliefs and perceptions are accompanied by a perpetual drive for thinness and continuous lowering of weight goals (Barbarich-Marsteller et al., 2011). The characteristic behaviours seen in AN to achieve weight-loss goals, such as extreme dietary restriction and over-exercise, have been described as

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evidence of the compulsive nature of the disorder (Godier and Park, 2014a; Park et al., 2014). Furthermore, individuals with AN show cognitive inflexibility (Tchanturia et al., 2004), a rigid cognitive style suggested to contribute to compulsivity (Fineberg et al., 2010).

Compulsivity can be defined as a trait in which actions are persistently repeated despite adverse consequences (Robbins et al., 2012). This can be seen in the repetitive, and highly ritualised behaviours of OCD, which impair patients ability to engage in normal daily activities (American Psychiatric Association, 2013), and in the lack of control felt over drug-seeking behaviour in substance dependence, despite the adverse consequences (Kalivas and Volkow, 2005). Compulsive behaviour in AN has been compared to both OCD (Steinglass and Walsh, 2006), and addiction (Barbarich-Marsteller et al., 2011; Godier and Park, 2014a, 2014b, 2015; Kaye et al., 2013; Park et al., 2014; Scheurink et al., 2010; Zink and Weinberger, 2010). Indeed, studies using the Iowa Gambling task in participants with AN, OCD and substance

dependence, suggest in all three disorders a tendency to make disadvantageous decisions when choosing between immediate or long terms gains (Lawrence et al., 2006; Tchanturia et al., 2007; Verdejo-Garcia et al., 2007), which may be linked to the compulsive, self-destructive and sometimes impulsive behaviours seen across these disorders (Tchanturia et al., 2007). Increased impulsivity, defined as the tendency to perform actions prematurely without foresight (Dalley et al., 2011), has previously been associated with engaging in binge-purge behaviours compared to restrictive behaviour (Claes et al., 2005; Favaro et al., 2005; Rosval et al., 2006; Waxman, 2009). The present study aimed to assess compulsivity more directly in AN, using tasks for which poor performance has been associated with compulsive behaviour in disorders such as OCD and addiction (Gillan et al., 2015, 2014, 2011; Sjoerds et al., 2013).

Emergent evidence suggests that compulsivity may arise, at least in part, as a result of over-reliance on habit-learning, at the expense of more considered modes of action selection. Habits are learnt (instrumental) behaviours that have been engaged in repeatedly and consequentially become fixed, occur without conscious effort, and can be elicited by external stimuli (Graybiel, 2008). Habit ('stimulus-response') learning can be contrasted with goal-directed ('action-outcome') control (Robbins et al., 2012). Goal-directed behaviours are purposeful actions driven by anticipation and evaluation of a rewarding outcome. As such, goal-directed actions are less likely to be performed if the value of their associated outcomes is lessened (Balleine and O'Doherty, 2010). However, if these new actions are engaged in repeatedly (over-trained), this may lead to the formation of stimulus-response associations, such that external stimuli can trigger habitual responses even when the consequences are no longer rewarding (Dickinson, 1985).

A shift in balance away from goal-directed control and towards excessive habit learning has been shown in substance dependence (Sjoerds et al., 2013; Voon et al., 2014), OCD (Gillan et al., 2015, 2014, 2011; Voon et al., 2014), binge eating disorder (BED) (Voon et al., 2014), and Tourette's syndrome (Delorme et al., 2015). Walsh (2013) outlines the mechanisms by which aberrant habit formation may contribute to the maintenance of dietary restriction in AN. Restrictive eating may begin as the result of goal-directed weight-loss behaviour, in which behaviour is associated with a rewarding outcome (weight loss). If restrictive eating behaviour is repeated enough it may become relatively independent of reward, such that weight loss as a rewarding outcome may be needed only intermittently, or even no longer necessary for this behaviour to continue. Habitual behaviour, as measured by the persistence of a devalued action may be reflective of the treatment resistance often observed in individuals with AN (Walsh, 2013).

The two studies presented here were exploratory in nature, and aimed to begin to test the hypothesis that a generalised reliance on habits, as seen in other compulsive disorders, may contribute to the development of the compulsive weight-loss behaviour, within a small group of individuals with AN. These studies were carried out in parallel at the New York State Psychiatric Institute (Study 1) and at the University of Oxford (Study 2). In Study 1, we studied individuals with restrictive and binge/purge subtype AN, and compared them to healthy controls. We used a simplified version of the outcome-devaluation task previously used to provide evidence for reliance on habits in OCD (Gillan et al., 2011), namely the Slips-of-action paradigm (for simplified version of the task see Worbe et al., 2015). In Study 2, we compared individuals both currently ill and recovered from restrictive AN (as starvation alone is associated with severe alternations in cognitive and physiological systems) (Cowdrey et al., 2011; Kaye et al., 2009; Wagner et al., 2008), to healthy controls on the Slips-of-action paradigm, replacing the fruit pictures with pictures of animals, in order to

avoid the confound of food stimuli in the AN participants. In addition, an adapted version of an avoidance habit task used previously by Gillan et al. (2014, 2015) was employed to further explore habit bias in AN, and whether this is modulated by valence, i.e. appetitive versus aversive learning (Gillan et al., 2015, 2014). This is an important consideration as AN features both avoidance behaviour; i.e. an aversion to energy-dense foods (Cowdrey et al., 2013), which are experienced as anxiogenic (Bailer et al., 2012; Zink and Weinberger, 2010), as well as the appetitive behaviour; i.e. pursuit of reward in the form of weight-loss (Godier and Park, 2014a). We hypothesised that individuals with current and past AN would show enhanced habit formation in each of the tasks, in both studies, evidenced by a persistence of previously learned responses despite devaluation of the outcome.

## 2. Methods

### 2.1. Study 1

#### 2.1.1. Participants

Forty-one participants were recruited for two groups: women with a current diagnosis of AN (AN group,  $n=23$ ), and healthy control subjects (HC group,  $n=18$ ). A power analysis indicated a 98% chance of detecting a significant effect based on a Cohen's  $d$  of 1.32 calculated from a previous study using the Slips-of-action paradigm (Gillan et al., 2011). Subjects were recruited by advertisements, the clinic website, clinician referral, and word of mouth. HC participants had no current or lifetime Axis I or II diagnoses and no exposure to psychotropic medications or psychotherapy. See [Supplementary Materials](#) for full inclusion and exclusion criteria. This study was approved by the New York State Psychiatric Institute Institutional Review Board.

#### 2.1.2. Procedures

Individuals with AN were tested within 3 weeks of hospital admission. All participants provided written informed consent to partake in this study. First, they were administered semi-structured psychiatric interviews by trained research staff and completed self-report questionnaires (see below), followed by the Slips-of-action paradigm. Height and weight were measured to calculate BMI.

#### 2.1.3. Measures

The Structured Clinical Interview for the Diagnostic Statistical Manual IV (SCID) (Spitzer et al., 2006) was used to screen for DSM-IV Axis-I disorders. Eating disorder symptoms were measured using the global mean scores on the Eating Disorder Examination (EDE) (Fairburn et al., 2008) and Eating Disorder Examination Questionnaire (EDE-Q) (Fairburn and Beglin, 2008). Depressive symptoms were measured using the Beck Depression Inventory (BDI-II) (Beck et al., 1996). Anxiety symptoms were measured using the State Trait Anxiety Scale (STAI) (Spielberger et al., 1983). Impulsivity was measured using the Barratt Impulsiveness Scale (BIS) (Patton et al., 1995). Internal consistency values for the measures used can be found in the [Supplementary materials](#).

#### 2.1.4. Slips-of-action paradigm

A validated and shortened version of the original 'Fabulous Fruit Task' designed to investigate goal-directed behaviour and habit learning was used (de Wit et al., 2012; Gillan et al., 2011) (see Worbe et al., 2015 for the simplified version). The task involves 3 stages: instrumental discrimination training, simple outcome devaluation choice test, baseline test vs. Slips-of-action test (see Fig. 1). In the initial instrumental training stage of this paradigm, participants learned by trial-and-error which responses led to

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