Maladaptive Rule-Governed Behavior in Anorexia Nervosa:

The Need for Certainty and Control

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Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor
of Philosophy, in the Department of
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ABSTRACT

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Abstract

Anorexia nervosa (AN) is a deadly disorder characterized by the persistence of dangerous behaviors (e.g., dietary restriction) even when deleterious health outcomes occur. Despite this, our understanding of factors that promote and maintain such rigidity is lacking. The current paper proposes a model suggesting that rigid behaviors in AN can be formulated as maladaptive rule-governed behavior (RGB) that emerges in situations of uncertainty, such as in the presence of affective arousal. An empirical study examining differences in RGB between individuals weight-recovered from AN (AN-WR) and healthy controls (CN) in neutral and stressful situations is described. Seventy-four adults (AN-WR: 36; CN: 38) were randomized to undergo either a stressful or neutral mood manipulation and then completed a laboratory assessment of RGB, the Wisconsin Card Sorting Test (WCST), along with questionnaires assessing degree of uncertainty experienced during the WCST and general intolerance of uncertainty. While the mood manipulation did not significantly impact WCST performance in either group, the AN-WR group demonstrated significantly more total correct items but a greater number of perseverative errors than the CN group. Furthermore, these outcomes were related to greater levels of uncertainty experienced during the task along with general fears of uncertainty. Results provide support for using the frame of maladaptive RGB in as a model of rigidity in AN and may explain why dangerous behaviors continue even when health consequences emerge. These findings extend our current knowledge of

rigidity in AN and suggest that targeting difficulties with uncertainty may be an important treatment component needed in interventions.

Dedication

This is dedicated to the women and men who participated in this study. I can only hope that this work honors your willingness to share your story.

Falling asleep at last

I vow with all beings

To enjoy the dark and the silence

And rest in the vast unknown

-Robert Aitken

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1. Introduction

Anorexia nervosa (AN) is a severe and poorly understood psychiatric disorder characterized by restriction of energy intake leading to a significantly low body weight, intense fear of weight gain, and disturbance in the way the body is experienced (American Psychological Association, 2013). As the leading cause of disability and mortality among psychiatric illnesses, including a 57-fold risk of death by suicide (Keel et al., 2003), the medical and psychological impact of the disorder is remarkable. Despite the serious nature of AN, our understanding of disorder etiology and maintenance remains limited, as exemplified by the current absence of effective treatments for adults (Bodell & Keel, 2010).

Those with AN are characterized as extremely ritualized and perfectionistic individuals who have difficulty adapting to change (Kaye, Wierenga, Bailer, Simmons, & Bischoff-Grethe, 2013; Strober, 1980). These individuals rigidly adhere to verbally formulated rules and routines despite the presence of negative outcomes, such as occurs with the relentless adherence to dietary rules even in the face of death. Furthermore, rigid and inflexible behaviors seem to predate illness onset and continue post recovery (Strober, 1980; Tchanturia et al., 2004). An enhanced understanding of this core phenomenology may lend important insight into the development of novel interventions.

This paper will propose that rigid behaviors in AN can be formulated as maladaptive rule-governed behavior (RGB) that emerges in contexts of uncertainty, such as in the presence of affective arousal. An overview of RGB will first be presented using findings from the human operant laboratory. A model of maladaptive RGB will then be described and discussed as a way to understand rigid behaviors in AN with a rationale suggesting that rigidity may be intensified in the presence of affective arousal. Emerging findings from the neurocognitive literature will be interpreted as evidence of the proposed model. Following this, an empirical study with aims to characterize RGB in AN and explore the influence of affective arousal will be presented and findings discussed.

1.1 RGB: An Overview

Using a model of maladaptive RGB to formulate rigidity in AN requires an understanding of how one acquires, adheres, and updates verbal rules in accordance with feedback from the environment. The study of verbal rule-learning and thus RGB is vast and a complete review is beyond the scope of the current paper. A basic introduction of RGB will be provided followed by several important findings from the operant laboratory that have direct implications for AN.

1.1.1 RGB Versus Contingency-Based Behavior

Behavior can be determined by verbal antecedents (i.e., RGB) and/or environmental contingencies (contingency-based behavior; Cantania, Shimoff, &

Matthews, 1989). According to Skinner (1969) "rules" reflect a class of verbal statements that describe contingencies of reinforcement or punishment. Rules, therefore, include instructions, advice, policies, and commands in addition to verbal contingencies specifically labeled as "rules" (Skinner, 1969). While rules include the internalization of external guidance from others (e.g., "Don't touch the stove") they also can be self-generated and have similar effects on behavior (Baumann, Abreu-Rodrigues, & da Silva Souza, 2009; Rosenfarb, Newland, Brannon, & Howey, 1992). As such, from a behavioral perspective, any behavior modulated by verbal antecedents is classified as "rule-governed" (Hayes, Thompson, & Hayes, 1989). In contrast, contingency-shaped behavior reflects behavior that develops and persists or ceases as a consequence of variable environmental factors. The distinction of RGB and contingency based behavior is important given these determinants of behavior show different patterns of *acquisition* and *extinction* as will be discussed below.

Verbal learning and contingency-based learning can generate similar behavioral responses. For example (see Cantania, 1997), one can rapidly learn that a stove should not be touched through a mother's verbal instruction of "Do not touch the stove as it will burn you" (RGB). This can also be learned via direct experience as the individual feels the heat intensity increase as her hand gets closer to the stove (contingency-shaped behavior). Each type of learning has different patterns of acquisition and extinction with unique advantages and limitations. RGB and contingency-based behavior are therefore more or less adaptive depending upon the situation.

The acquisition of RGB is faster than contingency-based behavior (Catania, 1997). For example, it will take a novice baker far less time to make cookies by following instructions than by trial and error. Without such verbal rules, the novice baker would have to use environmental contingences as a guide (e.g., when I bake the cookies at this temperature they are undercooked, but when I bake them at this temperature they burn). Verbal rules therefore quickly transfer the experience of one individual (e.g., professional baker) to another (e.g., novice baker) without the need for direct contact with the contingencies. Such rapid acquisition can be advantageous when contact with the environmental contingences would be burdensome and lengthy (e.g., baking chocolate chip cookies for the first time), impair safety (e.g., cutting yourself with a knife can be dangerous or even deadly), or when feedback from contingencies is distal (e.g., one cannot contact the negative impact of current smoking on the lungs until many years later). Thus, it is especially adaptive to quickly acquire new behaviors in particular situations.

While the acquisition of RGB occurs more rapidly than contingency-based behavior, verbally ascribed behavior is less sensitive to changing environmental contingencies (Hayes & Gifford, 1997). That is, a behavioral response under the control of verbal rules is slower to extinguish with the removal of reinforcement. Thus, even when consequences change, the response persists (e.g., continuing to bake cookies at a certain temperature in accordance with the "rule" even though the cookies keep burning). Termed the *insensitivity effect* (Catania, 1997), behavior acquired through verbal rules may continue even when maladaptive.

Contingency-based behavior, on the other hand, is more sensitive to changing conditions and extinguishes more quickly upon the removal of reinforcement (e.g., adjusting the temperature at which one bakes cookies rather than continuing to bake them with a temperature at which they have previously burned). This sensitivity to contingencies is often necessary in the presence of a changing environment and certainly for the moment-to-moment changes of internal experience. For example, the behaviors of initiating and stopping feeding most adaptively follow changes in internal experience (e.g., hunger and satiety).

In sum, rule-based and contingency-based behavior show unique patterns of acquisition and extinction. Responses controlled by verbal rules are faster to develop and therefore are essential in specific situations. However, RGB is slower to adapt to changes in environmental contingencies and responses may persist even when maladaptive (i.e., *insensitivity effect*). In contrast, contingency-based behavior emerges through a history of interaction with the environment and thus is slower to develop but faster to extinguish when responses are no longer reinforced. Some responses cannot be verbally guided and thus learning necessitates direct learning experiences.

While there are predictable patterns associated with RGB versus contingency-based learning, human behavior is complex and includes the integration of rules and shaped behavior. A rigid reliance on either mode of learning would lead to maladaptive outcomes outside of specific contexts under which they are effective (e.g., baking the cookies at a specific temperature may often work and is therefore adaptive; however, *always* baking cookies at that temperature even when using an oven of lower wattage would not be effective and would represent an overreliance on rules to the neglect of important contextual variables).

1.1.2 The Insensitivity Effect

Verbal rules have been found to induce the *insensitivity effect* by 1) precluding sufficient contact with environmental contingencies and 2) by blunting the effectiveness of experiential contact that does occur (Hayes, Brownstein, Zettle, & Rosenfarb, 1986; Hayes & Gifford, 1997). Work conducted in the operant laboratory by Hayes and colleagues demonstrates this lack of responsiveness to contingencies in the presence of verbal rules (Hayes et al., 1986). In this study, participants were asked to move a light through a matrix by pushing a button during three separate 32-minute sessions. Participants were informed that two different signal lights indicated the schedule of reinforcement (i.e., a green light signaled one to “go fast” indicating a fixed ratio schedule and a red light to “go slow” reflecting a differential-reinforcement of low-rate-schedule). The instruction lights were no longer illuminated after the first session for half of the participants. Individuals were randomized to one of three conditions, which differed by the pattern of signal light illumination. In two of the conditions, only one signal light, either the green light ("go fast" condition) *or* the red light ("go slow" condition), was exclusively illuminated during the experiment. In the third condition, illumination of the signal lights alternated between each other at one-minute intervals ("go fast/go slow" condition). Unbeknownst to the participants, the actual experimental reinforcement schedule alternated between a fixed ratio schedule and a differential-reinforcement of low-rate schedule every two minutes. As such, the signal lights were accurate only 50% of the time in each of the conditions. If instructions were followed in either the "go fast" or "go slow" condition, then participants would have learned only one of the responses that successfully moved the light through the matrix. However, individuals in the other condition were instructed to produce multiple responses in accordance with two lights that illuminated at different times. These participants should have learned that both pushing the button rapidly and pushing the button slowly at times resulted in the successful movement of the light through the matrix if they followed the instructions.

Overall, participants followed the instructions of their respective condition even when doing so interfered with successfully moving the light through the matrix (indicating rule-based insensitivity). However, when the instruction lights were no longer activated, a different pattern emerged. Individuals in the "go fast/go slow" condition immediately exhibited behavior consistent with the experimental reinforcement schedule. That is, once the instruction lights were no longer illuminated, these individuals rapidly demonstrated alternating behavioral responses in accordance with the reinforcement contingencies and successfully moved the light through the matrix. The authors suggest this indicates that the *insensitivity effect* was promoted via the instructions, or rules, initially exerting control over the behavioral responses instead of the actual reinforcement contingences. They argue that this may have been promoted by a history of rule-following mediated by social contingencies (i.e., the experimenter's instructions). An inaccurate understanding of the reinforcement contingencies was unlikely given they quickly responded adaptively after the instruction lights were removed. The participants in the "go fast" condition or the "go slow" condition, however, demonstrated continued adherence to their instructions even in the absence of the signal lights. This indicates that the instructions precluded full contact with the reinforcement contingencies. That is, because of the instructions, these individuals only learned that one behavioral response moved the light through the matrix. This response was only successful half of the time and learning other responses would have been more adaptive. The instructions therefore interfered or prevented these individuals from emitting other behavioral responses and they therefore failed to learn that another response was successful at moving the light through the matrix the rest of the time.

Although more empirical data are needed, individual differences may enhance the *insensitivity effect*. Wulfert and colleagues (1994) examined the correspondence between self-reported rigidity and rule-governed insensitivity to changing contingencies. They hypothesized that individuals classified as "rigid" would more likely have a history of experiencing a stronger reinforcement pattern for rule following. As such, their learning history would generate RGB even when following rules was ultimately maladaptive (Wulfert, Greenway, Farkas, & Hayes, 1994). A similar paradigm as described above was implemented comparing individuals classified as either "rigid" or "not rigid" using extreme scores on an index of self-reported rigidity. Individuals either received "minimal" instructions indicating they would receive points for moving a marker through a matrix or "accurate" instructions in which they were also informed that the specific color of a signal light corresponded with the best way to push the button (e.g., "fast pushes" work best when the light is blue). After two behavioral acquisition sessions, an unannounced extinction session followed during which the marker ceased any movement and no longer responded to any type of button push.

As expected, higher scorers on the rigidity scale predicted greater behavioral persistence during the extinction period despite the change in the reinforcement schedule. That is, individuals classified as "rigid" continued to engage in pushing the button despite a lack of movement by the marker. Furthermore, while behavioral persistence was more pronounced in the accurate instruction condition, there was also evidence of persistent behavior among those who received minimal instructions and therefore these individuals continued to follow even the minimal rule of "push the button" despite the absence of any reinforcement. Findings demonstrate that rigidity may in fact be an individual difference factor that is associated with enhanced rule-governed insensitivity as "rigid" individuals failed to adapt to the changing environmental contingencies.

1.1.3 Summary

In sum, basic research from the operant laboratory supports several important features of RGB. First, RGB can foster the rapid acquisition of behavioral responses, which may promote adaptive behavior more quickly than would contingency-based behavior. Second, RGB can enhance insensitivity to changing environmental contingencies via insufficient contact with feedback necessary for effective adjustment of behavior, reducing the effect contact with the contingencies does have, and individual difference factors including rigidity. As such, behavior that once was adaptive may persist despite an alteration in reinforcement schedules and this may be more likely among individuals with particular temperaments or trait features. Third, rule-following has the same impact on behavior whether derived from an external source or is self-generated.

1.2 Rigidity in AN as Maladaptive RGB

A model informed by findings from the operant laboratory will propose that rigid behaviors in AN can be conceptualized as maladaptive RGB. It will be suggested that an intolerance of uncertainty and the need for control promotes an overreliance on

RGB among individuals with AN in uncertain situations. It will then be argued that the consequences of RGB promote a self-maintaining system of rigid behaviors in AN. The application of the proposed model to the rigid adherence of dietary rules will be provided. Following this, a rationale suggesting that rigidity may be intensified in the presence of affective arousal will be presented.

1.2.1 Maladaptive RGB in AN: A Proposed Model

Individuals with AN are often characterized by a fear of uncertainty and a need for control (Konstantellou & Reynolds, 2010; Merwin et al., 2011; Piech, Hampshire, Owen, & Parkinson, 2009; Schmidt & Treasure, 2006; Sternheim, Konstantellou, Startup, & Schmidt, 2011). Individuals with AN report that the experience of uncertainty is highly aversive and necessitates behavioral strategies (e.g., scheduling) as a means to re-establish control (Sternheim et al., 2011). One individual from a recent qualitative study described her experience of uncertainty as "…feeling very out of control and it forces the need to have some certainty and predictability and the need for that gets transferred into day to day having routines, structure and lots of mental organizing and worrying about this and trying to problem solve because that means you have some control over a very certain life and world" (Sternheim et al., 2011, p. 19).

It is proposed that the fear and need for control in the presence of uncertainty drives an overreliance on rules, which are positively and negatively reinforced, even when they may ultimately be maladaptive. First, the reliance on rules is thought to initially work as an effective strategy as it results in positive outcomes (i.e., it works). Additionally, and importantly, rules may provide a sense of predictability and control by reducing the aversive experience of uncertainty. However, such rule-following would be expected to increase insensitivity to changes in environmental contingencies-and thus not extinguish even in the absence of continued reinforcement or when negative outcomes occur.

The reliance on verbal rules may also interfere with the individual learning alternative behaviors that may be more effective or conducive to valued living. The failure to learn other ways to cope with uncertainty outside of rule-following would subsequently promote the continued reliance on rules to guide behavior. This may occur, even when the individual receives (and contacts) feedback that the response is ineffective, as the individual has not learned alternative ways to respond and feels that rules are the solution. A self-perpetuating cycle is therefore proposed with rigidity in AN formulated as maladaptive RGB (see Figure 1).

The application of the model to dietary rules provides an illustration of the onset and maintenance of rigidity using the above formulation. It has long been demonstrated that individuals with AN use dietary rules to control weight and shape (Steinglass et al., 2011; Sysko, Walsh, Schebendach, & Wilson, 2005). Dietary needs for weight management depend on various uncontrollable and unknown factors such as metabolism and energy expenditure. Relying on the body to determine nutritional needs and regulate weight is likely to be too risky for these individuals who desire certainty and demand perfection (Bastiani, Rao, Weltzin, & Kaye, 1995; Frank et al., 2012; Halmi et al., 2000; Srinivasagam, Kaye, Plotnicov, & Greeno, 1995; Sternheim et al., 2011). As such, dietary rules (e.g., "I must not eat more than 600 calories per day") would presumably manage the *uncertainty* associated with the amount an individual should eat to lose weight by reinstating a sense of control and attenuating the uncomfortable emotional and physiological correlates of this feared state (e.g., rapid heartbeat, churning stomach). This would be much preferred to using feedback from the body (e.g., hunger and satiety cues) to continually assess one's nutritional needs, as this is an uncertain strategy with the potential for weight gain.

Following implementation of the dietary prescriptive of only 600 calories per day, the individual would receive feedback regarding the successfulness of this rule. Presumably with this calorie reduction the result would be weight loss (*positive reinforcement*). While the rule is effective as it led to weight loss, the reliance on the rule as a guide for behavior would lead to responses that persist even when the contingencies change. As such, the adherence to the dietary rules would be expected to continue even in the presence of negative outcomes (e.g., dangerously low weight), as the individual is insensitive to feedback. Furthermore, the individual would become insensitive to the very stimuli needed to adaptively regulate eating (i.e., hunger and satiety cues), which would require the continued reliance on dietary rules to guide eating.

Importantly, the adherence to dietary rules would prevent the individual from learning other more adaptive ways to regulate eating and cope with the experience of uncertainty. As such, even if the individual is able to contact the reality of dangerous health consequences, she would not have access to alternative coping strategies, such as practicing accepting the experience of uncertainty and using bodily cues to guide eating. She would therefore need to rely on the known and predictable strategy of dietary restriction, which would further perpetuate dietary rigidity.

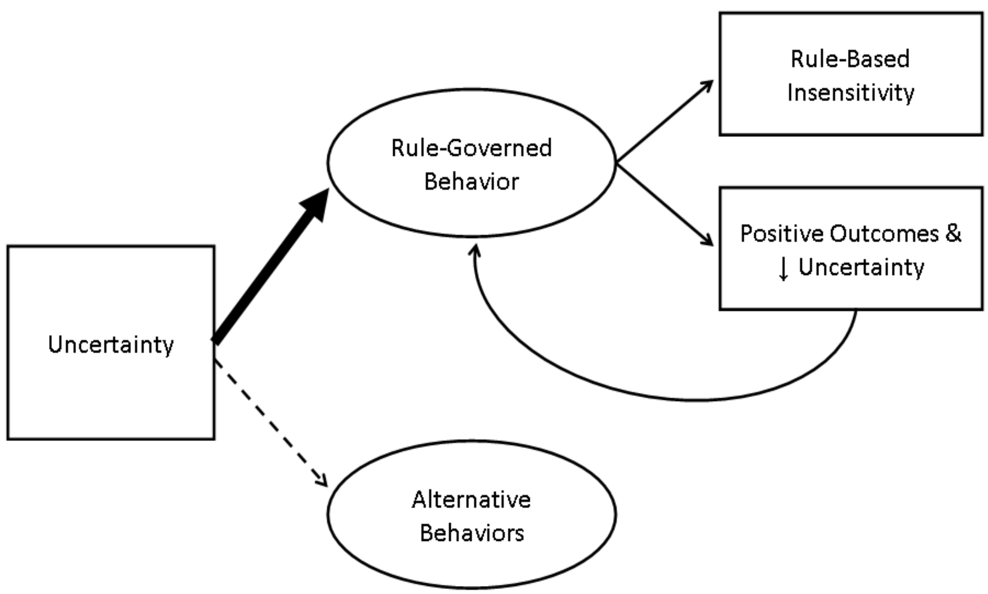

Figure 1: A Proposed Model of Maladaptive RGB in Anorexia Nervosa

1.2.2 Maladaptive RGB in AN: The Presence of Affective Arousal

In her classic work examining the spectrum of abnormal eating, Bruch (1961) argued that a core and common deficit in interoceptive awareness was the source of aberrant eating patterns. Bruch suggested that both obese individuals who engaged in overeating and underweight and emaciated individuals who engaged in severe restriction evidenced impairments in interoceptive awareness—awareness, identification, and responsiveness to internal physiological and emotional states (Bruch, 1961). A lack of interoceptive accuracy may promote confusion over current physiological and emotional states. In support of this, a substantial body of work has shown elevated levels of alexythymia (i.e., difficulty identifying and labeling emotional states) in individuals with AN (Bourke, Taylor, Parker, & Bagby, 1992; Cochrane, Brewerton, Wilson, & Hodges, 1993; Schmidt, Jiwany, & Treasure, 1993). As such, these individuals demonstrate difficulties distinguishing between hunger, satiety, and affective states making the "best" course of action highly uncertain (Bruch, 1961).

Furthermore, individuals with AN find emotional experience distressing (Haynos & Fruzzetti, 2011). It has been shown that individuals with AN perceive and/or experience emotions more intensely (Merwin et al., 2013; Zucker et al., 2013), demonstrate higher levels of emotional reactivity compared to controls (Uher et al., 2004; Zonnevylle-Bender et al., 2005), and struggle with emotion regulation (Harrison, Sullivan, Tchanturia, & Treasure, 2009; Harrison, Sullivan, Tchanturia, & Treasure, 2010;

Merwin et al., 2013). These individuals therefore not only find affective experience distressing, but they also struggle to find healthy ways to regulate, or control, their emotions. This may perpetuate uncertainty and a loss of control over their internal experience.

It is hypothesized that RGB and consequent rule-based insensitivity in AN is likely to emerge and intensify in the context of heightened affect, a presumed state of significant uncertainty for these individuals. Following the model, rules may arise as a way to reinstate predictability and control over internal experience. This view would be commensurate with theoretical models positing AN as a disorder of emotion dysregulation with symptoms used as a means to control affective experience (Harrison et al., 2009; Haynos & Fruzzetti, 2011; Merwin et al., 2011; Schmidt & Treasure, 2006). That is, AN symptoms, such as the rigid adherence to dietary rules, are thought to compensate for emotion regulation difficulties (Haynos & Fruzzetti, 2011; Merwin et al., 2011). Predictions from this would imply that in a state of heightened affect, those with AN would become increasingly rule-governed and thus insensitive to changing environmental contingencies resulting in behavioral rigidity even when maladaptive.

1.2.3 Summary

A model formulating behavioral rigidity in AN as maladaptive RGB has been presented. It has been proposed that rigid behaviors will increase in the presence of uncertainty, such as during states of affective arousal, and that this rigidity reflects rule-based insensitivity and a failure to learn alternative adaptive responses. Rule-based insensitivity may therefore explain why the dangerous behaviors seen in AN, such as dietary restriction, persist even in the face of deleterious health outcomes.

1.3 Maladaptive RGB in AN: Evidence from Neurocognitive Deficits

1.3.1 Set-Shifting Deficits as Rule-Based Insensitivity and Inflexibility

The neurocognitive analysis of set-shifting provides the greatest empirical support for behavioral rigidity in AN. Impaired set-shifting, or the ability to move back and forth between cognitive and behavioral sets, has been demonstrated among individuals currently ill with AN, recovered from AN, and among nonaffected sisters of AN probands using various laboratory tasks (e.g., Roberts, Tchanturia, & Treasure, 2010; Steinglass, Walsh, & Stern, 2006; Tchanturia et al., 2004). Such findings have led to the postulation of impairments in cognitive-behavioral flexibility as a potential endophenotype (Friederich & Herzog, 2011; Treasure, 2007; Zastrow et al., 2009).

Various laboratory tasks have been used to examine set-shifting in AN; however, the Wisconsin Card Sorting Task (WCST; Berg, 1948) is one of the most widely used tasks and continually demonstrates robust effects (Roberts et al., 2010; Tchanturia et al., 2012). Importantly, the WCST is a rule-based task that requires the acquisition and implementation of a derived rule along with the ability to shift to a new rule when given feedback that this behavioral response is no longer adaptive or “correct.” While different laboratory tasks have shown set-shifting deficits during the actively ill state, the WCST continues to demonstrate deficits post-recovery. Evidence from this comes from one of the largest studies on set-shifting to date, which implemented a battery of tests assessing set-shifting ability including the WCST, the Brixton Task, the Trail Making Test, and Haptic Illusion (Roberts et al., 2010). The sample of 270 individuals included those who currently met criteria for AN or had a past AN diagnosis but had been weight restored for at least one year and were absent of eating disorder symptoms, along with healthy controls and other eating disordered groups. Interestingly, while those with a current AN diagnosis evidenced deficits in set-shifting across the majority of tasks, individuals recovered from AN demonstrated deficits exclusively on the WCST, though to a lesser degree than their actively symptomatic counterparts.

It is important to note that not all studies have found set-shifting deficits post-recovery using the WCST (Nakazato et al., 2009), though this study included a sample of only 18 recovered individuals. While a couple studies have found evidence that set-shifting deficits are captured in other non-rule based tasks post recovery (Tchanturia et al., 2004; Tenconi et al., 2010), findings across studies demonstrate the most support for the WCST (Tchanturia et al., 2012; Tenconi et al., 2010). For example, Tchanturia and colleagues administered the WCST to a sample of 542 participants (including 90 individuals recovered from AN). Continued set-shifting deficits were again found among individuals post recovery, but as in Roberts et al. (2010), to a lesser degree than those in the acute stage of illness.

The Brixton Spatial Task (Burgess & Shallice, 1997) is also a rule-based task. It is not surprising, however, that Roberts and colleagues (2010) did not find set-shifting deficits post-recovery using this task, findings which have been replicated using a large sample of 72 individuals in long-term recovery from AN (Tchanturia et al., 2011). The Brixton Spatial Task, unlike the WCST, explicitly instructs participants that their derived rules will change. In other words, individuals are given a higher order *rule*. Thus, individuals with AN may be more successful in this task as the task is not ambiguous and following this higher order *rule* would actually lead to positive outcomes. Such findings are consistent with other studies that have demonstrated that individuals currently ill with AN did not differ from healthy controls on a set-shifting task when provided overt instructions, but performed significantly worse when instructions were ambiguous and a higher order *rule* was not given (Pignatti & Bernasconi, 2013).

Taken together, the WCST largely and almost exclusively continues to demonstrate set-shifting deficits in AN post recovery. Such findings potentially reflect that the WCST may be better able to capture set-shifting deficits, and perhaps an underlying source of such difficulties, that continues outside of the ill state. Unlike most other set-shifting tasks, the WCST is an ambiguous rule-based task. Furthermore, other rule-attainment tasks that explicitly provide instructions of a higher order rule do not evidence continued deficits among individuals with AN after recovery. Thus, one hypothesis is that the behavioral tendency to perseverate in AN, as demonstrated by set-shifting deficits on the WCST, may in part be explained by rule-based insensitivity.

The WCST requires individuals to sort cards consisting of different combinations of three variables: shape, color, number. Upon presentation of a target card (e.g., two red crosses), the participant is asked to sort the card into one of four stacks that each have a different face card (e.g., one red circle, two green stars, three blue squares, or four yellow crosses). The target card can match three of the face cards on different criteria. At any instance there are thus different potential ways in which the card can be correctly sorted. For example, the target card could be correctly sorted into the stack with the red circle face card as they both share the same color, the stack with the four yellow crosses face card as they share the same shape, or the stack with two green stars as they share the same number. The participant is given no additional instructions other than to sort the cards and is provided with feedback as to whether or not each card was sorted correctly. Unbeknownst to the participant, the predetermined sorting rule changes throughout the task providing an index of perseveration (i.e., continuing to sort in accordance with a previous rule despite feedback that the rule is incorrect; *perseverative errors*) and therefore rule-based insensitivity. The task is completed after the sorting of 128 cards with categorical rules changing after 10 cards are correctly sorted in accordance with the rule. The number of *categories completed* indicates the number of rules the individual successfully employs, which requires the ability to successfully acquire, maintain, and adjust rules in response to changing contingencies.

The WCST requires the capacity to implement hypothesis testing to derive a rule (*acquisition*) and then continuing to update behavior in accordance with changing contingencies. This requires one to stop behavioral responses following a rule that was once effective but is no longer effective (*extinction*). Additionally, this also requires one to adaptively implement rules and corresponding behavior in response to changing contingencies (*flexibility*). For example, a once successful rule may no longer be effective after a contingency change but may again be effective after a later contingency change. Thus, successful outcomes require the flexible application of rules.

Studies consistently demonstrate impairments in set-shifting in AN as operationalized by a greater amount of *perseverative errors*, with some studies also using number of *completed categories* relative to healthy control individuals (Roberts, Tchanturia, Stahl, Southgate, & Treasure, 2007; Roberts et al., 2010; Steinglass et al., 2006). Such findings may also be interpreted as rule-based insensitivity and inflexible RGB respectively. That is, *perseverative errors* provides an index of rule-based insensitivity as it measures the continued implementation of a rule that is no longer successful due to changing contingencies (i.e., the number of times an individual continues to sort a card based on a previously successful rule that is now "wrong"). The number of *completed categories* would provide a measure of rule flexibility as it encompasses the ability to acquire, maintain, extinguish and change rules adaptively.

While WCST findings suggest maladaptive RGB in AN, other outcomes further characterizing rule acquisition, extinction, and flexibility have either not been assessed or are have not been commonly been reported. Identifying the parameters of RGB will allow for the isolation of specific maladaptive response patterns and thus guide novel intervention development in AN (see Figure 2 for a diagram of potential maladaptive response patterns and Table 1 for a description of current and proposed WCST outcomes reflecting these parameters).

Describing rigidity at the level of neurocognition provides one important way from which to understand AN behaviors. However, formulating rigidity in terms of contextual variables (e.g., reinforcement contingencies) may complement these more biologically based explanations and allow for the advancement of CBT interventions.

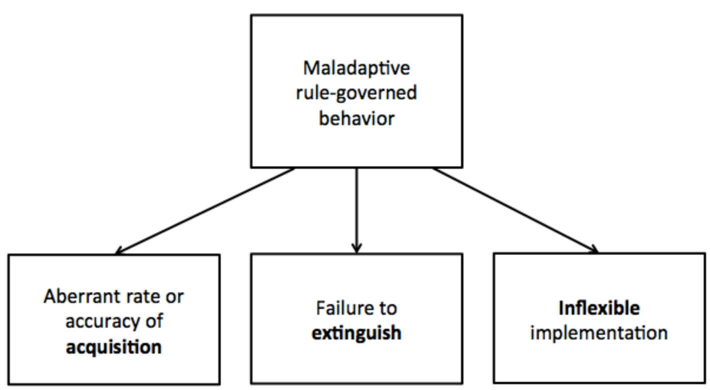

Figure 2: Potential Maladaptive RGB Response

Table 1: WCST Outcomes

WCST Score	Description	Rule-Learning Component
Rule Rate Accuracy*	Number of cards sorted before an accurate rule is implemented (lower scores = faster acquisition).	**Acquisition** rate of accurate rule in the 1st category.
# of Trials to Complete 1st Category	Number of cards sorted before first rule change including the 10 cards that must be accurately and consecutively sorted (lower scores = faster acquisition)	Rate of **acquisition** and ability to maintain behavior (i.e., follow an adaptive rule)
Total # Perseverative Errors	Number of responses sorted in accordance with a previously correct rule that is now incorrect (higher scores = greater rule-based insensitivity)	Ability to adaptively **extinguish** behavior and by extension **rule-based insensitivity** across the task
# Perseverative Errors in 2nd Category*	Number of perseverative errors during the 2nd category (higher scores = greater rule-based insensitivity)	Ability to adaptively **extinguish** behavior and by extension **rule-based insensitivity** after first and presumably most unexpected contingency change
# Categories Completed	Number of times a rule was accurately detected and maintained for 10 consecutive sorts (higher scores = greater flexibility)	General ability to acquire and flexibly adjust and implement rules in accordance with changing contingencies (**flexibility**)
Total Correct	Total number of cards correctly sorted (higher scores = greater flexibility)	General ability to acquire and flexibly adjust and implement rules in accordance with changing contingencies (**flexibility**)

Note. Rule implementation is defined as sorting consecutive cards in accordance with the same rule (e.g., color).
* Indicates a novel WCST score.

1.3.2 Affective Arousal and Neurocognition

To date, the influence of affective arousal on RGB outcomes has not been examined. Set-shifting deficits have been associated with anxious and depressive symptoms in AN (Giel et al., 2012; Roberts et al., 2010), but, to our knowledge, an experimental paradigm inducing mood state has not been conducted. Previous laboratory work with healthy controls has demonstrated improvements in neurocognition including cognitive flexibility after positive mood inductions, but negative mood inductions have not been shown to influence outcomes, though laboratory work is notably sparse (see Mitchell & Phillips, 2007 for a review). However, previous work has demonstrated that cognitive flexibility is influenced by motivational factors (e.g., hunger) in healthy controls (Piech et al., 2009), suggesting that cognitive functioning can be negatively impacted by internal states.

There is some evidence that negative mood states impair neurocognition in clinical populations (Graver & White, 2007; Mitchell & Phillips, 2007; Ravnkilde et al., 2002). For example, a recent laboratory study investigated the impact of psychosocial stress on neuropsychological functioning in individuals with social phobia and healthy controls (Graver & White, 2007). Stress was induced by informing participants that they would be videotaped while they completed a battery of neurocognitive tasks. Furthermore, they were informed that this tape would be used as a training video for "hundreds of expert clinicians." Psychosocial stress was found to negatively impact neuropsychological functioning, but exclusively among those struggling with social anxiety.

Taken together, the investigation of negative mood manipulations on acute and sustained cognitive performance is limited, in general, with even less investigation in AN. The work examining the influence of a negative mood induction on cognitive outcomes has not found evidence for impairment among healthy controls (see Mitchell & Phillips, 2007) although there is evidence that motivational factors can negatively impact cognitive functioning (Piech et al., 2009). Furthermore, albeit limited, previous work has shown that affective arousal negatively impacts cognitive functioning in clinical populations (Graver & White, 2007).

1.3.3 Summary

In sum, evidence from the neurocognitive literature suggests that rule-based insensitivity and impaired flexibility may be one way to interpret set-shifting deficits in AN. This formulation may explain inconsistent findings across neurocognitive laboratory tasks employed after recovery. That is, the continued detection of set-shifting deficits in AN after recovery primarily with the WCST, a rule-following task, suggests that aberrant rule-following may account for these differences in outcomes. Importantly, although the literature is small, the findings that set-shifting deficits continue in AN post recovery, although to a lesser degree than their actively ill counterparts, suggest that maladaptive rule-following is not exclusively a result of starvation (Roberts et al., 2007; Tchanturia et al., 2012; Tchanturia et al., 2011; Tenconi et al., 2010). Additional research further characterizing maladaptive RGB in AN and determining the contexts in which this behavior is strengthened outside of the state of starvation is needed. Although a negative mood induction has not been found to impair cognitive functioning in healthy control individuals (Mitchell & Phillips, 2007), some work suggests it has an impact in clinical populations (Graver & White, 2007) and little is known about the influence in AN. Exploration of the impact of affective arousal on RGB in AN may aid our understanding of factors that influence the onset and maintenance of rigid behaviors.

1.4 Current Study

1.4.1 Study Rationale

The previous section argued that rigid behaviors in AN can be formulated as maladaptive RGB. A model suggesting that an overreliance on rules emerges in situations in which the individual with AN experiences uncertainty and/or a loss of control. According to this model, rule following may be initially maintained by positive and negative reinforcement, but may persist in the presence of changing contingencies (including negative consequences) perhaps because of rule-based insensitivity and a poverty of alternative responses.

The neurocognitive literature provides a paradigm (i.e., WCST) to test RGB in AN. Findings from previous studies implementing the WCST provide evidence of rule-based insensitivity and impaired flexibility in AN, but research further characterizing maladaptive RGB in AN is needed. Additionally, the study of rigidity in AN has largely been circumscribed to the starved state of the illness with the few studies examining rigid behaviors post recovery. Exploring maladaptive RGB among individuals weight-recovered from AN will therefore add to this important literature attempting to parse behavioral patterns unique to AN versus those that are a consequence of starvation. Furthermore, identifying situations in which maladaptive RGB emerges outside of the state of starvation will provide important information on factors that contribute to the development and maintenance of behavioral rigidity. It is not known if maladaptive RGB is related to a fear of uncertainty with effects thus potentiated in the presence of affect, a distressing and uncontrollable state for individuals with AN (Haynos & Fruzzetti, 2011). If so, this would provide additional support for the model, as well as advance our understanding of the development and maintenance of rigid behaviors in AN thus providing insight into the needed advancement of interventions.

1.4.2 Study Aims and Hypotheses

Following above, the current study has the following aims and hypotheses:

Aim 1: Determine if there are differences between individuals weight-recovered from AN (AN-WR) and healthy control (CN) individuals in their intolerance of uncertainty, as measured by the Intolerance of Uncertainty Scale (IUS; Buhr & Dugas, 2002; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994); their self-reported ability to regulate emotion as evidenced by the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004); and explore if these variables are related to RGB parameters (Acquisition, Extinction, and Flexibility).

Hypothesis: The AN-WR group will show a greater intolerance of uncertainty and greater difficulties with emotion regulation than the CN group (i.e., IUS: AN-WR > CN; DERS: AN-WR > CN).

Hypothesis: Intolerance of uncertainty and difficulties in emotion regulation will be associated with poorer rule-following outcomes exclusively in the AN-WR group (i.e., IUS and DERS will negatively correlate with WCST scores measuring Acquisition and Flexibility and positively correlate with WCST scores measuring Extinction).

Aim 2: Compare levels of uncertainty reported during the WCST between the AN-WR and CN groups in neutral (Neutral) and anxious (Stress) states and explore if these variables are related to RGB parameters (i.e., Acquisition, Extinction, and Flexibility). Uncertainty during the WCST will be measured by the three following questions: *On average, how certain did you feel about your strategy for sorting the cards?* (WCST Certainty); *On average, how certain about your strategy for sorting the cards did you feel after you were told you were "wrong"?* (WCST Wrong); *What was the greatest level of uncertainty you felt during the task?* (WCST Uncertainty).

Hypothesis: The AN-WR group will report lower levels of certainty and higher levels of uncertainty than the CN group in a neutral state (i.e., WCST Certainty: AN-WR < CN; WCST Wrong: AN-WR < CN; WCST Uncertainty: AN-WR > CN).

Hypothesis: The AN-WR group will report lower levels of certainty and higher levels of uncertainty than the CN group in an anxious state (i.e., WCST Certainty: AN-WR < CN; WCST Wrong: AN-WR < CN; WCST Uncertainty: AN-WR > CN).

Hypothesis: Individuals recovered from AN in an anxious state will report lower levels of certainty and higher levels of uncertainty compared to individuals recovered from AN in a neutral state (i.e., WCST Certainty: AN-WR Neutral < AN-WR Stress; WCST Wrong: AN-WR Neutral < AN-WR Stress; WCST Uncertainty: AN-WR Stress > AN-WR Neutral).

Hypothesis: There will be no differences in reported uncertainty levels between health control individuals in a neutral state compared to healthy control individuals in an anxious state (i.e., WCST Certainty: CN Neutral = CN Stress; WCST Wrong: CN Neutral = AN-WR Stress; WCST Uncertainty: CN Neutral = CN Stress).

Hypothesis: Lower levels of perceived certainty and greater levels of perceived uncertainty will be associated with maladaptive RGB exclusively in the AN-WR group (i.e., WCST Certainty and WCST Wrong will positively correlate with WCST scores measuring Acquisition and Flexibility and negatively correlate with WCST scores measuring Extinction whereas WCST Uncertainty will negatively correlate with WCST scores measuring Acquisition and Flexibility and positively correlate with WCST scores measuring Extinction).

Aim 3: Compare parameters of RGB (i.e., Acquisition, Extinction, and Flexibility) using the WCST between the AN-WR and CN groups in neutral and anxious states.

Hypothesis: The AN-WR group will demonstrate maladaptive RGB relative to the CN group in a neutral state as defined by impaired extinction (i.e., a greater number of Total Perseverative Errors and Number of Errors in the 2^{nd} Category) and reduced flexibility (i.e., few Categories Completed and Total Correct), but will demonstrate faster rates of acquisition (i.e., a lower Rule Rate and fewer Number of Trials to Complete the 1^{st} Category).

Hypothesis: The AN-WR group will demonstrate maladaptive RGB relative to the CN group in an anxious state, as defined by impaired extinction (i.e., a greater number of Total Perseverative Errors and Number of Errors in the 2^{nd} Category) and reduced flexibility (i.e., few Categories Completed and Total

Correct), but will demonstrate faster rates of acquisition (i.e., a lower Rule Rate and fewer Number of Trials to Complete the 1^{st} Category).

Hypothesis: Individuals recovered from AN in an anxious state will demonstrate maladaptive RGB relative to individuals recovered from AN in a neutral state as defined by impaired extinction (i.e., a greater number of Total Perseverative Errors and Number of Errors in the 2^{nd} Category) and reduced flexibility (i.e., few Categories Completed and Total Correct), but will demonstrate faster rates of acquisition (i.e., a lower Rule Rate and fewer Number of Trials to Complete the 1^{st} Category).

Hypothesis: There will be no differences in parameters of RGB between healthy control individuals in a neutral state compared to healthy control individuals in an anxious state as defined by the absence of any significant differences in extinction (i.e., number of Total Perseverative Errors and Number of Errors in the 2^{nd} Category), flexibility (i.e., number of Categories Completed and Total Correct), or acquisition (i.e., Rule Rate and Number of Trials to Complete the 1^{st} Category).

2. Method

2.1 Participants

The sample included 74 adults (97.3% female) living in the Southeastern United States who agreed to participate in a study examining the way individuals with eating disorders process information. Participants were drawn from an initial sample of 88 individuals who expressed interest and underwent the initial diagnostic phone interview, 75 of whom qualified and participated in the current study. One individual who initially qualified for participation was determined to be ineligible on the day of study due to low weight status. Participants were classified into two groups based on a case-control design as follows: weight-restored with a prior diagnosis of AN (AN: n = 36), and no history of AN or other eating disorder (CN: n =38).

2.1.1 AN Inclusion Criteria

Participants in the AN group had to have a previous AN diagnosis in accordance with criteria established by the Diagnostic and Statistical Manual of Mental Disorders V (DSM-V; American Psychological Association, 2010). The criteria for an AN diagnosis are outlined as follows (American Psychological Association, 2010, p. 338):

> A. Restriction of energy intake relative to requirements leading to a significantly low body weight in the context of age, sex, developmental trajectory, and physical health. Significantly low weight is defined as a weight that is less than minimally normal, or, for children and adolescents, less than that minimally expected.
>
> B. Intense fear of gaining weight or becoming fat, or persistent behavior that interferes with weight gain, even though at a significantly low weight.

C. Disturbance in the way in which one's body weight or shape is experienced, undue influence of body weight or shape on self-evaluation, or persistent lack of recognition of the seriousness of the current low body weight.

In addition to a history of an AN diagnosis, individuals in the AN group also had to have been weight-recovered for at least 6 months. Weight recovery was defined as having a body mass index (BMI) greater than or equal to 18.5 unless the individual indicated that a healthy weight for their body was lower than the 18.5 cut-off. A weight below a BMI of 18.5 met eligibility for weight restoration if the following criteria were met: 1) the participant consistently maintained this weight without attempts to restrict calories or engage unhealthy weight loss behaviors (e.g., self-induced vomiting, excessive exercise), 2) the participant had a regular menstrual cycle, 3) there were no other signs of medical compromise at this weight.

2.1.2 CN Inclusion Criteria

Participants in the CN group were included if they did not have a history of AN or other eating disorder.

2.1.3. Exclusion Criteria

Study exclusion criteria selected to control for the influence of severe psychopathology. Participants were excluded from study participation if they had a lifetime diagnosis of bipolar disorder, a thought disorder such as schizophrenia, a learning disability, or were currently struggling with substance abuse. The use of psychotropic medication was permitted in both the AN-WR and CN groups as long as the participant had been on a steady dosage for at least two months.

2.2 Measures and Assessments

The self-report measures (see Table 2) and assessments described below were selected to characterize the sample on current eating disorder symptoms and attitudes, psychopathology, intolerance of uncertainty, emotion regulation ability, and intelligence.

2.2.1 Eating Disorder Examination—Questionnaire (EDE-Q)

The Eating Disorder Examination-Questionnaire (EDE-Q; Fairburn & Beglin, 1994) is a 41-item self-report version of the Eating Disorder Examination (EDE; Fairburn, Wilson, & Schleimer, 1993). Similar to the EDE, the EDE-Q measures eating disorder psychopathology and yields the same diagnostic criteria and four subscales scores. Normative data collected from a large sample of young adult women (*n* = 5231) between 18 and 42 years of age produced the following subscale means: Restraint (*M* = 1.30, *SD* = 1.40), Eating Concern (*M* = 0.76, *SD* = 1.06), Weight Concern (*M* = 1.79, *SD* = 1.51), Shape Concern (*M* = 2.23, *SD* = 1.65) (Mond, Hay, Rodgers, & Owen, 2006). Additionally, recent norms collected from a large AN sample (*n* = 382) had a Global Score mean of 4.17 (*SD* = 1.30) and a general population (*n* = 235) Global Score mean of 0.93 (*SD* = 0.86) (Aardoom, Dingemans, Slof Op't Landt, & Van Furth, 2012). Good convergence between the EDE and EDE-Q has been documented among community and clinical samples, though inconsistencies have been reported (e.g., Fairburn & Beglin, 1994; Mond, Hay, Rodgers, Owen, & Beumont, 2004). The internal consistency of the EDE-Q has been supported in clinical and college undergraduate populations (Peterson et al., 2007) and acceptable concurrent validity, criterion validity, and test-retest reliability have been documented (Mond et al., 2004).

2.2.2 Brief Symptom Inventory (BSI)

The Brief Symptom Inventory (BSI; Derogatis & Spencer, 1993) is a shortened form of the revised version of the Symptom Checklist-90 (Derogatis & Savitz, 1999), a self-report measure of symptom levels reflecting psychopathology. The BSI consists of 49-items that form nine symptom dimensions (Somatization, Obsession-Compulsion, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid ideation, and Psychoticism) and four additional clinically relevant items that do not factor into any of the dimensions. Participants are asked to indicate level of distress resulting from each symptom over the past seven days using a Likert scale ranging from "0 = Not at all" to "4 = Extremely." Sample items include "Feeling lonely," "Nausea or upset stomach," and "Temper outbursts that you could not control." Scores can be converted to T-scores with a recommended clinical cut-off of $T \geq 65$ (Derogatis & Spencer, 1993). The BSI has shown good internal consistency reliability for the nine dimensions with alpha coefficients ranging from 0.71 to 0.85, and test-retest reliability coefficients ranging from 0.68 to 0.91 (Derogatis & Spencer, 1993). Good convergent, construct, and predictive validity have been reported (Derogatis & Spencer, 1993).

2.2.3 Intolerance of Uncertainty Scale (IUS)

The Intolerance of Uncertainty Scale (IUS; Buhr & Dugas, 2002; Freeston et al., 1994) assesses the degree to which uncertainty is experienced as unacceptable, leads to frustration and stress, and impairs the ability to take action. The scale consists of 27-items using a five-point Likert scale ("1 = Not at all characteristic of me" to "5 = Entirely characteristic of me"). Higher scores indicate a greater intolerance of uncertainty. Sample items include "Uncertainty makes me uneasy, anxious or stressed," "Uncertainty makes life intolerable" and "My mind can't be relaxed if I don't know what will happen tomorrow." A recent study administered the IUS to a sample of individuals with an eating disorder and healthy controls (Piech et al., 2009). Results indicated a mean of 82.4 (*SD* = 19.4) among 30 individuals with AN compared to a mean of 48.3 (*SD* = 11.3) among 28 healthy controls (Frank et al., 2012). The IUS has demonstrated good psychometric properties. Excellent internal consistency has been shown with a Cronbach's alpha of 0.94 and item-total correlations ranging from 0.36 to 0.77 (Burh & Dugas, 2001). Good test-retest reliability has been demonstrated over a five-week period (*r* = 0.74) (Burh & Dugas, 2001). Cronbach's alpha for the current study was 0.94.

2.2.4 Difficulties in Emotion Regulation Scale (DERS)

The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) is a self-report assessment of emotion regulation capacities with higher scores indicating greater difficulties in emotion regulation. The scale consists of 36 statements related to emotion regulation capacities and asks the individual to indicate how often each of the statements apply using a five-point Likert scale ranging from "1 = Almost Never (0-10%)" to "5 = Almost Always (91-100%)". Sample items include "I know exactly how I am feeling," "When I'm upset, I have difficulty getting work done," and "When I'm upset, I feel guilty for feeling that way." Norms derived from a sample of female college aged students indicates a DERS overall mean of 77.99 (*SD* = 20.27). Good psychometric properties have been demonstrated, including high internal consistency (subscale Cronbach's alpha ranged between 0.80-0.89) and adequate construct and predictive validity (Gratz & Roemer, 2004). Cronbach's alpha for the current study was 0.82.

2.2.5 State-Trait Anxiety Inventory—Form Y (STAI)

The state scale of the State-Trait Anxiety Inventory (STAI; Spielberger,1983) was selected to assess the effect of the mood manipulation. The STAI state scale is a brief questionnaire intended to capture fluctuations in anxiety in response to stressors with higher scores indicating greater state levels of anxiety. The STAI state scale consists of 20 statements reflecting acute anxiety (e.g., "I am tense"; "I feel nervous") and asks people to indicate how they feel "right now, that is, at this moment" using a 4-point intensity scale (“0 = not at all” to “4 = very much so”). Norms derived from a sample of 645 female college-aged students indicates a mean STAI state scale score of 39.36 when tested in a nonstressful situation and 60.51 when tested in a stressful situation (Spielberger, 1983). Good psychometric properties have been demonstrated, including high internal consistency (median Cronbach’s alpha of 0.93) and low stability coefficients ranging from 0.16 to 0.62 (Spielberger, 1983); low stability coefficients are expected and reflect variability in anxiety in response to situational factors. The STAI state scale has demonstrated higher reliability coefficients when given under conditions of psychological stress (e.g., alpha reliability coefficient of 0.94 when administered immediately following a distressing film; Spielberger, 1983). Additionally, adequate psychometric properties have been established among both clinical and healthy populations (Spielberger, 1983).

Table 2: Self-Report Measures

Measure	Description	Scales/Subscales	#Questions & Expected Time for Completion
Eating Disorder Examination – Questionnaire (EDE-Q)	Self-report questionnaire assessing current eating disorder symptomatology	Restraint Eating Concerns Shape Concerns Weight Concerns Global Score	41 questions/~5-10 minutes
Brief Symptom Report (BSI)	Self-report questionnaire assessing secondary pathology	Somatization Obsession-Compulsion Interpersonal Sensitivity Depression Anxiety Hostility Phobic Anxiety Paranoid Ideation Psychoticism	49 questions/~5-10 minutes
Intolerance of Uncertainty	Self-report questionnaire assessing difficulties tolerating uncertainty	Overall IUS Score	27 items/~5 minutes
Difficulties in Emotion Regulation Scale (DERS)	Self-report questionnaire assessing emotion-regulation capacity	DERS Overall	41 items/~5-10 minutes
State-Trait Anxiety Inventory-Form Y (STAI)	Self-report questionnaire assessing state anxiety	STAI State Score	20 items/~5 minutes

2.2.6 Wechsler Abbreviated Scale of Intelligence (WASI)

The Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) is a shortened version of the Wechsler Adult Intelligence Scale—Third Edition (Wechsler, 1997). Full Scale IQ can be estimated from the four WASI subtests: vocabulary, similarities, matrix reasoning, and block design. The WASI has demonstrated good convergent validity with the WAIS-III and high levels of internal consistency for the Full

Scale IQ estimate (Wechsler, 1999). Raw scores can be converted to standard scores with a mean of 100 and a standard deviation of 15.

2.2.7 RGB

The Wisconsin Card Sorting Task (WCST; Berg, 1948) was selected to assess RGB. A computerized version of the WCST was implemented in the current study (Heaton, 2003). The computerized settings were as follows: Visual Feedback Duration 1.0 seconds; Audio Feedback Male Voice; Card Animation Move time 1.5 seconds, and Card Animation Frame Time 10 milliseconds. During the task, participants are asked to match a stimulus card (e.g., two blue triangles) to one of four target cards: single red triangle, two green stars, three yellow crosses, and four blue circles but are not given instructions on how to match the cards. Computerized feedback indicates whether or not the response was "right" or "wrong." Following feedback, participants are given a new card to match until a total of 128 cards have been sorted. Unbeknownst to the participant, the correct sorting rule changes automatically after 10 consecutive correct responses. In addition to standard WCST scores, the current study has developed novel scores to further aid in the characterization of RGB (i.e., acquisition, extinction, and flexibility of verbal rules). Outcome scores for the current study are described in Table 1.

After completion of the WCST, participants were asked three questions to assess their level of uncertainty during the task. The first two questions utilized a continuous sliding scale ranging from "Not at All" to "Extremely" and read as follows: *On average,* *how certain did you feel about your strategy for sorting the cards?* (WCST Certainty – higher scores reflect greater levels of certainty). *On average, how certain about your strategy for sorting the cards did you feel after you were told you were "wrong"?* (WCST Wrong – higher scores reflect greater levels of certainty after being told you were "wrong"). The last question utilized a continuous sliding scale ranging from "None" to "Extreme" and read as follows: *What was the greatest level of uncertainty you felt during the task?* (WCST Uncertainty - higher scores reflect a greater degree of uncertainty experienced during the task).

2.3 Procedure

All procedures were approved by the Duke University Medical Center Institutional Review Board.

2.3.1 Recruitment

Participants were recruited from Duke University, Duke University Medical Center, and the general community via poster and online advertisement. Individuals interested in study participation underwent an initial telephone interview conducted by a Ph.D. level graduate student. This interview assessed study eligibility and included a semi-structured interview assessing lifetime history of an AN diagnosis and weight recovery status. Individuals who met initial screening criteria were given an option to complete a full eating disorder history assessment either by telephone or Qualtrics.com®, a secure online survey platform. This two-step screening process reduced participant and research burden by facilitating the identification of ineligible individuals and allows for individuals to choose how they prefer to discuss their eating disorder history. All participants were offered a clinical referral resource list.

2.3.2 Laboratory Paradigm

Informed consent was obtained upon arrival to the study. Participants were then administered the WASI and completed self-report questionnaires including and ending with the STAI to provide a baseline assessment of stress and anxiety. Participants then underwent a stress or neutral mood manipulation (described below) based on random assignment. Immediately following the mood manipulation, all participants again completed the STAI to assess current level of stress and anxiety. Following this, all participants completed the WCST. Weight and height measurements were then taken (all participants were blind to their weight). Participants were asked questions about their level of uncertainty during the task (see description of WCST above), were interviewed about time since eating disorder symptoms (i.e., binge eating, self-induced vomiting, excessive exercise, laxative abuse, diuretic abuse, and diet pill abuse), and completed the EDE-Q. Participants were then debriefed and offered clinical resources.

2.3.3 Mood Manipulation

Participants were randomly assigned to either a Stress or Neutral condition via a random number generator. If randomly assigned to the neutral condition, participants were told that they were going to be given some time to take a break and were provided with a neutral magazine (i.e., a travel magazine that had scenic pictures and did not have images of people) to view. Participants were left alone in the study room for a 10-minute period and upon return were asked to complete another brief questionnaire (STAI) before moving on to a computer task. Participants randomly assigned to the Stress condition underwent a stress induction modeled after the well-validated Trier Social Stress Test (Kirschbaum, Pirke, & Hellhammer, 1993). Participants were taken to a room with a microphone and one-way mirror and told the following:

> "We're going to have you take the role of a job applicant for your dream job who has been invited in for an interview with the company's staff managers—three other individuals, who you'll meet a little later.
>
> In a little bit, we're going to ask you to give a speech lasting 5 minutes that convinces them you're the perfect applicant for this position. You'll have some time to prepare for your speech."

Participants were then taken to a small room located on the other side of the one-way mirror that contained audio and video recording equipment (which was set up for actual recording) along with chairs for the "staff managers." Participants were told the following:

> "Three individuals will watch and listen to your speech in this room. They have been trained to monitor nonverbal behavior and will be judging and evaluating your speech and your performance."

Participants were then taken back to the previous study room. They were provided with a pen and some paper and were told they would have some time to prepare for their speech. They were then left alone in the room for a period of 10-

minutes. After 10 minutes, the researcher returned to the room and told the participant that it looked like they had enough time to complete a computer task before beginning the speech task. They were then asked to complete another brief questionnaire (STAI) before moving on to the computer task (WCST). Immediately following completion of the WCST, participants were told that they were not actually going to give a speech. They were also asked the following: *Did you think you were going to have to give the speech—Yes No, or Maybe?*

WASI	Self-Report Measures (*STAI 1*)	Mood Manipulation	*STAI 2*	WCST	Eating Disorder Assessment	Debriefing

Figure 3: Study Day Assessment Order

3. Data Analytic Strategy

3.1 Normality

Distributions of all outcome measures were examined for univariate and multivariate normality via visual examination and measures of skewness and kurtosis. Transformations were conducted in the event of non-normality and parametric tests were planned if adequate normality could not be established.

3.2 Sample Demographics

Demographic variables, including current age, completed years of education, IQ and BMI, were compared across each of the four cells (AN-WR Stress, AN-WR Neutral, CN Stress, CN Neutral). Two-way between subjects analysis of variance (ANOVAs) were used to determine the effectiveness of random assignment on these variables.

3.3 Sample Characterization

One-way between-subjects ANOVAs were conducted to examine group differences (AN-WR vs. CN) on eating disorder symptoms (as assessed by the EDE-Q) and secondary psychopathology (i.e., Dimensional BSI T-scores). One-way between-subjects ANOVAs were conducted to ensure that there were not any differences between the two AN and CN conditions (AN-WR Stress vs. AN-WR Neutral; CN Stress vs. CN Neutral) across the following relevant clinical outcomes: eating disorder symptoms (as assessed by the EDE-Q), number of years since unhealthy low weight, and secondary psychopathology (i.e., anxiety and depression as assessed by the BSI T-scores). Pearson chi-square tests were conducted to examine whether there were any relationships between the two AN conditions (AN-WR Stress vs. AN-WR Neutral) and the lifetime presence of eating disorder symptoms (i.e., binge eating, self-induced vomiting, excessive exercise, diuretic abuse, laxative abuse, and diet pill abuse).

3.4 Manipulation Check

A repeated measures ANOVA with two between subject factors (Group and Condition) and one within subject factor (Time) was used to assess the success of the mood manipulation. Success of the mood manipulation was defined as significant increases between the STAI score at time one and time two exclusively among those in the Stress Condition (i.e., a Condition by Time interaction).

3.5 RGB and Difficulties with Uncertainty and Emotion Regulation

3.5.1 Group Differences

One-way between-subjects ANOVAs were conducted to assess hypothesized differences between the AN-WR and CN groups on intolerance of uncertainty (as assessed by the IUS) and difficulties with emotion regulation (as assessed by the DERS).

3.5.2 Associations Between RGB and Difficulties with Uncertainty and Emotion Regulation

Bivariate correlation analyses stratified by group (AN-WR and CN) were used to assess associations between RGB outcomes (WCST scores indexing acquisition, extinction, and flexibility) and intolerance of uncertainty (as assessed by the IUS) and emotion regulation capacity (DERS overall score) along with anxiety and depression (as assessed by the BSI).

3.6 RGB and WCST Uncertainty

3.6.1 Group Differences

Two-way between-subjects ANOVAs were used to analyze differences on the three uncertainty ratings related to WCST performance. The independent variables consisted of two levels of Group (AN-WR and CN) and two levels of Condition (Stress and Neutral) with the following dependent variables: *On average, how certain did you feel about your strategy for sorting the cards?* (WCST Certainty); *On average, how certain about your strategy for sorting the cards did you feel after you were told you were "wrong"?* (WCST Wrong); *What was the greatest level of uncertainty you felt during the task?* (WCST Uncertainty).

3.6.2 Associations Between RGB and WCST Uncertainty

Bivariate correlation analyses stratified by group (AN-WR and CN) were used to test the associations between the uncertainty ratings related to WCST performance (WCST Certainty, WCST Wrong, WCST Uncertainty) and RGB outcomes (WCST scores indexing acquisition, extinction, and flexibility).

3.7 RGB and the Presence of Affective Arousal

Three between-subjects multivariate analysis of variance controlling for IQ (MANCOVAs) were initially planned to examine differences in acquisition, extinction, and flexibility as measured by WCST outcomes (see Table 1). Tests controlling for IQ were selected given the potential impact of IQ on WCST scores. All MANCOVA's were to assess the main effects and interaction of independent variables (Group and Condition) and the following relevant WCST outcomes: *acquisition* (Rule Rate and Number of Cards to Complete First Category), *extinction* (Total Perseverative Errrors and Perseverative Errors During First Category Change), and *flexibility* (Total Correct and Number of Categories Completed). ANCOVAs were selected as an alternative analysis strategy when the statistical assumptions required for the MANCOVA were violated.

4. Results

4.1 Sample Demographics

See Table 3 for demographic information of the 74 individuals who participated in the current study. Most of the sample was female (97.30%) and the majority was Caucasian (67.60%). Participants' ages ranged from 18 to 36 with a mean of 22.76 years (*SD* = 3.95). The IQ of the sample was in the superior range of functioning with a mean of 120.27 (*SD* = 10.10). The mean BMI (*M* = 22.13, *SD* = 3.03) was in the normal range. Completed years of education ranged from 12 to 22 with a mean of 15.24 (*SD* = 2.25). Two-way between subjects ANOVAS indicated that there were no significant differences between Group, Condition, or the interaction of the two on age, IQ, or BMI. However, there was a significant main effect of Condition such that participants in the Stress condition (*M* = 15.86, *SD* = 2.46) had significantly more years of education than those in the Neutral condition (*M* = 14.67, *SD* = 1.88), $F(1,71) = 5.55$, $p < .05$, partial $\eta^2 = .07$.

Table 3: Sample Demographics

	AN-WR (*n* = 36)	CN (*n* = 38)	Total (*n* = 74)
Variable: Mean (*SD*)			
Age	22.53 (3.81)	22.97 (4.13)	22.76 (3.95)
IQ	121.97 (9.69)	118.66 (10.33)	120.27 (10.10)
Years of Education	15.14 (2.27)	15.26 (2.24)	15.20 (2.24)
Body Mass Index	21.55 (2.58)	22.68 (3.35)	22.13 (3.03)
Sex/Ethnicity: # (%)			
Female	35 (97.2%)	37 (97.4%)	72 (97.30%)
Male	1 (2.80%)	1 (2.60%)	2 (2.70%)
White/Caucasian	28 (77.80%)	22 (57.90%)	50 (67.60%)
Black/African American	2 (5.60%)	7 (18.40%)	9 (12.20%)
Asian	5 (13.90%)	6 (15.80%)	11 (14.90%)
Hispanic/Latino	0 (0.00%)	2 (5.30%)	2 (2.70%)
Mixed Race	1 (2.80%)	1 (2.60%)	2 (2.70%)

4.2 Sample Characterization

4.2.1 Eating Disorder Pathology

One-way between-subjects ANOVAs compared the mean EDE-Q subscale scores (EDE-Q Restraint; EDE-Q Eating Concerns; EDE-Q Shape Concerns; EDE-Q Weight Concerns; EDE-Q Global Score) between the AN-WR and CN groups (see Table 4). Due to the presence of non-normality, ANOVAs were conducted on logarithmic transformed EDE-Q variables. The AN-WR group means were significantly higher than the CN group means across all EDE-Q subscale scores indicating that the AN-WR group reported higher levels of eating disorder pathology.

4.2.2 Psychopathology

One-way between-subjects ANOVAs compared the mean BSI Dimensional T-Scores between the AN-WR and CN groups (see Table 4). The AN-WR group means were significantly higher than the CN group means across all BSI dimensions indicating that AN-WR group reported higher levels of psychopathology. Importantly, while the AN-WR group means were significantly higher than the CN group means, all of the AN-WR means were well below the recommended clinical cut-off of $T \geq 65$ (Derogatis, 1983). This indicates that the AN-WR group means did not reach clinical threshold.

Table 4: Characteristics of AN-WR and CN Groups

	AN-WR Mean (SD) (n = 36)	CN Mean (SD) (n = 38)	$F(1,73)$[1]	Cohen's d Effect Size
EDE-Q Restraint[2]	2.18 (0.98)	1.45 (0.50)	18.41***	0.94
EDE-Q Eating Concern[2]	1.73 (0.69)	1.12 (0.18)	32.82***	1.21
EDE-Q Shape Concern[2]	3.18 (1.31)	1.92 (0.99)	23.99***	1.09
EDE-Q Weight Concern[2]	2.77 (1.18)	1.70 (0.93)	23.35***	1.01
EDE-Q Global Score[2]	2.47 (0.90)	1.55 (0.57)	30.47***	1.22
BSI Somatization	50.81 (8.71)	44.58 (6.40)	12.37***	0.82
BSI Obsessive Compulsive	58.06 (9.94)	52.61 (9.67)	5.72*	0.56
BSI Interpersonal Sensitivity	57.69 (11.07)	52.76 (9.29)	4.32*	0.48
BSI Depression	56.28 (10.37)	50.61 (8.15)	6.89*	0.61
BSI Anxiety	52.58 (10.64)	46.84 (8.38)	6.69*	0.60
BSI Hostility	53.83 (7.35)	47.61 (8.70)	11.00***	0.77
BSI Phobic Anxiety	53.42 (8.51)	47.68 (5.18)	12.39***	0.81
BSI Paranoid Ideation	53.50 (9.99)	49.26 (8.07)	4.05*	0.47
BSI Psychoticism	58.97 (10.08)	53.32 (8.79)	6.65*	0.60
BSI Global Severity	56.72 (9.20)	48.92 (8.21)	14.85***	0.89

[1] Analysis of variance was conducted to test group differences.
[2] Data were analyzed after logarithmic transformation.
*$p < 0.05$; **$p < 0.01$; ***$p \leq 0.001$

4.3 AN-WR Sample Characterization

4.3.1 Eating Disorder Pathology

One-way between-subjects ANOVAs compared the mean EDE-Q subscale scores (EDE-Q Restraint; EDE-Q Eating Concerns; EDE-Q Shape Concerns; EDE-Q Weight Concerns; EDE-Q Global Score) between the AN-WR Stress and AN-WR Neutral conditions (see Table 5). There were no significant differences between the AN-WR Stress and AN-WR Neutral conditions on any EDE-Q outcome indicating that the two AN-WR conditions did not differ on eating disorder pathology. There also were not any significant differences between the CN Stress and CN Neutral conditions on eating disorder pathology.

4.3.2 Anxiety and Depression

One-way between-subjects ANOVAs compared the mean BSI Anxiety and Depression T-Scores between the AN-WR Stress and AN-WR Neutral conditions (see Table 5). There were no significant differences between the AN-WR Stress and AN-WR Neutral conditions indicating that the two AN-WR conditions did not differ on anxiety or depression. There also were not any significant differences between the CN Stress and CN Neutral conditions on anxiety or depression.

4.3.3 Number of Years Since Unhealthy Low Weight

The number of years since unhealthy low weight across the AN-WR sample ranged from 0.75 to 12 years with a mean of 4.29 (SD = 3.13). A one-way between-subjects ANOVA compared the mean number of years since low weight between the AN-WR Stress and AN-WR Neutral conditions (see Table 5). There were no significant differences between the AN-WR Stress (M = 21.77, SD = 3.17) and AN-WR Neutral (M = 4.69, SD = 3.55) conditions indicating that the two AN-WR conditions did not differ on the number of years since unhealthy low weight.

4.3.4 Eating Disorder Behavioral Symptoms

The percentage of lifetime presence of the following symptoms in the AN-WR sample are presented in Table 5. Pearson chi-square tests revealed that there was not a significant relationship between Condition and the lifetime presence of any eating disorder symptom. Additionally, over the past year, 2 individuals (5.60%) had engaged in binge eating, 1 individual (2.8%) had engaged in self-induced vomiting, and 10 individuals (16.70%) had engaged in excessive exercise for at least two times during a one-week period. No individuals had engaged in diuretic abuse, laxative abuse, or diet pill abuse in the past year.

Table 5: AN-WR Sample Characterization

	AN-WR Neutral (*n* = 19)	AN-WR Stress (*n* = 17)	Total (*n* = 36)
Variable: Mean (*SD*)			
Body Mass Index[1]	21.36 (1.98)	21.77 (3.17)	21.55 (2.58)
# Years Since Unhealthy Low Weight[1]	4.69 (3.55)	3.87 (2.65)	4.29 (3.13)
EDE-Q Restraint[1]	2.20 (0.97)	2.16 (1.02)	2.18 (0.98)
EDE-Q Eating Concern[1]	1.78 (0.52)	1.68 (0.85)	1.73 (0.69)
EDE-Q Shape Concern[1]	3.32 (1.32)	3.04 (1.31)	3.18 (1.31)
EDE-Q Weight Concern[1]	2.85 (0.94)	2.68 (1.43)	2.77 (1.18)
EDE-Q Global Score[1]	2.54 (0.78)	2.39 (1.04)	2.47 (0.99)
BSI Anxiety[1]	53.32 (10.35)	51.76 (11.22)	52.58 (10.64)
BSI Depression[1]	54.58 (10.10)	58.18 (10.66)	56.28 (10.37)
Variable: # (%)			
Lifetime Binge Eating[2]	7 (36.80%)	4 (23.50%)	11 (30.60%)
Lifetime Self-Induced Vomiting[2]	7 (36.80%)	6 (35.30%)	13 (36.10%)
Lifetime Excessive Exercise[2]	13 (68.4%)	14 (82.40%)	27 (75.00%)
Lifetime Diuretic Abuse[2]	3 (15.8%)	1 (5.9%)	4 (11.10%)
Lifetime Laxative Abuse[2]	6 (31.6%)	3 (17.6%)	9 (25.00%)
Lifetime Diet Pill Abuse[2]	3 (15.8%)	1 (5.90%)	4 (11.10%)

[1]Analysis of variance was conducted to test group differences.
[2] Pearson chi-square test of independence was performed to examine whether there was a relationship between Condition and the lifetime presence of the eating disorder symptom
*$p < 0.05$; **$p < 0.01$; ***$p \leq 0.001$

4.4 Manipulation Check

Participants in the Stress condition were asked to respond with "yes," "no," or "maybe" to the following question: "Did you think you were going to have to give a speech?" Most participants were convinced they were going to have to give a speech with 32 (89%) responding with "yes", 4 (11.1%) responding with "maybe", and 0 (0%) responding with "no." A repeated measures ANOVA with two between subject factors, Group (AN-WR and CN) and Condition (Stress and Neutral), and one within subject level Time (STAI Time 1 and STAI Time 2) was used to assess the success of the stress induction (see Table 6 for Means (*SD*)). There was a main effect of Time, $F(1,68) = 10.38$, $p < .01$, indicating that STAI scores significantly increased from Time 1 to Time 2. However, this was qualified by a significant Time X Condition interaction, $F(1,68) = 25.35$, $p < .001$, indicating that, as expected, scores only significantly increased in the Stress condition, but did not significantly change in the Neutral Condition (see Figure 4). There was not a significant Time X Group ($F(1,68) = .05$, $p = .82$) or Time X Condition X Group ($F(1,68) = .07$, $p = .80$) interaction indicating that the effect of the stress induction did not depend on group status.

Table 6: STAI Scores at Time 1 and 2

	STAI Time 1 Mean (*SD*)	STAI Time 2 Mean (*SD*)	Cohen's *d* Effect Size
AN-WR Neutral (n = 19)	33.11 (9.80)	32.11 (9.75)	0.10
AN-WR Stress (n = 17)	35.00 (12.18)	41.18 (11.99)	-0.51*
CN Neutral (n = 18)	28.11 (6.98)	26.39 (6.07)	0.26
CN Stress (n = 18)	27.61 (7.41)	33.83 (9.68)	-0.72**
AN-WR Group (n = 36)	34.00 (10.87)	36.39 (11.65)	-0.21
CN Group (n = 36)	27.86 (7.10)	30.11 (8.82)	-0.28
Neutral Condition (n = 37)	30.58 (8.80)	29.32 (8.56)	0.15
Stress Condition (n = 35)	31.20 (10.55)	37.40 (11.33)	-0.57***

*$p < 0.05$; **$p < 0.01$; ***$p \leq 0.001$

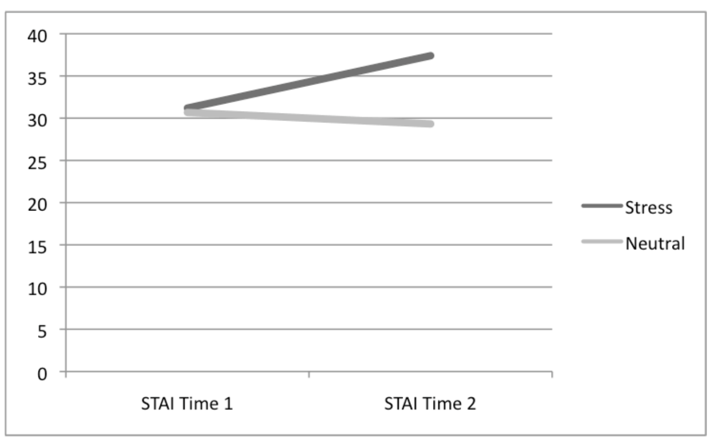

Figure 4: Change in STAI Score Across Time By Condition

4.5 RGB and Difficulties with Uncertainty and Emotion Regulation

4.5.1 Group Differences

A one-way between-subjects ANOVA compared the mean IUS score between the AN-WR and CN groups (see Table 7). Due to the presence of non-normality, the ANOVAs were conducted on IUS after logarithmic transformation. As hypothesized, the AN-WR IUS group mean (M = 66.89, SD = 18.61) was significantly higher than the CN group mean (M = 49.74, SD = 14.18), $F(1,73) = 23.00$, $p < .001$, partial $\eta^2 = .24$, indicating that individuals with AN reported a greater intolerance of uncertainty.

A one-way between-subjects ANOVA compared the mean DERS Overall score between the AN-WR and CN groups (see Table 7). Due to the presence of non-normality, the ANOVA was conducted on DERS Overall score after logarithmic transformation. As hypothesized, the AN-WR DERS Overall group mean (M = 79.75, SD = 19.53) was significantly higher than the CN group mean (M = 64.47, SD = 14.06), $F(1,73) = 14.06$, $p < .001$, partial $\eta^2 = .16$, indicating that individuals with AN reported great difficulties in emotion regulation.

Table 7: Group Differences

	Raw Scores			
	AN-WR Mean (SD) (*n* = 36)	CN Mean (SD) (*n* = 38)	$F(1,73)$[1]	Cohen's *d* Effect Size
Intolerance of Uncertainty[2]	66.89 (18.63)	49.74 (14.18)	23.00***	1.04
DERS Overall[2]	79.75 (19.53)	64.47 (14.45)	14.06***	0.89

[1]Analysis of variance was conducted to test group differences.
[2] Data were analyzed after logarithmic transformation.
*$p < 0.05$; **$p < 0.01$; ***$p \leq 0.001$

4.5.2 Associations Between RGB and Difficulties with Uncertainty and Emotion Regulation

Bivariate correlation analyses stratified by group (AN-WR and CN) were conducted to test the associations between RGB outcomes (6 WCST scores) and intolerance of uncertainty (as assessed by the IUS), and emotion regulation capacity (as assessed by the DERS overall score), along with anxiety and depression (as assessed by the BSI). Analyses were run on logarithmic transformed variables when raw scores were not normally distributed and with outliers excluded. The WCST Categories Completed score was not included in this analysis due to insufficient variability. There were not any significant associations between RGB and the outcomes of interest in the CN Group. Similarly there were not any significant associations between RGB and the outcomes of interest in the AN-WR Group with the exception of the IUS. More specifically, a greater intolerance of uncertainty was associated with more Total Perseverative Errors on the WCST in the AN-WR group, $r = .36$, $n = 35$, $p < .05$.

4.6 RGB and WCST Uncertainty

4.6.1 Group Differences

Two-way between-subjects ANOVAs were selected to analyze group differences on the three certainty ratings about WCST performance (see Table 8 for means (*SD*)). There were no significant effects of Group, $F(1,69) = 2.11$, $p = .15$, partial $\eta^2 = .03$, Condition, $F(1,69) = 1.23$, $p = .27$, partial $\eta^2 = .02$, or interaction of the two, $F(1,69) = .71$, $p = .40$, partial $\eta^2 = .01$, for WCST Certainty. This indicates that there were not any differences between the AN-WR or CN Groups or the Stress or Neutral Conditions on average certainty about strategy during the WCST. There was a significant effect of Group, $F(1,69) = 7.29$, $p < .01$, partial $\eta^2 = .10$, and Condition, $F(1,69) = 4.90$, $p < .05$, partial $\eta^2 = .07$, for WCST Wrong, but the interaction term was not significant, $F(1,69) = .43$, $p = .52$, partial $\eta^2 = .01$. This indicates that the AN-WR group ($M = 4.54$, $SD = 2.90$) was significantly less certain about their WCST strategy after being told they were "wrong" than the CN group ($M = 6.26$, $SD = 2.81$). Similarly, participants who underwent a stress induction ($M = 4.69$, $SD = 2.79$) were significantly less certain after being told they were "wrong" than individuals who were in the Neutral condition ($M = 6.26$, $SD = 2.81$). There was a significant effect of Group, $F(1,69) = 9.46$, $p < .01$, partial $\eta^2 = .12$, but not a significant effect of Condition, $F(1,69) = .39$, $p = .53$, partial $\eta^2 = .01$, or interaction of the two, $F(1,69) = .58$, $p = .45$, partial $\eta^2 = .01$, for WCST Uncertainty. This indicates that the AN-WR group ($M = 5.24$, $SD = 2.51$) experienced a greater level of uncertainty during the WCST task than the CN group ($M = 3.35$, $SD = 2.67$), but that undergoing a stress induction did not impact degree of uncertainty.

Table 8: WCST Uncertainty

	WCST Certainty Mean (*SD*)	WCST Wrong Mean (*SD*)	WCST Uncertainty Mean (*SD*)
AN-WR Neutral (n = 19)	7.30 (1.68)	5.02 (2.76)	5.28 (2.65)
AN-WR Stress (n = 17)	7.16 (2.69)	4.02 (2.75)	5.20 (2.42)
CN Neutral (n = 19)	8.41 (1.56)	7.15 (2.64)	2.92 (2.52)
CN Stress (n = 18)	7.46 (2.26)	5.33 (2.74)	5.20 (2.42)
AN-WR Group (n = 36)	7.23 (2.18)	4.54 (2.90) [b]	5.24 (2.51) [b]
CN Group (n = 37)	7.95 (1.96)	6.26 (2.81) [b]	3.35 (2.67) [b]
Neutral Condition (n = 38)	7.85 (1.70)	6.26 (2.81) [a]	4.13 (2.82)
Stress Condition (n = 35)	7.32 (2.45)	4.69 (2.79) [a]	4.47 (2.69)

[a] = groups significantly differed with a $p < 0.05$; [b] = groups significantly differed with $p < 0.01$; [c] = groups significantly differed with a $p \leq 0.001$

4.6.2 Associations between RGB and WCST Uncertainty

Bivariate correlation analyses stratified by group (AN-WR and CN) were conducted to test the associations between uncertainty ratings related to WCST performance (WCST Certainty – higher scores reflect greater levels of certainty; WCST Wrong – higher scores reflect greater levels of certainty after being told you were "wrong"; WCST Uncertainty – higher scores reflect a greater degree of uncertainty experienced during the task) and RGB outcomes (WCST scores, with the exception of Categories Completed). Analyses were run on logarithmic transformed variables when raw scores were not normally distributed and with outliers excluded.

4.6.2.1 Acquisition

No significant associations between degree of uncertainty during the WCST (WCST Certainty, WCST Wrong, WCST Uncertainty) and rate of acquisition (Rule Rate and Number of Trials to Complete First Category) were found in the CN group. Similarly, there were no significant relationships in the AN-WR group with the exception of the association between Rule Rate and WCST Certainty, $r = -.36$, $n = 35$, $p < .05$. This indicates that greater levels of certainty during the WCST task were associated with faster acquisition of a correct rule only in the AN-WR group.

4.6.2.2 Extinction

Analyses assessing the relationship between WCST Certainty and extinction outcomes (i.e., rule-based insensitivity) in the CN Group indicated that greater levels of certainty was associated with fewer Total Perseverative Errors, $r = -.47$, $n = 36$, $p \leq .001$, and fewer Total Perseverative Errors After the First Category Change, $r = -.41$, $n = 36$, $p \leq .01$. That is, greater degree of certainty related to better extinction as evidenced by fewer perseverative errors. Similarly, results indicated that greater levels of certainty after being wrong were associated with fewer Total Perseverative Errors, $r = -.44$, $n = 36$, $p \leq .01$, and fewer Total Perseverative Errors After the First Category Change, $r = -.38$, $n = 36$, $p \leq .05$, in the CN group. There were no significant relationships between WCST Uncertainty and extinction outcomes in the CN group. Taken together, results indicate that greater levels of certainty were associated with fewer perseverative errors in the CN group.

Analyses assessing the relationship between WCST Certainty, WCST Wrong and rule-based insensitivity outcomes in the AN-WR Group indicated that greater levels of certainty were associated with fewer Total Perseverative Errors, (WCST Certainty: $r = -.52$, $n = 35$, $p \leq .001$; WCST Wrong: $r = -.53$, $n = 36$, $p \leq .001$). Additionally, results indicated that higher levels of uncertainty were associated with more Total Perseverative Errors, $r = .54$, $n = 35$, $p \leq .001$. No significant associations were found among certainty of strategy during the WCST and Total Perseverative Errors After the First Category Change in the AN-WR group. Results together indicate that greater levels of certainty were associated with fewer perseverative errors and, likewise, higher levels of uncertainty were associated with more perseverative errors in the AN-WR group.

4.6.2.3 Flexibility

No significant associations between certainty during the WCST (WCST Certainty, WCST Wrong, WCST Uncertainty) and flexibility (Total Correct) were found in the CN group. Similarly, there were no significant relationships in the AN-WR group with the exception of the association between Total Correct and WCST Uncertainty, $r = .44$, $n = 36$, $p < .01$. This indicates that a greater level of uncertainty during the WCST task was associated with a greater number of Total Correct on the WCST in the AN-WR group.

4.7 RGB and the Presence of Affective Arousal

4.7.1 Acquisition

Initially, a two-way between-subjects MANCOVA controlling for IQ was planned to assess differences between Group (AN-WR and CN) and Condition (Stress and Neutral) on rule *acquisition* (Rule Rate and Number of Cards to Complete First Category). Initial examination of the data indicated univariate violations of normality on both dependent variables. The dependent variables underwent logarithmic transformation and two outliers were removed establishing adequate univariate normality. However, Box's Test of Equality of Covariance Matrices was significant indicating that the assumption of equal dependent variables covariance matrices was violated. Given this, a MANCOVA was no longer determined to be appropriate and thus separate two-way between subjects ANCOVAs were conducted.

A two-way between-subjects ANCOVA controlling for IQ was used to analyze Rule Rate (post logarithmic transformation with two outliers removed) with two levels of Group (AN and CN) and two levels of Condition (Stress and Neutral) as the independent variables. No effects were found to be statistically significant. More specifically, there was not a significant main effect of Condition, $F(1,67) = .13$, $p = .72$, partial $\eta^2 = .002$, or Group, $F(1,67) = .47$, $p = .50$, partial $\eta^2 = .007$, and there was not a significant Condition X Group Interaction, $F(1,67) = .132$, $p = .72$, partial $\eta^2 = .002$ (see Table 9 for means (*SD*)).

Table 9: Acquisition

	WCST Rule Rate Mean (*SD*)	WCST # Cards to Complete 1st Category Mean (*SD*)
AN-WR Neutral (n = 19)	3.84 (1.38)	12.58 (3.34)
AN-WR Stress (n = 16)	4.06 (1.48)	12.25 (1.88)
CN Neutral (n = 20)	3.45 (0.69)	11.80 (1.82)
CN Stress (n = 17)	3.71 (0.92)	13.71 (7.25)
AN-WR Group (n = 35)	3.94 (1.41)	12.43 (2.74)
CN Group (n = 37)	3.57 (0.80)	12.67 (5.10)
Neutral Condition (n = 39)	3.64 (1.09)	12.18 (2.66)
Stress Condition (n = 33)	3.88 (1.22)	13.00 (5.34)

[a] = groups significantly differed with a $p < 0.05$; [b] = groups significantly differed with $p < 0.01$; [c] = groups significantly differed with a $p \leq 0.001$

A two-way between-subjects ANCOVA controlling for IQ was used to analyze Number of Cards to Complete First Category (post logarithmic transformation with two outliers removed) with two levels of Group (AN and CN) and two levels of Condition (Stress and Neutral) as the independent variables. No effects were found to be statistically significant. More specifically, there was not a significant main effect of Condition, $F(1,67) = .31$, $p = .58$, partial $\eta^2 = .01$, or Group, $F(1,67) = .03$, $p = .87$, partial $\eta^2 = .000$, and there was not a significant Condition X Group Interaction, $F(1,67) = .72$, $p = .40$, partial $\eta^2 = .01$ (see Table 8 for means (*SD*)).

Taken together, in contrast to what was hypothesized, findings indicate that stress did not impact rule *acquisition*, as operationalized by Rule Rate and Number of Cards to Complete First Category, in the AN-WR or CN groups. Additionally, there were no differences between the AN-WR or CN groups on rule *acquisition* outcomes.

4.7.2 Extinction

Initially, a two-way between-subjects MANCOVA controlling for IQ was planned to assess differences between Group (AN-WR and CN) and Condition (Stress and Neutral) on *rule-based insensitivity* (Total Perseverative Errors and Total Perseverative Errors after First Category Change). Initial examination of the data indicated univariate violations of normality on both dependent variables. The dependent variables underwent logarithmic transformation and two outliers were removed establishing adequate univariate normality. However, Box's Test of Equality of

Covariance Matrices was significant indicating that the assumption of equal dependent variables covariance matrices was violated. Given this, a MANCOVA was no longer determined to be appropriate and thus separate two-way between subjects ANOVAs were implemented.

A two-way between-subjects ANCOVA controlling for IQ was instead selected to analyze Total Perseverative Errors (post logarithmic transformation with two outliers removed) with two levels of Group (AN and CN) and two levels of Condition (Stress and Neutral) as the independent variables. A significant main effect of Group was found, $F(1,67) = 7.33$, $p < .01$, partial $\eta^2 = .10$, indicating that the AN-WR group had more Total Perseverative Errors than the CN group (see Table 10 for means (*SD*)). There was not a significant main effect of Condition, $F(1,67) = 1.47$, $p = .23$, partial $\eta^2 = .02$, or significant Condition X Group Interaction, $F(1,67) = .21$, $p = .65$, partial $\eta^2 = .003$.

A two-way between-subjects ANCOVA controlling for IQ was used to analyze Total Perseverative Errors after First Category Change (post logarithmic transformation with two outliers removed) with two levels of Group (AN and CN) and two levels of Condition (Stress and Neutral) as the independent variables. No effects were statistically significant. More specifically, there was not a significant main effect of Condition, $F(1,66) = 0.8$, $p = .80$, partial $\eta^2 = .001$, or Group, $F(1,66) = 3.59$, $p = .06$, partial $\eta^2 = .05$, and there was not a significant Condition X Group Interaction, $F(1,66) = 1.76$, $p = .19$, partial $\eta^2 = .03$ (see Table 10 for means (*SD*)).

Taken together, in contrast to what was hypothesized, findings indicate that stress did not impact the number of perseverative errors made by the AN-WR or CN groups. However, as hypothesized, the AN-WR group made a greater number of perseverative errors throughout the task compared to the CN group.

Table 10: Extinction

	WCST Total Perseverative Errors Mean (*SD*)	WCST Total Perseverative Errors after First Category Change Mean (*SD*)
AN-WR Neutral (n = 19)	8.12 (3.78)	1.84 (0.96)
AN-WR Stress (n = 16)	9.00 (5.73)	1.75 (1.57)
CN Neutral (n = 20)	6.55 (2.14)	1.35 (0.93)
CN Stress (n = 17)	7.00 (3.87)	1.44 (0.89)
AN-WR Group (n = 35)	9.72 (8.61) [b]	1.80 (1.26)
CN Group (n = 37)	6.76 (3.02) [b]	1.39 (0.90)
Neutral Condition (n = 39)	7.31 (3.11)	1.59 (0.97)
Stress Condition (n = 33)	9.26 (8.96)	1.59 (1.23)

[a] = groups significantly differed with a $p < 0.05$; [b] = groups significantly differed with $p < 0.01$; [c] = groups significantly differed with a $p \leq 0.001$

4.7.3 Flexibility

Initially, a two-way between-subjects MANCOVA controlling for IQ was planned to assess differences between Group (AN-WR and CN) and Condition (Stress and Neutral) on *flexible* rule-following (Total Correct and Number of Categories Completed). Initial examination of the data indicated univariate violations of normality on both dependent variables. Additionally, visual analysis of the Number of Categories Completed dependent variable indicated insufficient variability with 94.60% of the sample (70 of 74 individuals) completing all 6 six categories. The dependent variables underwent logarithmic transformation and one outlier was removed. This resulted in adequate normality for Total Correct but the Number of Categories Completed failed to reach acceptable normality as expected. Given this, a MANCOVA was no longer determined to be appropriate.

A two-way between-subjects ANCOVA controlling for IQ was selected to analyze Total Correct (post logarithmic transformation with one outlier removed) with two levels of Group (AN-WR and CN) and two levels of Condition (Stress and Neutral) as the independent variables. A significant main effect of Group was found, $F(1,68) = 5.18$, $p < .05$, partial $\eta^2 = .07$, indicating that the AN-WR group scored significantly higher on Total Correct than the CN group (see Table 11 for means (*SD*)). There was not a significant main effect of Condition, $F(1,68) = .62$, $p = .44$, partial $\eta^2 = .01$, or significant Condition X Group Interaction, $F(1,68) = 1.56$, $p = .22$, partial $\eta^2 = .02$. In contrast to what was hypothesized, findings indicate that stress did not impact *flexible* rule-following as defined by Total Correct. Additionally, contrary to what was expected, the AN-WR group scored significantly higher on Total Correct than the CN group.

Table 11: Flexibility

	WCST Total Correct Mean (*SD*)
AN-WR Neutral (n = 19)	71.05 (6.45)
AN-WR Stress (n = 16)	70.53 (8.74)
CN Neutral (n = 20)	66.10 (4.18)
CN Stress (n = 17)	68.71 (6.31)
AN-WR Group (n = 35)	70.81 (7.51) [a]
CN Group (n = 37)	67.39 (5.35) [a]
Neutral Condition (n = 39)	68.62 (5.89)
Stress Condition (n = 33)	69.62 (7.57)

[a] = groups significantly differed with a $p < 0.05$; [b] = groups significantly differed with $p < 0.01$; [c] = groups significantly differed with a $p \leq 0.001$

5. Discussion

Individuals with AN relentlessly persist in dangerous behaviors even in the presence of deleterious health outcomes. Such rigidity predates illness onset, continues post recovery, and contributes to high rates of morbidity and mortality (Strober, 1980; Tchanturia et al., 2004; Keel et al., 2003). Despite this, our knowledge of factors that lead to the development and maintenance of rigidity is lacking. This paper proposed that rigidity may be formulated as maladaptive RGB in AN that emerges in situations of uncertainty and inhibits contingency-based learning which would establish more adaptive responses. The current study examined parts of this model in the following ways: 1) Determining whether there are group differences between individuals weight-recovered from AN and healthy controls in their intolerance of uncertainty and ability to regulate emotion and exploring whether these variables are related to RGB parameters; 2) Comparing degree of uncertainty reported between AN-WR and CN groups during a rule-following task and exploring the relationship to rule-governed parameters; 3) characterizing RGB in individuals recovered from AN relative to healthy controls and exploring how these behaviors change in the presence of affective arousal, a presumed state of uncertainty and loss of control in AN. Findings from the current study provide tentative support for this model which will be discussed in detail below.

5.1 RGB and Difficulties with Uncertainty and Emotion Regulation

To date, little attention has been given to factors that may promote rigidity in AN. Previous research has shown associations between behaviors that can be formulated as rule-based insensitivity and anxiety and depression in AN (Giel et al., 2012; Roberts et al., 2010), although the current study did not replicate these findings. The current study sought to extend this work by examining other factors thought to promote maladaptive RGB in AN.

Our proposed model suggested that maladaptive RGB would be related to an intolerance of uncertainty and difficulties with emotion regulation among individuals with AN. We therefore hypothesized that individuals with AN would report greater difficulties with uncertainty and emotion regulation and that these difficulties would be associated with RGB parameters. As expected, individuals with AN reported a greater general intolerance of uncertainty and difficulties with emotion regulation. These results add to the broader literature showing that individuals with AN continue to struggle with uncertainty and emotion regulation post weight restoration. Furthermore, the general fear of uncertainty was associated with outcomes suggesting the AN-WR group evidenced increased rule-based insensitivity. This provides support for the model indicating that broad difficulties with uncertainty are related to a reliance on RGB and thus rule-based insensitivity.

In contrast to what was expected, however, emotion regulation capacity was not associated with RGB. This may suggest that RGB is not related to the ability to regulate emotion and therefore does not support the hypothesis that RGB is used as an emotion regulation strategy among individuals with AN. However, it is also possible that RGB is related to specific deficits in emotion regulation, such as a limited access to emotion regulation strategies, rather than general difficulties. Future research is needed to further clarify this relationship.

5.2 RGB and WCST Uncertainty

The proposed model suggests that RGB emerges in contexts of uncertainty. Given the ambiguous nature of the WCST, we hypothesized that individuals with AN would report lower levels of certainty and higher levels of uncertainty during the WCST and that uncertainty would be related to RGB outcome. Findings partially supported these hypotheses as the AN-WR group reported greater levels of uncertainty and less certainty during the WCST and degree of uncertainty was related to maladaptive RGB in the AN-WR group. More specifically, greater levels of certainty during the WCST were associated with fewer perseverative errors and, likewise, greater levels of uncertainty were related to more perseverative errors or rule-based insensitivity. Taken together, findings suggest that uncertainty is related to a reliance on RGB and thus rule-based insensitivity in AN, which would provide tentative support for the model.

Interestingly, degree of certainty was associated with faster acquisition whereas degree of uncertainty was associated with greater levels of rule flexibility in the AN-WR group. It is unclear how to interpret these findings. That greater levels of certainty were associated with faster acquisition may be a result of the questions being asked after task completion. That is, those who were initially more successful might have later reported greater levels of certainty. It seems unlikely, however, that actual performance on the WCST would be driving the relationship between uncertainty and flexibility given greater levels of uncertainty were associated with better rather than worse performance. A more plausible explanation is that uncertainty during the task motivated the use of rules as a strategy, which was ultimately successful for the AN-WR group.

Importantly, findings need to be interpreted with caution. Questions were asked after task completion and thus may have been influenced by performance. Additionally, findings are only correlational and thus direction cannot be established and relationships may be explained by additional variables. In light of these limitations, however, results suggest that uncertainty is related to RBG outcomes in AN. This provides preliminary support that maladaptive RGB is likely to occur during states of uncertainty.

5.3 RGB in AN

Consistent with the phenomenology of AN, we proposed that those with AN are overly reliant on rules to guide behavior and thus have difficulty or are unwilling to use environmental feedback to guide behavior. We chose to examine RGB in a sample of individuals weight-recovered from AN to parse out the impact of malnutrition on outcomes. Study findings indicate some significant differences between AN-WR and CN groups, irrespective of whether a negative mood was induced, on some but not all RGB parameters.

First, we predicted that those with AN would demonstrate a faster rate of acquisition of rule-based behavior, perhaps as a function of their excessive reliance on this strategy. In contrast to what was hypothesized, no differences were found between the AN-WR and CN groups. This potentially indicates that individuals with AN do not exhibit faster rates of acquisition as was expected. It is also possible, however, that the WCST was not sensitive enough to detect such differences. While not directly stated to the participant, the WCST requires individuals to sort cards based on three main variables (i.e., color, shape, and number). Although it is possible that other rules can be inaccurately derived, results indicated that most individuals identified the first correct sorting rule within three attempts at sorting the cards. That is, participants on average received feedback that their strategy was "wrong" two times before they received feedback that their strategy was "right." It is therefore likely that the participants of the current study quickly identified the three different ways to sort the cards and then strategically implemented each of these possible rules until they received feedback that the rule was in fact correct. The implementation and successfulness of this strategy is likely reflective of the high sample IQ. Other laboratory tasks that allow for a variety of response patterns (see review of RGB for task descriptions) may demonstrate differences in acquisition between AN-WR and CN groups that the WCST was unable to detect.

Consistent with earlier studies (e.g., Tchanturia et al., 2012; Roberts et al., 2010; Tenconi et al., 2010), our model predicted that those with AN would evidence a greater number of perseverative errors indicating rule-based insensitivity. As expected, the AN-WR group continued to sort cards based on a previously successful rule when given feedback it was no longer working more frequently than the CN group. This suggests that the reliance on verbal rules to guide behavior during the task led to impairments in extinction in the AN-WR group. That is, while individuals in the AN-WR group were able to successfully acquire rules, the reliance on these rules as a guide for behavior negatively impacted their ability to incorporate and adjust behavior in accordance with feedback.

Per the model, we also predicted that individuals with AN would demonstrate overall impairments in rule flexibility. Interestingly, while the AN-WR group evidenced impairments in extinction, they demonstrated greater overall rule flexibility compared to the CN group as shown by significantly more correct responses on the WCST. Importantly, only one study to date has explored differences in the total number correct on the WCST between individuals recovered from AN and healthy controls (Tchanturia et al., 2012). While that study did not find any statistical differences between healthy control and individuals recovered from AN, IQ was not reported or controlled for in analyses, which may have impacted findings (Ardila, Pineda, & Rosselli, 2000). The current study did not find any differences in total categories completed between the AN-WR and CN groups, as almost 95% of the sample completed all six categories. Only a couple studies incorporating individuals recovered from AN have reported number of categories completed (e.g., Tenconi et al., 2010; Tchanturia et al., 2012). Findings have been mixed with one study demonstrating no significant differences between individuals recovered from AN and healthy controls (Tchanturia et al., 2012), and the other showing fewer categories completed than healthy controls (Tenconi et al., 2010). Importantly, neither study reported or covaried for IQ.

This study is therefore the first to demonstrate greater rule flexibility among individuals recovered from AN compared to healthy controls. This suggests that the reliance on rules to guide behavior was overall an adaptive strategy. While not initially hypothesized, such findings are not surprising given rule-following is proposed to be a strategy that individuals with AN rely on because it has resulted in successful outcomes in the past. If this strategy was not successful, then it would have been abandoned. The rules formulated throughout the WCST task were reinforced and were thus adhered to, which likely helped these individuals maintain more adaptive behavior throughout the task. Additionally, individuals with AN have been shown to be highly sensitive to harm and punishment (Cassin & von Ranson, 2005; Fassino et al., 2002). The punishment of an incorrect response (i.e., feedback that the previously successful rule was now "wrong") may have been a more aversive experience in the AN-WR group. Individuals in the AN-WR group may have been more motivated to avoid the negative experience associated with incorrect responses and thus were more adept at developing and adhering to rules than individuals in the CN group.

Taken together, findings indicate that individuals with AN relied on rules to guide their behavior and that this strategy was ultimately successful. Such success, although not hypothesized, supports the proposed model as it provides evidence of the potentially reinforcing nature of rule-following in AN (i.e., it works). However, this strategy becomes problematic when environmental contingencies change. The reliance on rules led to feedback insensitivity in the AN-WR group. While this was not problematic in the laboratory task, as it did not impair overall performance, such insensitivity may explain the dire consequences that occur with the rigid persistence of behavioral symptoms seen in AN. That is, the adherence to RGB provides one way to understand why individuals with AN continue to engage in restrictive eating patterns or follow extreme exercise regimens, for example, even when they encounter negative health consequences.

5.4 RGB and Affective Arousal

We proposed that RGB in AN occurs in situations of uncertainty or a loss of control, such as in the presence of affective arousal. We therefore expected that individuals in the AN-WR group randomized to the Stress condition would experience greater levels of uncertainty during the WCST task and would evidence faster rates of acquisition but impaired extinction and flexibility. In contrast to what was hypothesized, levels of uncertainty did not differ between the AN-WR Stress or Neutral groups, with the exception that all participants randomized to the Stress Condition reported feeling less certain about their WCST strategy after being told they were wrong. Additionally, the presence of affective arousal did not impact RGB outcomes among the AN-WR or CN groups. The lack of findings in healthy control individuals is commensurate with the small body of work demonstrating that a negative mood induction does not impact executive functioning among typical controls (Mitchell & Phillips, 2007). That affective arousal did not have an impact on the AN-WR group is in contrast to what was hypothesized. While this suggests that affective arousal does not impact level of uncertainty or RGB among individuals with AN, findings need to be interpreted with caution as other factors may have impacted the results.

A failure of the mood induction to yield sufficient anxiety may be one factor that contributed to a lack of effects found in the current study. A modified Trier Social Stress Test (Kirschbaum et al., 1993) was used to manipulate anxiety level. While this resulted in a significant increase in anxiety scores from pre-to-post mood manipulation exclusively in the Stress Condition, scores were still lower than other studies before and after the mood manipulation (see Spielberger, 1983). Surprisingly, the mean anxiety score of the Stress Condition after mood manipulation in the current study was actually lower than the state anxiety mean of a large sample of female undergraduate students in a neutral context (Spielberger, 1983). While there is significant laboratory support demonstrating increased anxiety via self-report and physiological measures using the Trier Social Stress Test (Hellhammer & Schubert, 2012), self-report ratings of the current study bring into question whether the mood manipulation was meaningful enough to impact RGB outcomes, especially given physiological measurements were not taken.

The time given to prepare for the speech in the Stress Condition may also have interfered with the impact of the mood manipulation by inadvertently attenuating anxiety levels in the AN-WR group. Other physiological studies of the Trier Social Stress Test show that anxiety increases during the speech preparation period (Hellhammer & Schubert, 2012). However, this may have actually had the opposite affect in the AN-WR group. That is, this time for planning and establishing "rules" for the speech task may have helped reinstate a sense of certainty and control for individuals weight-recovered from AN. The current study does not allow for the assessment of this as physiological measurements were not taken and self-reported anxiety levels were only collected after the 10-minute period.

Lastly, the uncertainty of the WCST may have made the task stressful for all participants in the AN-WR group and interfered with the expected potentiation of effects in the presence of affective arousal. The WCST is ambiguous as participants are not given instructions as to how to complete the task and the task contingencies change throughout the task. This may have in itself induced anxiety among individuals with AN. As such, there may be a ceiling effect in that greater levels of affective arousal beyond that produced by the task it itself does not have any additional effect on RGB. The current study did not assess RGB in a predictable context and thus the potential confound of affective arousal present in the WCST is an important limitation.

In summary, while results from the current study did not support a model suggesting that maladaptive RGB in AN would intensify in presence of affective arousal, several factors may have impacted results. Additional research using other mood induction paradigms that allow for the effects of uncertainty and affective experience to be parsed is necessary for the model to be accurately tested.

5.5 Summary and Limitations

Taken together, results from the current study provide preliminary support for a model formulating rigidity in AN as maladaptive RGB that occurs in the presence of uncertainty. More specifically, individuals with AN demonstrated maladaptive RGB, which is best characterized by deficits in extinction. Furthermore, degree of uncertainty was associated with RGB parameters in the AN-WR group suggesting that the presence of uncertainty is related to an increase in RGB. However, a negative mood induction did not increase reported levels of uncertainty or intensify maladaptive RGB as expected. This may indicate that RGB does not increase in emotional contexts, or alternatively, a lack of finding may be due to a methodological limitation. More specifically, the uncertainty of the laboratory task may have induced anxiety, especially in the AN-WR group, and therefore blunted the effects of the intended mood manipulation. Additional research testing this aspect of the model is needed with methodology that parses the effects of uncertainty and affective arousal.

The findings of the current study need to be interpreted in light of its limitations. First, although comparable to other AN studies, the sample size was small. The power and thus ability to find effects was limited and future studies with larger sample sizes are needed. Additionally, the current study only included individuals weight-recovered from AN. While this adds to a growing body of work demonstrating continued rigidity post recovery, findings may therefore not generalize to other stages of illness, especially those actively ill, and additional research is needed. Third, using the WCST to explore RGB may have limited results. The WCST was selected so that study findings could be interpreted within the broader research on rigidity. However, as previously described, the WCST may not be as sensitive to differences in RGB as other tasks and thus actual differences between the AN-WR and CN groups may not have been detected (e.g., differences in acquisition). Furthermore, the uncertainty inherently present in the WCST may have induced anxiety and thus prevented a true investigation of RGB in the presence of affective arousal compared to RGB in a neutral state. It will be important for future studies to use alternative laboratory tasks to perhaps more accurately capture RGB in AN and the influence of affective arousal.

5.6 Implications for Treatment

While the replication of study results is needed along with assessment in individuals in the acute stage of illness, findings from the current study have important applications for the development of novel treatments. The current study suggests that a general difficulty tolerating uncertainty is associated with rigidity in AN and that maladaptive RGB is associated with greater levels of uncertainty. Treatments that target how individuals with AN respond to uncertainty, such as by increasing acceptance of this distressing state and promoting alternative healthy and adaptive strategies outside of a reliance on RGB, may therefore improve treatment outcomes for individuals with AN. For example, in addition to targeting weight and shape concerns directly, findings suggest that individuals with AN need help coping with the uncertainty associated with using bodily cues to guide healthy eating. Similarly, findings suggest that treatments targeting cognitive flexibility among individuals with AN would benefit from extending training to situations that promote uncertainty, which is likely when rigidity occurs.

6. Conclusion

AN is a deadly disease characterized by unrelenting rigidity. Understanding factors that promote and maintain rigidity may guide novel treatments for this dangerous disorder with a poverty of effective treatments for adults (Bodell & Keel, 2010). The current paper proposed a model suggesting that rigidity in AN can be formulated as maladaptive RGB that emerges in contexts of uncertainty and/or loss of control.

As expected, individuals with AN demonstrated maladaptive RGB best characterized by problematic extinction. Furthermore, results lend support for the argument that maladaptive RGB is related to difficulties tolerating uncertainty, both generally as a trait feature along with uncertainty during the task at hand. These significant relationships, while only correlational at this point, provide preliminary evidence that difficulties with uncertainty may lead to the reliance of RGB as a strategy. Findings did not support the hypothesis that maladaptive RGB would increase in the presence of affective arousal; however, limitations in the study design indicate that this should be interpreted with great caution and future research is needed using different methodology.

Findings suggest that individuals with AN may rely on RGB as it is overall a successful strategy. However, this strategy comes at the cost of increased rule-based insensitivity. While the consequence of rule-based insensitivity was relatively benign during the WCST, the reliance on RGB may explain the insensitivity to the dire health consequences that occur when these individuals persist in the deadly eating disordered behaviors (e.g., extreme and dangerous dietary and exercise rules).

In sum, study findings provide preliminary support for using the frame of maladaptive RGB as an explanatory model of rigidity in AN that occurs in the presence of uncertainty. This extends the current knowledge of perseverative behaviors in AN by suggesting that rigidity is impacted by additional factors such as an intolerance of uncertainty. Although additional research and replication of study findings are necessary, results have direct and important implications for treatment development and suggest that targeting difficulties with uncertainty may be a key component currently absent in treatments.

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Biography

Ashley Moskovich was born in 1982 in Chicago Heights, Illinois. She received a Bachelor of Arts degree in Psychology from the University of California, Los Angeles in 2005 and a Master of Arts degree from Duke University in 2011. Ashley completed her Predoctoral Internship in Clinical Psychology at the UCLA Semel Institute for Science and Human Behavior in 2014.

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