



## Intolerance of uncertainty and eating disorder behaviour: Piloting a consumption task in a non-clinical sample

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### ABSTRACT

**Background and objectives:** Intolerance of uncertainty (IU) is a transdiagnostic process contributing to the maintenance of anxiety disorders, and is a potential target for treatment. Recent literature has investigated IU as a cognitive process underpinning pathological fear and anxiety in Anorexia Nervosa (AN). The current study was designed to examine trait and state IU, and their relationship to restrictive eating disorder symptoms, anxiety, worry, cognitive rigidity and eating behaviour. **Methods:** A sample of undergraduate women ( $N = 85$ ) completed measures of eating disorder symptoms, IU, cognitive rigidity and worry. Participants were randomised to complete an eating task under one of two conditions: the “certain” condition received a high-calorie meal and nutritional information, while the “uncertain” condition received the meal alone. During the meal, state IU and state anxiety were examined at three time-points (baseline, pre-eating, post-eating). **Results:** Trait IU was correlated with cognitive rigidity, worry, global eating disorder symptoms, and, in particular, dietary restraint. No differences emerged between conditions with respect to eating-related anxiety, or amount of food eaten. Controlling for condition and eating disorder symptoms, state IU predicted pre-eating anxiety. Beyond the contribution of condition, BMI and eating disorder symptoms, state IU predicted consumption, specifically greater dietary restriction. **Limitations:** The study employed a non-clinical sample. **Conclusions:** IU may be implicated in a rigid cognitive style, the anxiety response to energy-dense food, and restrictive eating behaviour. Should these findings be replicated in a clinical sample, then IU might emerge as an adjunctive treatment target for AN.

Anorexia Nervosa (AN) is among the most recalcitrant of psychiatric illness, and is associated with high morbidity, mortality and public health costs (Arcelus, Mitchell, Wales, & Nielsen, 2011; Weissman & Rosselli, 2017). A significant proportion of patients require hospitalised re-feeding to treat medical complications and prevent death by starvation (Mitchell & Crow, 2006). Outcomes remain modest even when aided by evidence-based treatments, with over half of all patients receiving treatment failing to remit (Watson & Bulik, 2013), and 30–50% of inpatients experiencing relapse in the year following discharge (Carter, Blackmore, Sutandar-Pinnock, & Woodside, 2004; Khalsa, Portnoff, McCurdy-McKinnon, & Feusner, 2017; Pike, 1998). The identification of a subgroup of individuals who progress to develop a ‘severe and enduring’ illness characterised by a chronic and unremitting course (Touyz et al., 2013) is further testament to the debilitating and complicated nature of the disease. Evidently, research is needed to identify novel treatment targets to enhance existing interventions and facilitate sustained cognitive and behavioural recovery.

The anxious, rigid and obsessional phenotype associated with AN renders patient engagement with change-oriented treatment a substantial clinical challenge. A significant proportion of patients discharge prematurely and enter a distressing cycle of relapse and readmission (Mahon, 2000; Wallier et al., 2009). Engaging in treatment requires

cognitive and behavioural flexibility, and the ability to tolerate uncertainty, as entrenched cognitions and behaviours are replaced by new cognitive-behavioural patterns with unknown consequences (Abbate-Daga, Quaranta, Marzola, Amianto, & Fassino, 2015; Sternheim, Fisher, Harrison, & Watling, 2017). Deficits in cognitive-behavioural flexibility are well-documented in AN (Buhren et al., 2012) and are associated with poor treatment engagement and illness recovery (Brockmeyer et al., 2013; Crane, Roberts, & Treasure, 2007; Dahlgren, Lask, Landrø, & Rø, 2014). Extensive empirical investigation has focused on the inflexible neurocognitive profile of AN, with adjunctive treatments such as Cognitive Remediation Therapy developed to address these specific cognitive weaknesses (Tchanturia, Lloyd, & Lang, 2013). However, comparatively little is known about the importance of tolerating uncertainty in AN, both as it relates to illness psychopathology and to the ability to flexibly adopt new patterns of behaviour that are required to sustain recovery. The emergence of a small body of empirical research in this area has recently confirmed what had long been observed in clinical practice: that patients with AN exhibit a specific intolerance of uncertainty (IU; Konstantellou, Hale, Sternheim, Simic, & Eisler, 2019; Sternheim, Konstantellou, Startup, & Schmidt, 2011a; Sternheim, Startup, & Schmidt, 2011b). Indeed, qualitative research suggests that an aversion to uncertainty may play a role in restrictive eating, with

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patients citing that restriction functions to reduce the perceived ‘threat’ associated with uncertainty (Sternheim et al., 2011a).

The definition of IU has undergone subtle iterations since its conception over two decades ago (Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994). More recently, IU has been defined as “an individual’s dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and sustained by the associated perception of uncertainty” (Carleton, 2016a, p. 31). IU is a well-established construct within the anxiety disorders literature and has been incorporated as a target of effective treatments for generalized anxiety disorder (GAD; Dugas & Ladouceur, 2000) and obsessive-compulsive disorder (OCD; Overton & Menzies, 2005), among others (Hewitt, Egan, & Rees, 2009). Accumulative evidence supports IU as a robust transdiagnostic construct that confers risk for multiple psychiatric disorders, particularly for those in which anxiety presents as a significant clinical feature (Carleton, 2016a; Carleton, 2016b). Up to two thirds of individuals with AN meet diagnostic criteria for an anxiety disorder (Kaye, Bulik, Thornton, Barbarich, & Masters, 2004), with the presence of comorbid anxiety symptoms placing patients at greater risk of treatment drop out and poor treatment outcomes (Eisler, Le Grange, & Asen, 2003; Keel & Brown, 2010). Recently, IU has been hypothesised as a potential mechanism underpinning anxiety and anxiety-driven behaviours in AN (Brown et al., 2017; Kesby, Maguire, Brownlow, & Grisham, 2017; Sternheim & Harrison, 2018).

Several studies, including a meta-analysis, have reported that women with AN experience significantly higher degrees of IU compared to those with other types of eating disorders or healthy controls (HCs; Brown et al., 2017). Notably, the level of IU seen in AN is comparable to that reported in the anxiety disorders literature (Sternheim et al., 2011b; Sternheim, Startup, & Schmidt, 2015). Among individuals with AN, IU shows significant relationships with illness severity, drive for thinness, body dissatisfaction, harm avoidance (Frank et al., 2012) and safety behaviours (Waller & Kyriacou, 2013). Furthermore, behavioural tasks used to induce uncertainty generate significantly greater distress in individuals with AN compared to HCs (Sternheim et al., 2011b). At the symptom level, IU shows a significant and direct association with dietary restraint, but no such relationship with binge eating symptoms (Renjan, McEvoy, Handley, & Fursland, 2016). This adds to growing evidence supporting the clinical relevance of IU in AN, where controlling and rigid behaviours dominate, as opposed to bulimia nervosa or binge eating disorder, where loss of control is a core diagnostic feature.

Individuals with high levels of IU perceive uncertainty as threatening (Carleton, 2016a; Carleton, 2016b), and may engage in excessive approach and avoidance behaviours to manage uncertain situations (Berenbaum, Bredemeier, & Thompson, 2008; Boswell, Thompson-Hollands, Farchione, & Barlow, 2013; Vasa, Kreiser, Keefer, Singh, & Mostofsky, 2018). Caloric restriction and ritualistic or obsessive behaviour in AN can be conceptualised as excessive approach and avoidance responses that may develop as a means of coping with poor uncertainty tolerance. For instance, food restriction in AN may, in part, represent an attempt to avoid the uncertainty associated with not knowing the exact composition of the food (e.g., calories, macro-nutrients), or the consequences of ingestion (e.g., ‘will eating this food make me gain weight; how long do I need to work out to burn off this food?’). Similarly, ritualistic behaviours (e.g., cutting food into tiny pieces, feeling hip bones repeatedly, compulsively weighing food) may develop, at least partially, as a means to increase feelings of certainty, minimise doubt, and dampen the experience of ‘threat’ or anxiety surrounding eating or weight gain (Sternheim et al., 2011a; Vasa et al., 2018). Clearly, further empirical research is needed to determine whether IU is contributing to discrete clinical features in AN.

Outside the AN literature, research has distinguished state IU from the transdiagnostic construct of trait IU (Mahoney & McEvoy, 2012). Indeed, the specific situation or context in which an individual encounters uncertainty partially explains the expression of different

disorder symptoms (Mahoney & McEvoy, 2012). For instance, uncertainty regarding negative evaluation in social anxiety disorder (SAD), or uncertainty about cleanliness and contamination in OCD (Mahoney & McEvoy, 2012). State IU has been found to predict symptoms over and above the influence of trait IU across a range of anxiety and depressive disorders (Jensen & Heimberg, 2015; Mahoney & McEvoy, 2012). It has been suggested that utilising salient in vivo tasks to examine the behavioural and affective components of state IU would further advance this body of literature (Shihata, McEvoy, Mullan, & Carleton, 2016). To our knowledge, investigating state IU as it pertains to diagnostically relevant situations in AN (e.g., re-feeding, weight, shape) is yet to be undertaken.

The current study was designed to investigate baseline relationships between trait and state IU, eating disorder psychopathology, worry, anxiety and cognitive rigidity. Our first hypothesis was that trait IU would be positively associated with eating disorder psychopathology, cognitive rigidity, worry, baseline anxiety and state IU. Secondly, we predicted state IU would correlate positively with state anxiety during the consumption task.

The present study was also designed to pilot an experimental task intended to manipulate the level of state uncertainty experienced in relation to an energy-dense food stimulus, and to determine whether this affected self-reported anxiety across three time points relative to consumption (T1: baseline; T2: pre-eating; T3: post-eating). The manipulation involved providing detailed nutritional information about the food stimulus (i.e., calories, fat, protein) to participants randomised to the “certain” condition; participants in the “uncertain” condition received the food stimulus without accompanying information. It was hypothesised that, averaged across the three time points, the uncertain condition would yield higher ratings of state anxiety, compared to the certain condition. We also aimed to examine the relationship between state IU and state anxiety during the consumption task. It was hypothesised that over and above the contribution of eating disorder symptoms, greater pre-eating state IU would predict higher pre-eating anxiety. Finally, we predicted that higher state IU prior to eating would predict greater restrictive eating behaviour during the consumption task, controlling for eating disorder symptoms and body mass index (BMI).

## 1. Method

### 1.1. Participants

Participants consisted of 85 women (Age:  $M = 19.76$ ,  $SD = 2.17$ ; BMI:  $M = 21.37$ ,  $SD = 2.77$ ) recruited from a pool of students studying undergraduate psychology at the University of New South Wales, Australia. The study included individuals with all levels of eating disorder symptoms, but deliberately over-recruited those endorsing high levels of dietary restraint behaviour using scores from a pre-screen battery administered to the cohort. Participants were informed that the study was designed to examine how individual psychological traits related to food preferences. Students were required to abstain from eating for two hours prior to the study and received course credit in return for their participation.

### 1.2. Measures

#### 1.2.1. Intolerance of Uncertainty Scale - 12 item (IUS-12; Carleton, Norton, & Asmundson, 2007)

The IUS-12 is a brief self-report measure that assesses reactions to uncertainty. Items are scored on a 5-point scale from 1 (Not at all characteristic of me) to 5 (Entirely characteristic of me). The IUS-12 consists of two subscales; Prospective IU which relates to anxiety and fear of future events (e.g., *unforeseen events upset me greatly*) and Inhibitory IU which relates to uncertainty impeding action (e.g., *when I am uncertain I can't function very well*). Although the total score is

typically used (Renjan et al., 2016), research has suggested that the two subscales relate differently to specific disorder characteristics, and thus subscale scores are also reported (Hong & Lee, 2015; McEvoy & Mahoney, 2011). The IUS-12 possesses adequate psychometric properties including excellent internal consistency ( $\alpha = 0.91$ ; Carleton et al., 2007).

### 1.2.2. Eating Disorder Examination-Questionnaire (EDE-Q; Fairburn & Beglin, 1994)

The EDE-Q is a 33-item measure derived from the Eating Disorder Examination (EDE) diagnostic interview (Fairburn & Cooper, 1993) that assesses eating attitudes and behaviours over the past 28 days. The EDE-Q uses a 7-point rating scale and results in four subscale scores (Restraint, Weight Concern (WC), Eating Concern (EC), Shape Concern (SC)) as well as a Global score. The EDE-Q demonstrates good concurrent validity, acceptable criterion validity (Mond, Hay, Rodgers, Owen, & Beumont, 2004) and excellent internal consistency ( $\alpha = 0.93$ ; Aardoom, Dingemans, Sloft Opt Landt, & Van Furth, 2012).

### 1.2.3. Detail and flexibility questionnaire (Dflex; Roberts, Barthel, Lopez, Tchanturia, & Treasure, 2011)

The Dflex is a 24-item scale that was designed for use in eating disorder populations and assesses two aspects of neurocognitive functioning: cognitive rigidity and attention to detail. The current study only utilised responses on the cognitive rigidity subscale (e.g., *I like doing things in a particular order or routine*). Items are rated on a 6-point scale from 1 (Strongly Agree) to 6 (Strongly Disagree). The subscale demonstrates excellent internal consistency ( $\alpha = 0.95$ ), construct validity and strong discriminant validity (Roberts, Bartel, Lopez, Tchanturia, & Treasure, 2011).

### 1.2.4. Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990)

The PSWQ is a 16-item measure assessing worry (e.g., *Once I start worrying, I cannot stop*), on a 5-point scale from 1 (Not at all typical of me) to 5 (Very typical of me). Considerable evidence attests to the strong psychometric properties of the PSWQ, including good test-retest reliability, convergent validity (Molina & Borkovec, 1994) and excellent internal consistency among HCs ( $\alpha = 0.90$ ) and anxious samples ( $\alpha = 0.93$ ; Brown, Antony, & Barlow, 1992).

### 1.2.5. The State-Trait anxiety inventory- form Y (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983)

Only the state subscale (form Y) of the STAI was used in this study. The state scale involves positively worded (e.g., *I feel nervous*) and negatively-worded (e.g., *I feel calm*) items that are rated on a 4-point scale from 1 (Not at all) to 4 (A lot). The state scale demonstrates high discriminant and convergent validity (Spielberger et al., 1983), has excellent internal consistency ( $\alpha = 0.91$ ; Barnes, Harp, & Jung, 2002) and is sensitive to experimental manipulation (Chapman & Cox, 1977).

### 1.2.6. Intolerance of uncertainty – Situation Specific version (IUS-SS; Mahoney & McEvoy, 2012)

The IUS-SS is a 12-item measure adapted from the IUS-12. Items are rated on a 5-point scale from 1 (Not at all characteristic of me) to 5 (Entirely characteristic of me) and are completed in reference to an individual's primary diagnostic concern (e.g., social interactions in SAD or intrusive thoughts in OCD). Considering that eating was the situation of interest in the present study, all items were altered to reference consumption of the laboratory meal (e.g., item 5 '*a small unforeseen event in this situation can spoil everything, even with the best planning*' was amended to '*a small unforeseen event while eating this meal can spoil everything, even with the best planning*'). The IUS-SS demonstrates excellent internal consistency ( $\alpha = 0.94$ ), and good discriminant and convergent validity (Mahoney & McEvoy, 2012). This is the first time the IUS-SS has been adapted for use in situations of relevance to eating disorder

psychopathology.

## 1.3. Procedure

Participants underwent a two-stage procedure: completion of self-report measures (IUS-12, EDE-Q, Dflex and PSWQ) followed by the consumption task. The consumption task employed a  $2 \times (3)$  mixed design, with condition (uncertain, certain) as the between-subjects variable, and time relative to food presentation (T1: baseline; T2: pre-eating; T3: post-eating) as the within-subjects variables. The dependent variables were state anxiety (STAI) and state IU (IUS-SS) in anticipation of eating (i.e., T2), and consumption of the food stimuli (grams).

Participants completed the IUS-12, EDE-Q, Dflex and PSWQ, followed by the STAI and IUS-SS to obtain baseline (T1) measures of anxiety and state IU. Participants were then presented with the food stimulus, a piece of chocolate confectionary (approximately 65g; 313 calories), and were randomised to receive either nutritional information (certain condition) or no information (uncertain condition). The nutritional information provided details of the chocolate confectionary, including calories, fat, carbohydrate and protein content. Following presentation of the food stimulus (and accompanying information in the certain condition), participants again completed the STAI and IUS-SS to assess anticipatory eating anxiety and IU immediately prior to consumption (T2). Participants were then told to 'eat as much or as little as you like' of the food stimulus. After participants indicated they had finished the meal, they completed the STAI and IUS-SS for a final time to measure post-eating anxiety and IU (T3). The remaining food was weighed using Salter kitchen scales (precise to 1g) to determine the amount consumed.

## 1.4. Statistical analysis

All data were analysed using SPSS (version 23.0). No cases of missing data were identified. The absence of multicollinearity was confirmed by inspecting the Variance Inflation Factor and Tolerance values, all of which were less than 5, and exceeded 0.2, respectively. Although there were indications of a slight positive skew for STAI T2 (skewness = 0.44, SE = 0.26; kurtosis = -0.21, SE = 0.51) and consumption (skewness = 0.19, SE = 0.26; kurtosis = -0.93, SE = 0.51), inspection of the plots of standardized residuals suggested reasonably normal distribution. Two outliers with standardized residual values greater than 3.3 (Tabachnick & Fidell, 2001) were identified. Cooks Distance values indicated that these outliers were not having a significant influence on the model, and were therefore retained.

Zero order correlations were used to investigate relationships between key variables. An independent samples *t*-test was used to check for differences in baseline (T1) STAI scores between conditions. A two-way mixed ANCOVA was then used to examine mean STAI scores across time (T2, T3) and condition (certain, uncertain), with STAI (T1) entered as a covariate to control for significant baseline differences. An independent samples *t*-test was conducted to determine whether consumption differed significantly according to condition. Hierarchical regression was used to evaluate whether state IU prior to eating predicted anticipatory eating anxiety (T2), over and above the contribution of experimental condition and eating disorder symptoms. A second regression was used to determine whether pre-state IU (T2) predicted consumption (grams) beyond the contribution of experimental condition, BMI and eating disorder symptoms.

## 2. Results

### 2.1. Descriptive statistics

Means, standard deviations and Cronbach's alpha for baseline measures are presented in Table 1. Using the clinical cut off of  $\geq 4.0$  utilised by previous research (Carter, Stewart, & Fairburn, 2001; Mond,

**Table 1**  
Means, standard deviations and Cronbach's alpha for measures (N = 85).

Measure	Mean	SD	$\alpha$
IUS-12 Total	29.48	8.55	.90
IUS-12 Prospective	18.56	5.01	.83
IUS-12 Inhibitory	10.92	4.33	.88
EDE-Q Global	2.62	1.32	.95
EDE-Q Restraint	2.16	1.42	.86
EDE-Q EC	1.73	0.95	.79
EDE-Q SC	3.52	1.68	.92
EDE-Q WC	3.07	1.77	.90
Dflex CR	38.04	10.16	.87
PSWQ	53.75	12.13	.95
STAI T1	36.60	8.66	.90
IUS-SS Total T1	18.35	7.04	.90
IUS-SS Prospective T1	11.28	4.81	.87
IUS-SS Inhibitory T1	7.07	2.66	.72

IUS-12: Intolerance of Uncertainty Scale – 12 item version; EDE-Q: Eating Disorder Examination-Questionnaire; EC: Eating Concern; SC: Shape Concern; WC: Weight Concern; Dflex CR: Detail and Flexibility Scale, Cognitive Rigidity; STAI: State Trait Anxiety Inventory; T1: Baseline; IUS-SS: Intolerance of Uncertainty Scale – Situation Specific.

Hay, Rodgers, & Owen, 2006), 12.94% of the current sample scored in the clinically significant range on Restraint, 4.71% on EC, 43.53% on SC, 34.12% on WC and 17.65% on the Global score. Caloric restriction was the most frequent disordered eating behaviour experienced over the past month, with 62.35% of participants reporting at least one day of deliberate restriction and 12.94% reporting daily frequency of this behaviour. Binge eating, that is eating what other people would regard as an unusually large amount of food, accompanied by a loss of control, was experienced by 44.71% of participants over the past month. A greater proportion of women engaged in excessive and driven exercise (32.94%) than reported self-induced vomiting (3.53%) or laxative misuse (2.35%) over the past month. On average, the sample endorsed high levels of worry on the PSWQ, with 55.29% of participants falling into the 'high worry' category, 30.59% in the 'moderate-high' and 14.12% classified as 'low worry' (Korte, Allan, & Schmidt, 2016).

2.2. Correlations

Table 2 presents zero-order correlations between variables of interest. Trait IU showed a small positive correlation with overall eating

**Table 2**  
Zero-order correlations between variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. IUS-12 TS	1															
2. IUS-12 P	.93**	1														
3. IUS-12 I	.90**	.68**	1													
4. Restraint	.24*	.19	.25*	1												
5. EC	.36**	.32**	.34**	.74**	1											
6. SC	.20	.19	.18	.73**	.69**	1										
7. WC	.21	.20	.17	.73**	.63**	.91**	1									
8. Global	.26*	.24*	.24*	.88**	.81**	.95**	.94**	1								
9. BMI	.01	.01	.02	.42**	.37**	.56**	.53**	.54**	1							
10. Dflex CR	.69**	.69**	.56**	.10	.22*	.16	.13	.16	.00	1						
11. PSWQ	.53**	.50**	.48**	.13	.35**	.21	.20	.23*	-.01	.50**	1					
12. STAI T1	.49**	.42**	.47**	.25*	.42**	.23*	.19	.28*	.12	.49**	.48**	1				
13. IUS-SS T1	.55**	.54**	.46**	.33**	.44**	.39**	.35**	.41**	.31**	.53**	.20	.36**	1			
14. STAI T2	.37**	.30**	.37**	.48**	.39**	.45**	.42**	.49**	.30**	.40**	.37**	.69**	.36**	1		
15. IUS-SS T2	.28*	.25*	.26*	.55**	.39**	.55**	.51**	.56**	.41**	.26*	.06	.24*	.61**	.59**	1	
16. STAI T3	.43**	.36**	.44**	.50**	.53**	.49**	.48**	.55**	.26*	.41**	.47**	.71**	.38**	.88**	.56**	1
17. IUS-SS T3	.38**	.35**	.35**	.59**	.49**	.63**	.57**	.64**	.42**	.37**	.23*	.33**	.64**	.64**	.90**	.64**

IUS-12: Intolerance of Uncertainty Scale – 12 item version; TS: Total Score; P: Prospective; I: Inhibitory; EDE-Q: Eating Disorder Examination-Questionnaire; EC: Eating Concern; SC: Shape Concern; WC: Weight Concern; BMI: Body Mass Index; Dflex CR: Detail and Flexibility Scale, Cognitive Rigidity; PSWQ: Penn State Worry Questionnaire; STAI: State-Trait Anxiety Inventory; IUS-SS: Intolerance of Uncertainty-Situation Specific; T1: Baseline; T2: Pre-eating; T3: Post-eating. \*p < .05; \*\*p < .01.

disorder psychopathology ( $p < .05$ ) and the Restraint subscale of the EDE-Q ( $p < .05$ ), and a large correlation with cognitive rigidity ( $p < .001$ ). Inhibitory IU was more closely related to Restraint ( $p < .05$ ) than Prospective IU ( $p > .05$ ). Scores on the IUS-12 showed positive associations with state anxiety ( $p < .001$ ) and state IU at baseline ( $p < .001$ ). Positive correlations also emerged between state anxiety and IU at baseline ( $p < .01$ ), pre-eating ( $p < .001$ ) and post-eating ( $p < .001$ ).

2.3. Experimental manipulation

Independent samples *t*-test yielded significant differences in baseline (T1) STAI scores between conditions, such that the uncertain condition scored on average 5.36 units higher than the certain condition,  $t(1,82) = -2.98, p = .004, d = .65$ . Accordingly, baseline (T1) STAI scores were entered as a covariate in the two-way mixed ANCOVA used to examine mean STAI scores across time (T2, T3) and condition (certain, uncertain). Analyses revealed no significant main effect of condition  $F(1, 82) = 0.57, p = .45, \eta^2 = 0.007$ , or time  $F(1, 82) = 0.46, p = .50, \eta^2 = 0.006$ , and no significant interaction  $F(1, 82) = 0.06, p = .80, \eta^2 = 0.001$ . Independent samples *t*-test revealed that consumption ( $M = 37.31, SD = 20.11$ ) did not differ as a function of condition,  $t(83) = -0.89, p = .38, d = 0.20$ .

2.4. Predicting pre-eating anxiety from state IU

A hierarchical regression was performed to examine whether state IU predicted anxiety in anticipation of eating (STAI T2), holding condition and overall eating disorder symptoms constant. Condition and EDE-Q scores were entered in block 1, followed by pre-eating state IU (IUS-SS T2) in block 2. The results of the regression indicated that the three predictors explained 39.6% of the variance in pre-eating anxiety ( $R^2 = 0.39$ , adjusted  $R^2 = 0.37, F(3, 81) = 17.71, p < .001$ ). Experimental condition and eating disorder symptoms together explained 26% of the variance in pre-eating state anxiety,  $F(2, 82) = 14.39, p < .001$ . Including state IUS-SS T2 in the model explained an additional 13.6% of variance in STAI T2 scores,  $\Delta F(1, 81) = 18.27, p < .001$ , with a 1 unit increase in IUS-SS at T2 predicting a 0.63 unit increase in STAI at T2,  $B = 0.63, SEB = 0.15, \beta = 0.45, t(81) = 4.27, p < .001$ .

## 2.5. Predicting consumption

A hierarchical regression was utilised to evaluate whether state IU prior to eating (T2) predicted consumption over and above the contribution of experimental condition, BMI and eating disorder symptoms. The results of the regression indicated that the four predictors explained 11.3% of the variance in consumption ( $R^2 = 0.11$ , adjusted  $R^2 = 0.07$ ,  $F(4, 80) = 2.55$ ,  $p = .045$ ). The initial block containing experimental condition and BMI explained 1.3% of the variance in consumption,  $F(2, 82) = 0.52$ ,  $p = .60$ . The addition of EDE-Q scores in the second block did not increase the variance accounted for,  $\Delta F(1, 81) = 0.02$ ,  $p = .90$ . Including IUS-SS T2 in the model explained an additional 10% of variance in consumption,  $\Delta F(1, 80) = 9.06$ ,  $p = .004$ . A one unit increase in IUS-SS T2 predicted a 1.06 g decrease in consumption,  $B = -1.06$ ,  $SEB = 0.35$ ,  $\beta = -0.39$ ,  $t(80) = -3.01$ ,  $p = .004$ .

## 3. Discussion

The goal of the current study was to investigate associations between IU, eating disorder psychopathology, anxiety, worry and cognitive rigidity in a non-clinical sample. We also piloted an experimental paradigm to examine whether manipulating uncertainty affected self-reported anxiety and eating behaviour during a laboratory meal.

Consistent with hypotheses, trait IU showed a small positive correlation with global eating disorder psychopathology. More specifically, trait IU showed a small positive correlation with Restraint, a finding that supports previous literature suggesting IU is most strongly related to restrictive eating disorder features (Brown et al., 2017). Further examination revealed that the relationship between IU and Restraint was most strongly driven by scores on the Inhibitory subscale, which measures behavioural inaction as a response to uncertainty. This finding lends preliminary support to the conceptualisation of dietary restraint as a type of inaction or behavioural paralysis that may occur in response to uncertainty regarding the contents of a meal or the consequences of consumption.

As predicted, trait IU also demonstrated a large correlation with cognitive rigidity on the Dflex. To our knowledge, this is the first published finding to connect these two areas of literature – IU and cognitive rigidity – to research concerning AN. Given that research suggests a relationship between elevated IU and difficulties with decision making (Carleton et al., 2016c; Luhmann, Ishida, & Hajcak, 2011), our results support the notion that IU may represent a vulnerability factor for the inflexible cognitive profile seen in AN (Kesby et al., 2017; Merwin et al., 2011). Lastly, echoing the findings of an already vast literature and conceptual framework (Dugas & Ladouceur, 2000), trait IU showed a significant moderate association with worry.

During the consumption task, correlation analyses revealed strong associations between trait IU and anxiety at baseline, pre-eating and post-eating. Moreover, at each of the three time points, state IU was significantly associated with state anxiety. Together, these findings are in line with literature demonstrating IU is an important factor involved in anxiety related processes and symptoms (Carleton, 2016b). Interestingly, state IU (at all three time points), but not trait IU, showed medium to large correlations with all scales of the EDE-Q. These findings echo existing literature demonstrating that, compared to trait IU, state IU is a greater predictor of disorder specific symptoms (Mahoney & McEvoy, 2012).

Contrary to hypotheses, the experimental manipulation failed to yield significant differences in anxiety regarding consumption. One possible explanation for this unexpected result is that the study design lacked sufficient salience to induce or adequately highlight the experience of uncertainty. Given the non-clinical sample, participants in the uncertain condition experienced a somewhat typical everyday situation (i.e. consuming pre-prepared food in the absence of nutritional information). Thus, it may be that healthy individuals become

accustomed to a baseline level of uncertainty in the context of food and eating, and that our manipulation lacked sufficient salience to distinguish the task from a typical everyday eating situation. Moreover, as the instructions to ‘eat as little or as much as you like’ did not indicate an explicit expectation to consume all, or indeed any, of the (potentially uncertain) food, participants may have relied upon using food avoidance or restriction to manage anxious mood. This may have impacted subsequent ratings of anxiety.

As hypothesised, in anticipation of consuming the energy-dense food, higher state IU predicted greater anxiety, over and above the influence of condition and eating disorder symptom scores. Furthermore, higher state IU prior to eating predicted restrictive eating behaviour, over and above the variance accounted for by condition, EDE-Q scores and BMI. These findings suggest that in addition to eating disorder symptoms, state IU may be titrating the level of anxiety experienced directly prior to eating. Furthermore, our findings raise the possibility that this may, in turn, contribute to downstream restrictive eating behaviour, as has been previously suggested by qualitative patient accounts (Sternheim et al., 2011a).

### 3.1. Clinical implications

Previous research has shown that higher pre-meal anxiety is associated with lower caloric intake (Steinglass et al., 2010). As such, food-related anxiety is a critical target in the treatment and prevention of relapse in AN (Steinglass et al., 2011). Psychotherapeutic interventions for the treatment of anxiety, including exposure and response prevention, yield significant reductions in anxiety and increase calorie consumption in AN (Steinglass et al., 2012). Against this background of research, our findings raise the possibility that anxiety in response to food and eating may relate to distress about not knowing, or about needing to be certain, of the meal situation and the consequences of ingestion. This desire for certainty may drive food avoidance, or a type of ‘uncertainty paralysis’ (Berenbaum et al., 2008) that manifests in caloric restriction. Given that reductions in anxiety improve engagement in nutritional rehabilitation for eating disorders (Steinglass et al., 2012), our findings suggest that state IU may be an important, and hitherto neglected, component of anxiety that warrants further investigation in this complex clinical population.

Research has demonstrated that trait IU plays a role in the maintenance of learned fear (Morriss, Christakou, & van Reekum, 2016) and is both targetable and modifiable across a range of psychiatric disorders (McEvoy & Erceg-Hurn, 2016; van der Heiden, Muris, & van der Molen, 2012). Learning to tolerate the uncertainty associated with eating a challenging meal or ‘forbidden’ food, or the unknown consequences associated with resisting the urge to exercise or purge, have long been considered inherent components of eating disorder treatment. However, as empirical research investigating the real-world cognitive and behavioural implications of poor uncertainty tolerance in eating disorders has been limited, current interventions do not include poor uncertainty tolerance as a specific treatment target. Should clinical research replicate and strengthen the findings reported here, then specifically targeting IU, both as a trait disposition and as a unique feature contributing to areas of diagnostic concern (i.e., fear of food, weight and shape), might constitute a novel and targeted approach to existing cognitive-behavioural treatments. Indeed, trials are currently underway to translate treatment protocols originally designed to target trait IU in GAD (Dugas & Ladouceur, 2000) to adolescent patients receiving treatment for AN, with promising findings (Sternheim & Harrison, 2018).

### 3.2. Limitations and future research

The results of this study should be interpreted in the context of some limitations. First, the use of a nonclinical sample prevents any clinical conclusions from being drawn. Secondly, the eating disorder symptoms

endorsed by our sample were heterogeneous in nature, and included restrictive practices, binge-eating and compensatory behaviours. Given that IU likely differs across eating disorder diagnoses (Brown et al., 2017; Frank et al., 2012), firm conclusions regarding the ways in which IU might function in restrictive eating disorders are limited. Finally, the experimental manipulation proved unsuccessful and was limited by a range of potential confounds that have been previously discussed.

Future research should aim to extend the current findings to a clinical sample with AN. A longitudinal design would enable researchers to track the trajectory of trait and state IU across treatment, and determine whether changes in IU predict key indicators of treatment success, or appear to drive clinically meaningful reductions in fear or anxiety. Positive findings may have implications regarding whether targeting trait IU, state IU or a combination of the two, would be advantageous to treatment (Thibodeau et al., 2015; Shihata et al., 2016). In light of research suggesting that patients with AN possess a strong dislike of change and uncertainty and are neuropsychologically prone to engaging in rigid cognitive and behavioural responses, it is unsurprising that engagement with change-oriented treatment remains fraught (Mahon, 2000). Therefore, it is possible that targeting both trait and state IU may help patients better cope with the inherent uncertainty that accompanies physical, cognitive, emotional and social changes that take place during treatment and recovery. Investigating whether an intervention that enhances tolerance for uncertainty yields any benefit to patient engagement or treatment retention, is another possible avenue for future research.

#### 4. Conclusions

The significant proportion of patients with AN who do not respond to evidence-based treatment highlights the urgency with which novel treatment adjuncts are required. There is growing recognition that, in addition to weight restoration, targeted transdiagnostic mechanisms may help to advance theoretical conceptualisation and targeted interventions for AN (Murray, Loeb, & Le Grange, 2018; Sternheim & Harrison, 2018). Our findings are consistent with the proposal that IU may represent a cognitive bias involved in the development and maintenance of eating disorder symptoms, including debilitating anxiety, inflexible thinking and restrictive eating behaviour (Brown et al., 2017; Kesby et al., 2017; Merwin et al., 2011). It is hoped that future research recommendations outlined above will encourage the continued uptake of empirical research into the various manifestations of IU in AN populations. The recent decision to pilot treatments targeting IU in patients with AN (Sternheim & Harrison, 2018) attests to the strengthening momentum that exists in this domain of intersecting research. Continued enquiry may see IU emerge as a transdiagnostic (or, as some have suggested, a *trans*-therapy; McEvoy & Ercceg-Hurn, 2016) mechanism of change that could aid in the evolution of targeted interventions for AN.

#### Funding

This research was supported by an Australian Government Research Training Program (RTP) Scholarship

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