

Toward a Structurally-Sound Model of Uncertainty-Related Personality Traits

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Alex Rautu

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Advisor: Colin G. DeYoung, Ph.D.

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## **Abstract**

Numerous personality constructs have been proposed over the last 70 years to describe individual differences in attitudes toward uncertainty, including Intolerance of Ambiguity (IA), Intolerance of Uncertainty (IU), Uncertainty Orientation (UO), Need for Closure (NFC), and Personal Need for Structure (PNS). Despite differences in their theoretical foundations and applications, these constructs share considerable similarities in conceptualization and measurement, which have confounded researchers about how they can be meaningfully distinguished. Study 1 examined the facet- and construct-level overlap among multiscale measures of IA, IU, and NFC—constructs that have received the lion’s share of research attention—also including the Uncertainty Response Scale (URS; Greco & Roger, 2001). Confirmatory factor analysis revealed that the general factors underlying each measure were identical or near-identical with one another (in two US samples but not an Italian sample), and exploratory factor analyses of both the items and facets of each measure found that only four factors replicated across US and Italian samples. Moreover, the four factors uncovered showed strong concurrent validity with trait measures of neuroticism, orderliness, curiosity/exploration, and naïve epistemic beliefs, which suggested that they reflect distinct types of responses to uncertainty, consistent with the model assumptions of the URS. Another two studies examined the discriminant predictive validity of the four factors with respect to evidence gathering (Study 2) and avoidance of ambiguity under conditions of threat and high cognitive demand (Study 3). Their results confirmed that these factors predict different behavioral outcomes and have more predictive power than NFC, IA, and IU scales. Overall, this

work demonstrates that a four-factor model has psychometric and conceptual advantages over current measures of uncertainty-related constructs, which are lacking in discriminant validity.

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## **Introduction**

The study of individual differences in responses and attitudes toward uncertainty has a long history in personality psychology, dating back to Frenkel-Brunswik's (1949) seminal article on Intolerance of Ambiguity (IA). Since then, a variety of similar constructs have been proposed under various labels, including but not limited to Intolerance of Uncertainty (IU; Freeston, Rheume, Letarte, Dugas, & Ladouceur, 1994), Need for Closure (NFC; Webster & Kruglanski, 1994), Need for Structure (NFS; Neuberg & Newsom, 1993), and Uncertainty Orientation (UO; Sorrentino & Short, 1986). Generally speaking, these constructs originated from independent research inquiries, often with little apparent influence on each other, and have found application in different areas of study and practice. For instance, IA emerged from research interest in ethnic prejudice and, more broadly, the authoritarian personality (Adorno, Frenkel-Brunswik, Levinson, & Sanford, 1950); NFC was initially conceived of as an epistemic motive guiding the formation of knowledge and is now widely employed in social and political psychology research; and IU was proposed to explain why people worry and is of special interest to researchers and practitioners in mental health-related fields.

Despite the divergent origins and applications noted, researchers have increasingly recognized that there is confusing overlap in both the conceptualization and assessment of these constructs, which merits investigation. Two papers, in particular, have sought to differentiate IU from IA or other constructs (e.g., NFC, UO) by comparing their definitions and instruments of measurement, and by proposing hypotheses regarding their differences and similarities that could be substantiated in future research (Grenier,

Barette, & Ladouceur, 2005; Rosen, Ivanova, & Knauper, 2013). A more recent paper, on the other hand, assumes that constructs like IU and IA are similar enough that they warrant conceptual integration rather than differentiation (Hillen, Gutheil, Strout, Smets, & Han, 2017). In this paper, the authors synthesized insights from 18 questionnaires of uncertainty constructs (namely, IA, IU, and NFC) to offer an integrative definition and conceptual model of “Uncertainty Tolerance.”

An important piece of the puzzle that is missing from these conceptual investigations and which I address in this thesis is whether or not measures of uncertainty constructs (which consist mostly of questionnaires) do in fact measure distinct traits. If they do, then it would provide an empirical rationale for efforts to clarify how these personality constructs are distinct, whereas if they do not, it would justify attempts to integrate them under a unifying model. Alternatively, if there are strong theoretical reasons to distinguish the constructs, then a lack of psychometric discrimination could mean that one or more of the measures is lacking in construct validity, in which case efforts might be directed towards improving measurement. Examining the discriminant validity of the measures can therefore inform how the confusing overlap among the constructs should be resolved.

One particular reason to suspect that there might not be adequate discrimination among existing measures has to do with their multifacetedness. The NFS (Neuberg & Newsom, 1993) and NFC (Webster & Kruglanski, 1994) scales, for example, both consist of two or more subscales purporting to measure various facets of their respective constructs, and likewise, factor analytic studies of the IU Scale (Freeston et al., 1994) and

various IA scales have both led to the development of newer measures with multiple subscales (Birell et al., 2011; Lauriola, Foschi, Mosca, & Weller, 2015). Importantly, these subscales share significant similarities across measures and in some cases they appear to measure the same facet, such as, a “discomfort with ambiguity,” a “desire for predictability,” or a “need for order and structure.” It is sometimes pointed out that these similarities are limited to only one or a few facets (e.g., Webster & Kruglanski, 1994), yet this overlooks a key assumption—that the facets are expressions of the same underlying trait. Under this assumption, it is enough for two measures to have just one facet in common to question whether they are indeed measuring different things.

Given that there is likely considerable overlap among the subscales, one must also ask how many distinct traits (facets) are being measured across all instruments. To the extent that the subscales measure similar traits, one would expect to find a number of factors (i.e., in a factor analysis) that is smaller than the number of subscales, which would further demonstrate psychometric redundancy. Additionally, the benefit of investigating the factor structure of existing instruments is that this structure may inform the development of a more psychometrically-sound measure of uncertainty-related traits.

The initial objective of this dissertation was, therefore, to evaluate the discriminant validity of uncertainty-related measures at both the construct and facet levels of analysis. I focused specifically on multi-scale questionnaires of IA, IU, and NFC, as these constructs have received the most research attention and their measures can be factor analyzed at the item level and do not share any items.<sup>1</sup> The Uncertainty

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<sup>1</sup> Although relevant to this dissertation, the NFS scale was not looked at as its subscales are subsumed with only minor alteration by the Need for Closure Scale (see Kruglanski et al. [1997] for a discussion of the

Response Scale (Greco & Roger, 2001), a measure of three styles of coping with uncertainty, was also examined for two reasons: one is that its subscales have overt similarities to those of the other measures, and the second is that, in an exploratory data analysis, the URS subscales loaded on a general factor similar to NFC. In the following section, I review the theoretical and psychometric development of each construct and instrument in order provide adequate context for their selection.

The second objective of this work is to provide empirical and theoretical support for a four-factor model of uncertainty-related traits that may, with further development, supplant existing measures of uncertainty-related constructs. This four-factor model is suggested by the results of a factor analysis described in Study 1, which demonstrate substantial overlap among the facets of IA, IU, and NFC. It is appropriate therefore to consider the second objective as a logical extension of the outcome of the first objective.

## **Review of Uncertainty-Related Constructs and Measures**

### **Intolerance of Ambiguity**

IA was originally proposed to explain two seemingly related patterns of behavior observed in children who scored extremely high on ethnic prejudice (Frenkel-Brunswik, 1949). One was their tendency to describe or evaluate people in strictly categorical terms, such as good/bad or strong/weak, and another was their tendency to form premature judgments on tasks involving perceptual ambiguity, coupled with a slowness to change perceptions in response to new, conflicting information. Frenkel-Brunswik interpreted

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common origin of the NFS and NFC constructs). I also decided not to cover Uncertainty Orientation, as its measurement includes an authoritarianism scale coupled with a projective personality test, which does not lend itself to a factor analysis of questionnaire items.

these tendencies as “different aspects of what may be a fairly coherent characteristic” (p. 14), namely, an inability to tolerate conflicting emotions or perceptions.

Despite initial failure to find convergent validity among different tests and questionnaire measures of IA (e.g., Kenny & Ginsberg, 1958), researchers continued to refine the construct. Budner (1962) influentially re-conceptualized IA as “tolerance-intolerance of ambiguity,” where “intolerance” described the tendency to regard ambiguous situations as sources of threat, and “tolerance” described the tendency to perceive such situations as desirable—thereby acknowledging that one could experience either aversion or attraction toward ambiguity. Ambiguous situations were defined as those that could not be adequately structured or categorized due to the absence of any familiar cues (novelty), the presence of too many cues (complexity), or the presence of conflicting cues (conflict). Furthermore, Budner identified anxiety, denial and avoidance as responses to ambiguity that is threatening, yet, interestingly, he never specified what makes ambiguity desirable or attractive. McLain (2015) would later fill in this conceptual gap by proposing that ambiguity can be desirable if it allows one to engage with novel or complex stimuli in a non-threatening context, in which case it may elicit curiosity and other positive affect.

Factor analyses of existing IA questionnaires suggest a multidimensional structure (Furnham, 1994; Lauriola, Foschi, Mosca, & Weller, 2015). In the most recent investigation to date, Lauriola and colleagues (Study 1; 2015) factor analyzed 133 items from seven different measures of IA and discovered three factors in both US and Italian samples: Discomfort with Ambiguity (e.g., “It intensely disturbs me when I am uncertain

of how my actions will affect others.”), Moral Absolutism/Splitting (e.g., “There are two kinds of people in the world: the weak and the strong”), and Need for Complexity and Novelty (e.g., “I enjoy tackling problems which are complex enough to be ambiguous.”). Notably, these factors approximated three of the factors that had been identified in a previous factor analysis (Furnham, 1994), thus lending the results additional support. The three-factor structure was subsequently replicated in a confirmatory factor analysis (CFA) of 30 items (10 selected for each factor), which resulted in a new measure of IA, named the Multidimensional Attitude Toward Ambiguity Scale (MAAS; Study 2; Lauriola et al., 2015). In this CFA, the authors also found support for a bifactor model, consisting of one general factor and three specific factors for the facets, which suggests that IA is a multifaceted yet cohesive trait.

### **Intolerance of Uncertainty**

IU originated independently of the IA construct from attempts to understand the psychological roots of excessive worry (Freeston et al., 1994). It has been defined as the tendency “to consider the possibility of a negative event occurring as both unacceptable and threatening, irrespective of the probability of its occurrence” (Carleton et al., 2012, p. 1). Freeston and colleagues (1994) posited that IU might underlie various phenomena associated with worry, citing their clinical observations of patients with Generalized Anxiety Disorder (GAD) as well as a host of studies showing that worriers tend to interpret ambiguous events as threatening, overestimate risk, and are slower to make decisions in ambiguous situations. Although they acknowledged the extensive literature on IA, they argued that IA was a broader concept than theirs and noted that factor

analyses (Furnham, 1994) had identified several IA factors, of which only one bore a resemblance to IU.

Drawing upon their clinical insights, Freeston et al. (1994) developed the Intolerance of Uncertainty Scale (IUS), which showed excellent internal consistency and was successfully validated against measures of worry and GAD in both clinical and nonclinical groups. Initially, five factors were identified within this scale, but other studies would later identify anywhere from two to five factors. Birell and colleagues (2011) reviewed the factor solutions reported in nine studies and determined that the highest quality publications supported two factors in both the IUS and a shortened 12-item version of the IUS (Carleton, Norton & Admundson, 2007). The first factor, Prospective IU, described a desire for and active engagement in seeking predictability (e.g., “I always want to know what the future has in store for me.”), and the second factor, Inhibitory IU, described cognitive and behavioral paralysis in the face of uncertainty (e.g., “When I am uncertain, I can’t go forward.”). Due to its short length and coverage of the two factors mentioned, the 12-item version of the IUS has been widely adopted as an alternative measure to the original IUS.

### **Need for Closure**

Need for closure is conceptually defined as a desire for “a definite answer on some topic, any answer as opposed to confusion and ambiguity” (Kruglanski, 1989, p. 14). It emerged as a motivational construct in Kruglanski’s theory of lay epistemics (1989), which describes how knowledge is formed and modified. Kruglanski (1989) postulated a need to avoid closure as functionally opposite to the need for closure, and he

noted that which need was aroused in any given situation was a function of the perceived costs and benefits of seeking vs. postponing closure. Seeking closure, for example, might be aroused in situations where there is time pressure, the demands of processing information are high, or the task at hand is dull and uninteresting, yet it could also be costly if it leads to a premature, erroneous conclusion when accuracy is important (Webster & Kruglanski, 1994). A desire to postpone closure, on the other hand, might be elicited in situations where information processing is intrinsically rewarding. These relationships were indeed supported by studies demonstrating that the need for closure is moderated by a host of situational factors, such as task attractiveness, time pressure, fatigue, and environmental noise (Kruglanski & Freund, 1983; Kruglanski, Webster, & Klem, 1993; Webster, 1993).

Although the NFC was initially studied as a transient motivational state, Webster and Kruglanski (1994) proposed that it also constitutes a stable individual difference, which led to the development of the NFC scale (NFCS). The NFCS consists of 42 items, 16 of which were designed to measure the opposing need to avoid closure, and 5 subscales that represent different ways in which the need for closure manifests, including a Preference for Order and Structure (e.g., "I think that having clear rules and order at work is essential for success"), Discomfort with Ambiguity (e.g., "I don't like situations that are uncertain."), Desire for Predictability (e.g., "I don't like to go into a situation without knowing what I can expect from it"), Closed-mindedness (e.g., "I do not usually consult many different opinions before forming my own view") and Decisiveness (e.g., "I usually make important decisions quickly and confidently").

In its seminal publication (Webster & Kruglanski, 1994), the NFCS showed adequate reliability, and it demonstrated criterion validity by replicating some of the effects of situational inductions of NFC, which had been observed in previous studies. Furthermore, as evidence of discriminant validity, it was only moderately positively correlated with the Intolerance of Ambiguity Scale (Eysenck, 1954), which the authors noted was consistent with the fact that Discomfort with Ambiguity is one of several facets of NFC. The authors also found that a one-factor model with correlated errors within the five facets best fit the data, which supported their theory that NFC is a unitary trait.

Subsequent studies have found that the Decisiveness facet is not reliably related to the other NFC facets (Mannetti, Pierro, Kruglanski, Tavis, & Bezinovic, 2002; Neuberg, Judice, & West, 1997), possibly because it represents the ability rather than the need to attain closure (Mannetti et al., 2002). As a result, a new set of items were written to measure a Need for Decisiveness (e.g. “I would rather make a decision quickly than sleep over it.”), which replaced the original Decisiveness subscale in the revised NFCS (Roets & Van Hiel, 2007).

### **Uncertainty Response Scale**

In contrast to the other constructs and measures reviewed, the Uncertainty Response Scale (URS; Greco & Roger, 2001) purports to measure three styles of coping with uncertainty, and it was not developed on the basis of any theory. Instead, its items were generated using a scenario technique, whereby a group of 30 participants were asked to indicate how they would feel, what they would think, and how they would act in

situations described by ten vignettes about uncertainty in everyday life (e.g., being notified of a change in an itinerary for a holiday trip, which means going someplace you have never been to). The free responses to the vignettes were then edited, minimally, and administered as Likert-type statements to a group of undergraduate students. Using exploratory factor analysis (EFA), the authors identified three factors underlying responses to uncertainty: Emotional Uncertainty described negative emotional reactions (e.g., “I get worried when a situation is uncertain.”), Cognitive Uncertainty described the desire to reduce uncertainty through strategies such as planning ahead, seeking clarification and gathering information (e.g., “I try to have my life and career clearly mapped out.”), and Desire for Change described curiosity and the desire to experience new things (e.g., “I find the prospect of change exciting and stimulating.”).

The URS subscales were shown to have excellent internal consistency, and they were also found to be moderately correlated with one another (Greco & Roger, 2001), which suggests that they may also be measuring a higher-order dimension. In an informal EFA of the URS subscales that preceded the research described in this thesis, I discovered that the subscales, indeed, load on a general factor, which explained 57% of their variance and was strongly correlated with the NFCS. Other evidence of the relationship of the URS with uncertainty-related scales can be found in the results of Study 1 in Lauriola et al. (2015). In this study, moderate to strong positive correlations were reported among Emotional Uncertainty (URS), Discomfort with Ambiguity (MAAS), and the IUS, and Desire for Change (URS) was strongly correlated with Need

for Complexity and Novelty (MAAS). Altogether, this evidence suggested to me the relevance of the URS for this dissertation.

### **Comparison of uncertainty-related constructs and measures**

Although the constructs and measures reviewed here have been compared in more detail elsewhere (e.g., Rosen et al., 2013), it is necessary that I highlight some important differences and similarities. Conceptually, IA, IU, and NFC, all purport to describe a dispositional aversion to ambiguity or uncertainty.<sup>2</sup> Theories of IA and IU concur that this aversion stems from perceptions of threat and concomitant states of anxiety and worry, but IA theorists also maintain that ambiguity can be attractive to the extent that it is interesting or enjoyable to solve, in the absence of threat (Budner, 1962; McLain, 2015). It is appropriate therefore that the MAAS has separate subscales measuring attraction and aversion to ambiguity (i.e., Discomfort with Ambiguity and Need for Complexity and Novelty). These two motivational orientations toward ambiguity are also alluded to in the discussion of situational moderators of the opposing needs of seeking versus avoiding closure (Webster & Kruglanski, 1994). For instance, people may seek closure when threatened with failing to meet a deadline, yet, they may seek to avoid closure when a task is inherently interesting or rewarding. It is unclear, however, how these needs are operationalized in the NFCS, because the items that purport to measure them are spread across multiple subscales.

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<sup>2</sup> In this work, I use the terms “aversion to ambiguity” and “aversion to uncertainty” interchangeably. Chapter 3, in particular, focuses on the sources of uncertainty in ambiguous stimuli, and therefore “aversion to ambiguity” is more appropriate in that context, whereas “aversion to uncertainty” becomes more appropriate within the context of discussing how people respond to uncertainty.

At a lower level of analysis, one may also identify similar item content across the subscales of each measure. Preference for Order (NFCS) and Cognitive Uncertainty (URS) share content related to planning ahead, being organized, and following a schedule; Discomfort with Ambiguity (NFCS, MAAS) and Emotional Uncertainty (URS) describe negative affect in response to ambiguity or uncertainty; Need for Novelty and Complexity (MAAS) and Desire for Change (URS) both emphasize positive responses to novel, complex, and otherwise ambiguous stimuli (e.g., interest, enjoyment, approach, etc.); and Desire for Predictability (NFCS) and Prospective IU essentially describe a desire for certainty regarding future events.

One crucial difference between the measures reviewed concerns their assumed dimensionality. Although all measures consist of two or more subscales, only those of the NFCS and IUS are taken to represent facets of an overarching trait. By contrast, the MAAS assumes that IA is a multidimensional construct that is best represented as three separable traits, and the URS purports to measure three different traits (i.e., styles of coping with uncertainty) that happen to be correlated with one another.

### **Overview of Dissertation**

Chapter 1 provides evidence from three samples (US students and Mechanical Turk users, and Italian students) that measures of IA, IU, and NFC, including the URS, are lacking in discriminant validity. Addressing the facet-level overlap, an EFA of the items and facets from 12 subscales showed support for only four replicable factors across samples—Uncertainty Distress, Preference for Structure, Preference for Novelty/Complexity, and Categorical Thinking, which correlated strongly with trait

measures of neuroticism, orderliness, curiosity and exploration, and naïve epistemic beliefs, respectively. Secondly, a CFA revealed that the latent traits underlying each scale (NFC, etc.) were virtually indistinguishable from one another as they showed inter-correlations in excess of .90 (in the US samples but not the Italian sample—likely reasons for this discrepancy are discussed in Chapter 1).

The redundancy found among the measures in Study 1 suggested to me that a measurement model based on the four factors should be looked into as an alternative. As discussed at the end of Chapter 1, this model assumes that the factors reflect fundamentally distinct responses to uncertainty, consistent with the model assumptions of the URS (Greco & Roger, 2001), and therefore they should not be considered interchangeable indicators of a unitary trait like NFC (etc.). To substantiate this assumption, Studies 2 and 3 provide evidence for the discriminant predictive validity of the four factors with regards to two types of behaviors: the gathering of evidence to make decisions (Study 2) and the avoidance of ambiguous stimuli under threatening and cognitively demanding conditions (Study 3). Equally important, these studies demonstrate that the four factors have greater predictive power than IA, IU, and NFC scales.

Finally, in Chapter 4, I lay out a tentative theoretical framework for thinking about responses to uncertainty in order to provide greater context for my interpretations of the four factors. This framework synthesizes insights from a variety of sources, including research on goals, emotions, coping, and personality, among other topics.

Although the studies in this thesis do not assume knowledge of this framework, the reader may nevertheless benefit from reading Chapter 4 ahead of the other chapters.

## **Chapter 1: Exploring the Psychometric Overlap Among Uncertainty-Related Scales**

The main goals of this study are to resolve two questions regarding the psychometric overlap among questionnaires of IA, IU, NFC, including the Uncertainty Response Scale (URS; Greco & Roger, 2001). The first relates to how many distinct traits they measure at the facet level, and the second relates to their discriminant validity as measures of coherent overarching constructs. Note that the URS does not purport to measure an overarching construct; nevertheless, its higher-order dimensionality is suggested by moderate correlations among its subscales (Greco & Roger, 2001) and an exploratory data analysis that was conducted prior to this study. The aforementioned questions are addressed using three samples, consisting of US students and Mechanical Turk (MTurk) users, and Italian students from Study 1 of the research described by Lauriola and colleagues (2015).

To answer the first question, a hierarchical factor analysis of the scales' items and subscales was conducted in each sample, and the replicability of the factors across samples was analyzed. This approach enabled me to compare factor solutions and determine at which solution the factors were no longer replicable. Then, to shed more light on the nature of the factors that were replicated, I examined their concurrent validity with other personality traits including individual differences in decision-making styles. These individual differences are of particular relevance to this study because decision-making entails uncertainty about the outcomes of different courses of action; thus, how people make decisions reflects on how they cope with uncertainty.

In the second part of this study, CFA was used to test the correlations between the constructs as latent traits. For this purpose, each measure was specified as a bifactor model with one general factor and additional factors for every subscale. Should the correlations between the general factors approach unity, it would provide evidence that the questionnaires are measuring the same latent trait.

It is important to mention that the design of the present study was in part informed by the results of a previous EFA of 130 items measuring not only IA, IU, and NFC, but also curiosity, sensation seeking, orientations to threat, dogmatism, and epistemological beliefs (Rautu & DeYoung, 2017). This wider selection reflected our interest in exploring the structure of loosely-related traits that have conceptual ties to uncertainty<sup>3</sup> rather than assessing their discriminant validity. Although I did not seek to replicate the results of this earlier investigation, I expected to find very similar factors in the present study, and therefore some of the measures that were relevant to our earlier investigation (e.g., measures of curiosity, threat orientation, etc.) were used in this study for evidence of concurrent validity between the emergent factors and other personality traits.

## **Methods**

### **Participants and Procedure**

US participants consisted of 377 undergraduate students enrolled at the University of Minnesota ( $M_{\text{age}} = 20.1$ ,  $SD = 3$ , 71% female), who participated for course credit, and 303 Mechanical Turk (MTurk) users ( $M_{\text{age}} = 37.2$ ,  $SD = 10.9$ , 59% female), who were

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<sup>3</sup> We considered relevant any trait that had to do with responses or attitudes toward novelty, complexity, ambiguity, risk, unpredictability, incentive reward, and threat—all of which tend to elicit uncertainty. As a result of this broad criterion, we cast a wide net that included measures that were less conceptually cohesive than measures of IA, IU, and NFC.

paid \$2 for their participation and entered into a raffle for an additional \$50. To further incentivize participation, both groups were also offered optional feedback on their personality trait scores, which was made available immediately upon completion of the study materials. They completed a series of personality questionnaires, at their convenience, in an online survey that took approximately 70 minutes to do. Italian participants were 360 undergraduate students from the Sapienza University of Rome ( $M_{age} = 23.7$ ,  $SD = 4.8$ , 74% female) who also participated for course credit. They filled out the questionnaires in a paper-and-pencil survey that was administered after class over a period of roughly an hour.

**US survey.** Participants completed the URS (Greco & Roger, 2001), revised Need for Closure Scale (NFCS; Roets & Van Hiel, 2007), 12-item Intolerance of Uncertainty Scale (IUS; Carelton et al., 2007), and Multidimensional Attitude Toward Ambiguity Scale (MAAS; Lauriola et al., 2015). Additionally, they completed measures of the Big Five traits and aspects, threat orientation, curiosity and exploration, epistemic beliefs, decision-making styles, and other traits that were not looked at in this study (cognitive rigidity, attention to detail, Obsessive Compulsive Personality Disorder, Right-Wing Authoritarianism, political orientation, and disgust sensitivity).

The Big Five traits and their 10 aspects were measured with the Big Five Aspect Scale (BFAS; DeYoung, Quilty, & Peterson, 2007), which includes subscales for Compassion and Politeness (aspects of Agreeableness), Enthusiasm and Assertiveness (aspects of Extraversion), Orderliness and Industriousness (aspects of

Conscientiousness), and Openness and Intellect (aspects of Openness to Experience). Scores from each pair of aspects are averaged to obtain the Big Five scores.

The Threat Orientation Scale (Thompson, Schlehofer, & Bovin, 2006) was used to measure individual differences in two types of responses to threat, one that involves asserting control by taking action and precautions to protect oneself from threat (e.g., “My approach to possible dangers is to find out how to protect myself.”), and another that involves overestimating and worrying about threats (e.g., “No matter what I do to feel more secure, I frequently worry about my safety.”). These responses were originally labeled “control-based” and “heightened-sensitivity-based” (orientations to threat), but, for greater transparency, I refer to them in this study as “preventive coping” and “anxious coping”. Preventive coping was measured with 8 items from the control-based scale ( $\alpha = .76$ ), and anxious coping was measured with 6 items from the heightened-sensitivity-based scale ( $\alpha = .83$ ).

Measures of trait curiosity and exploration included the Curiosity and Exploration Inventory-II (CEI; Kashdan et al., 2009), Brief Sensation Seeking Scale (BSSS; Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002), and 8 items from the Short Form of the Need for Cognition Scale (NCS; Cacioppo, Petty, & Kao, 1984) that had good internal consistency in this study ( $\alpha = .87$ ). The first of these scales was selected as a measure of general curiosity, and the latter two were selected as measures of sensory and intellectual curiosity, respectively.

Naïve epistemic beliefs were measured as a single dimension using 12 items from the Epistemic Belief Inventory (Schraw, Bendixen, & Dunkle, 2002) and 3 items from

the DOG scale (Altemeyer, 2002), which were selected based on data from an earlier study (Rautu & DeYoung, 2017) (for items, see Appendix A-1). Among other things, the items described belief in absolute truth, simple knowledge, and quick learning, as well as a dogmatic certainty in one's beliefs. In the present study, they showed adequate internal consistency ( $\alpha = .82$ ).

Several instruments were used to assess individual differences in decision-making. The Rational and Intuitive Decision Styles Scale (RIDSS; Hamilton, Shih, & Mohammed, 2016) assessed rational decision-making (e.g., "I weigh a number of different factors when making decisions.") and intuitive decision-making (e.g., "I weigh feelings more than analysis in making decisions.") styles. Avoidant styles of decision-making were measured with the Melbourne Decision Making Questionnaire (MDQ; Mann, Burnett, Radford, & Ford, 1997) and included buck-passing (e.g., "I do not make decisions unless I really have to."), hypervigilance (e.g., "I cannot think straight if I have to make a decision in a hurry."), and procrastination (e.g., "I delay making decisions until it is too late."). The General Decision-Making Style (GDMS; Scott & Bruce, 1995) scale was used to assess a spontaneous style ("I often make decisions on the spur of the moment."), and decision-making certainty (e.g., "I rarely doubt my decisions.") was measured with 5 items that were written for this study and 1 item from the Decisiveness facet of the NFCS ( $\alpha = .76$ ) (for items, see Appendix A-1).

All questionnaires were administered with a 5-point Likert response scale ("strongly disagree" to "strongly agree"), and items from different questionnaires were intermingled to prevent response sets from influencing responses to the survey.

**Italian survey.** Participants were administered Italian translations of the URS, the original NFCS (Webster and Kruglanski, 1994), the original IUS (Freeston et al. 1994), and 8 IA scales whose items were incorporated into the MAAS (Lauriola et al., 2015).<sup>4</sup> It is important to note that, with the exception of the Need for Decisiveness subscale of the revised NFCS, these measures included all of the items that were administered to US participants, thus enabling me to select and match items between the two datasets. Italian students also completed the Eysenck Personality Questionnaire–Revised (not examined in this study; Eysenck, Eysenck, & Barrett, 1985), and the Decision Making Style Inventory (Nygren, 2000), which measures analytical- (i.e., rational-), intuitive-, and regret-based decision-making styles.

Unlike the questionnaire survey administered to the US samples, measures in the Italian study were administered in their original form (i.e., without mixing items from different questionnaires) with their original response scales, some of which were dichotomous (True/False) and others which were Likert scales.

## **Analysis and Results**

### **Factor Structure of Uncertainty-Related Scales**

**Analysis.** All EFA-related analyses were conducted in R version 3.4.3 (R Core Team, 2017) using the “psych” package (Revelle, 2018). EFAs were conducted at two levels of analysis—first, using the questionnaire items and second using the subscales. In total, 122 items from 12 subscales were analyzed. The Decisiveness facets (NFCS) were not included in this analysis since US and Italian participants completed different

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<sup>4</sup> Two of the 30 items that were selected to be included in the final version of the MAAS were reworded to make them more appropriate for different audiences (see p. 5 of Lauriola et al., 2015).

versions (i.e., Decisiveness and Desire for Decisiveness), but they were used subsequently to explore the relationship between the emergent factors and decision-making traits. Also, two items from the MAAS (#44 and #71; see Appendix in Lauriola et al., 2015) were excluded from the analysis as they were deemed to be superficially-reworded copies of other items from that scale (#123 and #126).

As noted earlier, some of the measures in the Italian study were administered using a dichotomous response scale, which affected 5 of the 122 items analyzed. The presence of both dichotomous and non-dichotomous items meant that factor analytic procedures based solely on Pearson correlations would not be appropriate for the Italian data. Therefore, I obtained a heterogeneous correlation matrix, consisting of tetrachoric and Pearson correlations, which was used as the data input for the item EFA.

Additionally, in order to compute the facet scores as the mean item score, the 5 dichotomous items were recoded to conform to the 7-point response scale of the other items they belonged with. Specifically, 1 and 0 (True/False) were recoded as 6 and 2 (values for 'Agree' and 'Disagree').

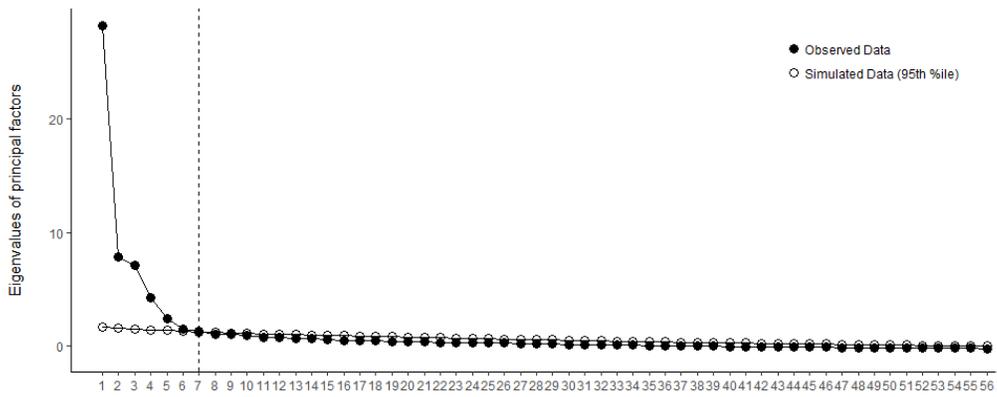
EFA's were conducted using an approach that enabled me to explore the hierarchical structure of the factors extracted in each solution. This approach was developed by Ostendorf (1990) and Saucier (1997), popularized by Goldberg (2006), and more recently employed by Lauriola et al. (2015) in their factor analysis of IA scales. The hierarchical approach has proven to be uniquely useful for testing the replicability of different factor solutions across samples, as demonstrated by Lauriola et al. (2015), thus providing a criterion for accepting and rejecting solutions. The current procedure

involved extracting 1 through n factors (e.g., one was extracted, then two, then three, etc.), where n was the number of factors recommended by the results of a parallel analysis. Factors were extracted using maximum likelihood and rotated obliquely (direct oblimin), and with each extraction the factor scores were saved. Subsequently, the correlations between factors at adjacent levels of the hierarchy were computed. This procedure was repeated for each of the three samples and the results were compared.

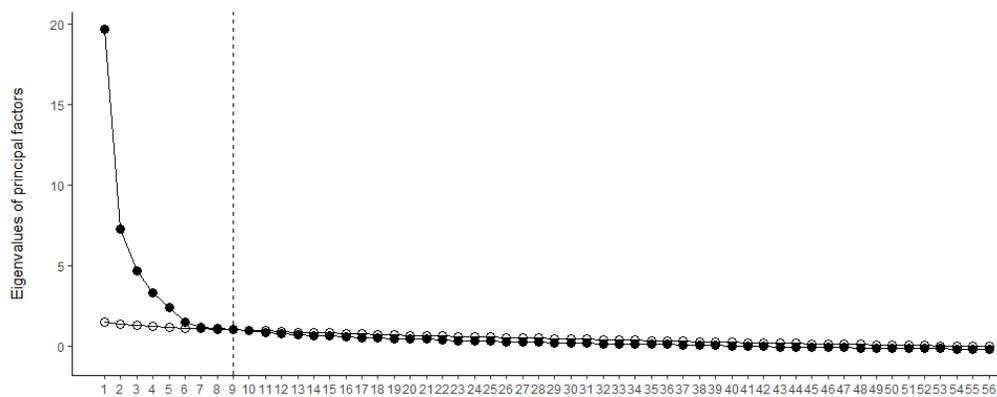
I then examined the degree to which the factors replicated across samples by computing Tucker's index of factor congruence, which is analogous to the correlation between the factor loadings and ranges from -1 to 1. Congruence coefficients greater than .95 are considered evidence of replication or perfect equivalence, and those greater than .85 are indicative of similarity (Lorenzo-Seva & TenBerge, 2006). These coefficients were initially used to decide whether factors emerging from different samples were similar enough that they could share the same label when reporting the EFA results, and, subsequently, they were used to determine which factor solution was the most replicable.

**Item EFA.** Parallel analyses suggested that I extract 7, 9, and 10 factors for the US MTurk, US student, and Italian student data, respectively. Scree plots of the results are displayed in Figure 1.1, and the hierarchical structures of the factors in each sample are displayed in Figure 1.2.

US Mturk:



US student:



Italian student:

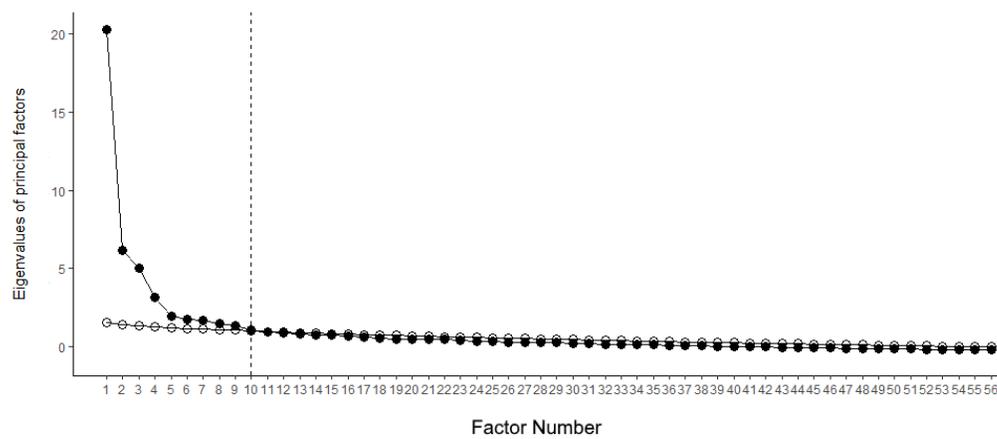


Figure 1.1. Scree plots of the item-based parallel analysis results by sample. Only the first 56 of 122 possible factors are displayed.

*US MTurk*. Lying at the top of the hierarchy, the first factor was labeled Uncertainty Aversion (Figure 1.2, Panel a) as it reflected negative attitudes toward uncertainty, unpredictability and ambiguity. At the second level of the hierarchy, the first factor was replicated, and the second factor reflected an interest in learning new things and engaging in cognitively-challenging activities such as solving complex problems, hence it was labeled Cognitive Engagement. At Level 3, Uncertainty Aversion split into two factors: Uncertainty Distress described negative emotionality and cognitive and behavioral inhibition in the face of uncertainty, and Preference for Structure described the tendencies to plan ahead, follow routine, stay organized, and take action to reduce states of uncertainty. While similar to Cognitive Engagement, the third factor was labeled Preference for Novelty/Complexity, as it described a general interest in experiencing new things, in addition to solving problems, similarly to Need for Complexity and Novelty (MAAS). Level 4 saw the emergence of a new factor, Categorical Thinking, whose highest-loading items originated from the Moral Absolutism/Splitting (MAAS) facet and which described a tendency to think in either-or terms, especially as it relates to judging peoples' character (e.g., most people are either honest or crooked). At the next level, Preference for Structure changed to encompass a narrower set of dispositions (planning, organizing, and following routine) while allowing a new factor to emerge, Uncertainty Resolution, which described the tendency to gather information towards reducing or resolving uncertainty. At Level 6, Preference for Novelty/Complexity decomposed into two aspects: Novelty Seeking entailed seeking new sensations and experiences, and embracing change; whereas, Preference for Complexity entailed an interest in

cognitively-challenging activities (similarly to the Cognitive Engagement factor that emerged earlier). Level 7 produced a factor describing Discomfort in Ambiguous Situations, such as not understanding others' behavior or intentions and lacking much-needed information. Most of the items loading on this factor came from the “Discomfort”-related facets of the NFC and MAAS. Although a parallel analysis suggested stopping at Level 7, I also looked at an 8-factor solution to be sure that there were no more meaningful factors. The 8<sup>th</sup> factor in this solution, indeed, proved to be non-substantive, as it did not have any loadings exceeding those of other factors.

*US student.* The first four factor solutions in the US student data produced very similar factors to those that were found in the MTurk data (see Figure 1.2, Panel b). Starting from the top, the first unrotated factor, Uncertainty Aversion, split into Uncertainty Distress and Preference for Novelty/Complexity factors at Level 2, while the next two levels introduced new factors corresponding to Preference for Structure (Level 3) and Categorical Thinking (Level 4). The only notable difference in these results from previous ones is that the Novelty-related factor emerged at the second level rather than the third. Level 5 saw the Preference for Novelty/Complexity factor decay into Novelty Seeking and Preference for Complexity factors. At Level 6, a Discomfort in Ambiguous Situations factor splintered off from the Uncertainty Distress factor. Then, at Level 7, a new factor with ties to Novelty Seeking was observed—Preference for Predictability, whose items expressed enjoyment or lack of enjoyment for unpredictable experiences and people. At level 8, the item content of the Preference for Structure factor became skewed towards planning and resolving uncertainty, allowing a separate Organization factor to

emerge, which described a need to maintain an orderly living environment and a consistent routine. Subsequently, Level 9 introduced a new factor describing Interest in Ambiguity (e.g., open-ended questions, obscure symbolism, artistic meaning, etc.), which was similar to Preference for Complexity. Also, at this level, the Preference for Structure factor decayed into two factors: Uncertainty Resolution and Planning/Organization, which reflected the tendency to plan ahead, tidy up, and follow routine.

*Italian student.* Compared to the results from the US data, no substantive differences were noted in the first four factors to emerge that would warrant using different labels (see Figure 1.2, Panel c). The factors included Uncertainty Distress and Preference for Novelty/Complexity (Level 2), Preference for Structure (Level 3), and Categorical Thinking (Level 4). Level 5 introduced a new factor, Open-mindedness, describing the tendency to consider multiple viewpoints or solutions when thinking about an issue or a problem. This factor more or less mapped onto the Closed-mindedness (NFCS) facet. Level 6 confirmed a factor describing Discomfort in Ambiguous Situations, as observed in the US data. At Level 7, Uncertainty Distress split into two factors corresponding to Emotional Uncertainty (URS) and general IU, judging by the scale-specific item loadings on each factor; therefore, the factors were named after their corresponding instrument. While it is possible they emerged largely due to shared method variance among the items of each instrument, one notable difference between the factors is that IU emphasized the tendency to feel inhibited by uncertainty. At level 8, Preference for Structure split into two factors with item loadings mostly from the Preference for Order and Structure (NFCS) and Cognitive Uncertainty (URS) facets, respectively (note:

the influence of shared method variance was, again, likely at play). Compared to the factors in the US data, the former was more or less similar to the Organization factor, while the latter was similar to the Planning and Uncertainty Resolution factors. At Level 9, another split was observed, this time between the Novelty Seeking and Complexity aspects of the Preference for Novelty/Complexity factor. Finally, Level 10 saw the emergence of Preference for Predictability from the Cognitive Uncertainty and Novelty Seeking factors.



*Figure 1.2.* Hierarchical structure of uncertainty-related scales for US Mturk (Panel a), US student (Panel b), and Italian student (Panel c) samples. Diagrams were drawn with Diagrammer 1.1b (Levitin, Schaaf, & Goldberg, 2005). Arrows denote correlations between antecedent and descendant factors, and the box sizes reflect the proportion of total variance accounted for by each factor. Some factor labels use abbreviations: Pref = Preference for; Res = Resolution; Think = Thinking; Ambig Sit = Ambiguous Situations; Seek = Seeking; Predict = Predictability; Interest Ambig = Interest in Ambiguity; Openminded = Open-mindedness; Emo = Emotional; Cog = Cognitive; IU = Intolerance of Uncertainty.

**Facet EFA.** Given a pool of 12 facets, parallel analyses recommended the extraction of up to 4 factors in all samples (scree plots are displayed in Figure 1.1.2). Overall, the factor solutions mirrored those based on the items very closely, and there were no meaningful differences across samples for the first three solutions. Therefore, I describe the factors from the fourth solution, in the order that they emerged throughout the hierarchy. The first factor received its strongest loadings from facets describing negative emotionality and inhibition: Emotional Uncertainty (URS), Inhibitory IU, and Discomfort with Ambiguity (NFCS, MAAS). Loadings on the second factor came from facets describing a preference for order and structure, and a desire for clarity and predictability regarding one's future. They included Preference for Order (NFCS), Cognitive Uncertainty (URS), Prospective IU, and Desire for Predictability (NFCS). Facets loading on the third factor tapped positive attitudes towards uncertainty-eliciting stimuli, and responses such as curiosity, excitement, and exploration. The strongest indicators were Need for Complexity and Novelty (MAAS), Desire for Change (URS), and Desire for Predictability (NFCS). Factor loadings on the fourth factor were somewhat

inconsistent across US and Italian datasets. In the US data, the strongest factor indicators were Closedmindedness (NFCS) and Moral Absolutism/Splitting (MAAS), whereas in the Italian data, they were Discomfort with Ambiguity (MAAS, NFCS) and Moral Absolutism/Splitting (MAAS).<sup>5</sup>

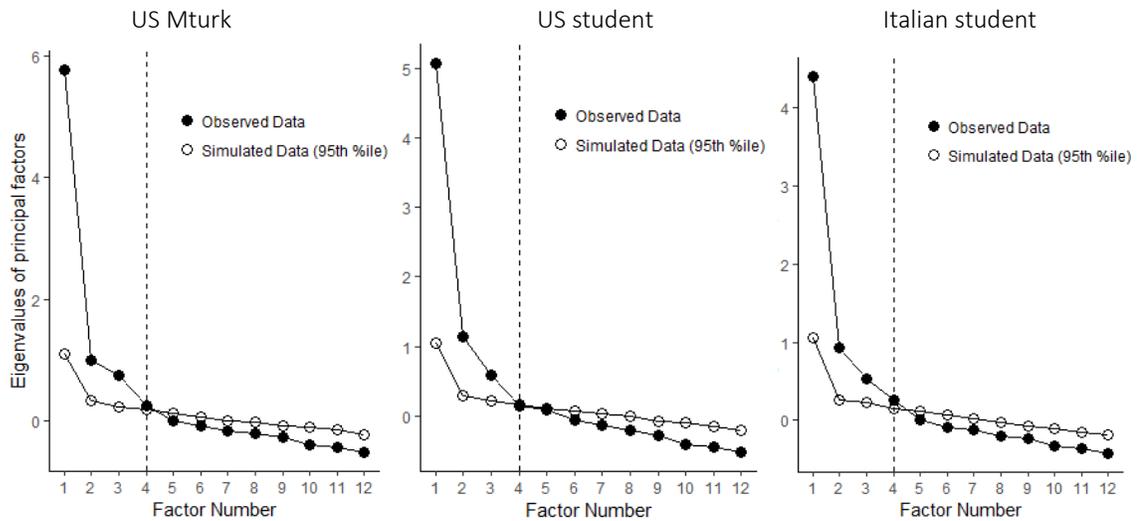


Figure 1.3. Scree plots of the facet-based parallel analysis results by sample.

**Replicability analysis.** Factor congruence coefficients were computed for each pair of datasets (e.g., US student and Italian student) and for each hierarchical level from the item EFA (up to 7 levels) and facet EFA (up to 4 levels). As shown in Table 1.1, there was strong evidence of replication for the factors from the item EFA that emerged at Level 3— Uncertainty Distress, Preference for Structure, and Preference for

<sup>5</sup> In the US student data, a 5-factor solution presented a new factor with primary loadings from the Discomfort with Ambiguity facets, resembling the 4<sup>th</sup> factor from the Italian data. It appears then that the overlap among these identically-named facets was in part responsible for the cross-sample inconsistencies noted for the 4<sup>th</sup> factor.

Novelty/Complexity—whose identities did not change significantly with the extraction of additional factors. The fourth factor to emerge, Categorical Thinking, did not reach the standard for replicability, but it showed strong similarity between the US samples and somewhat weaker similarity between US and Italian samples. Some evidence of replicability or similarity was also obtained for the factors labelled Preference for Complexity and Discomfort in Ambiguous Situations in the 6- and 7-factor solutions, but those solutions were not comparable across datasets; therefore, I accepted the four-factor solution. Likewise, Table 1.2 shows that the first four factors from the facet EFA all replicated or showed similarity.

Table 1.1

*Factor Congruence Coefficients for Item EFA*

Level	Datasets	Factors						
		UD	PNC	PS	CT	*	*	*
1	USM, USS	.97						
	USM, ITAS	.97						
	USS, ITAS	.96						
2	USM, USS	.97	.82					
	USM, ITAS	.94	.64					
	USS, ITAS	.96	.90					
3	USM, USS	.98	.97	.96				
	USM, ITAS	.96	.93	.95				
	USS, ITAS	.96	.91	.94				
4	USM, USS	.98	.97	.94	.87			
	USM, ITAS	.96	.95	.92	.89			
	USS, ITAS	.96	.94	.96	.75			
5	USM, USS	.98	.90	.96	.86	.42		
	USM, ITAS	.96	.91	.94	.86	-.51		
	USS, ITAS	.96	.90	.96	.67	-.70		
6	USM, USS	.98	.91	.97	.86	.92a	.70	
	USM, ITAS	.94	.95	.94	.92	-.64	-.64	
	USS, ITAS	.95	.89	.95	.77	-.69	.88b	
7	USM, USS	.98	.88	.95	.91	.94a	.87b	.36
	USM, ITAS	.91	.95	.95	.92	-.64	.95b	.40
	USS, ITAS	.90	.88	.95	.85	-.64	.89b	.42

*Note.* USM = US Mturk; USS = US student; ITAS = Italian student; UD = Uncertainty Distress; PNC = Preference for Novelty and Complexity; PS = Preference for Structure; CT = Categorical Thinking.

\* Factors beyond the four listed were not similar in all samples (i.e., did not have the same interpretation).

Those that were similar are denoted by a letter next to the coefficient. a = Preference for Complexity. b = Discomfort in Ambiguous Situations.

Table 1.2

*Factor Congruence Coefficients for Facet EFA*

Level	Datasets	Factors			
		UD	PNC	PS	CT
1	USM, USS	.99			
	USM, ITAS	.99			
	USS, ITAS	.99			
2	USM, USS	.99	.84		
	USM, ITAS	.99	.90		
	USS, ITAS	.99	.98		
3	USM, USS	.99	.99	.99	
	USM, ITAS	.99	.99	.99	
	USS, ITAS	.99	.98	.97	
4	USM, USS	.99	.99	.98	.93
	USM, ITAS	.98	.98	.99	.84
	USS, ITAS	.98	.98	.99	.82

*Note.* UD = Uncertainty Distress; PNC = Preference for Novelty/Complexity; PS = Preference for Structure; CT = Categorical Thinking.

**Evidence of concurrent validity.** Table 1.3 displays correlations between the four uncertainty factors (saved as factor scores) and trait measures administered to the US samples only. As this table shows, each factor had strong concurrent validity with at least one other personality trait. In particular, Uncertainty Distress was strongly correlated with anxious coping ( $r = .73$ ) and the Withdrawal aspect of Neuroticism ( $r = .83$ ), consistent with its negative affective content. Preference for Structure was strongly correlated with preventive coping ( $r = .69$ ) and the Orderliness aspect of Conscientiousness ( $r = .66$ ). Preference for Novelty/Complexity was almost indistinguishable from a measure of curiosity and exploration ( $r = .88$ ), and it was also

moderately correlated with Extraversion ( $r = .44$ ) and Openness/Intellect ( $r = .52$ ), which have been described as markers of exploration geared toward attaining rewards and information, respectively (DeYoung, 2014). Finally, Categorical Thinking was strongly correlated with naïve epistemic beliefs ( $r = .73$ ), such as belief in absolute truth and simple knowledge.

Further evidence of concurrent validity can be seen in the uncertainty factors' correlations with measures of decision-making traits (see Table 1.4; note: US and Italian samples were administered different measures). Uncertainty Distress was strongly related to avoidant styles of decision making, including avoiding or shifting responsibility (buck-passing), procrastinating, searching frantically for a quick solution (hypervigilance), and worrying about making a regretful decision. It was also positively correlated with measures of (in)decisiveness and a desire for decisiveness from the NFCS. Preference for Structure, in turn, was strongly positively correlated with a rational style that entails gathering information about different options and carefully weighing different factors (e.g., risks/benefits) before making a decision. Notably, a spontaneous decision-making style was negatively correlated with Preference for Structure and positively correlated with Preference for Novelty/Complexity. And, lastly, Categorical Thinking stood out as the strongest correlate of certainty during decision-making.

Table 1.3

*Correlations Between Uncertainty Factors and Personality Traits (US Samples Only)*

	UD	PS	PNC	CT
Curiosity/exploration (CEI)	-.35	-.13	.88	-.28
Sensation seeking (BSSS)	-.19	-.43	.72	-.19
Need for Cognition (NCS)	-.29	.13	.57	-.27
Anxious coping (TOS)	.73	.16	-.16	.20
Preventive coping (TOS)	.30	.69	-.07	.11
Naïve epistemic beliefs (EBI)	.24	.11	-.29	.73
<b>Big Five traits and aspects</b>				
Openness/Intellect	-.19	.16	.52	-.40
Intellect (aspect)	-.39	.19	.39	-.28
Openness (aspect)	.08	.08	.44	-.37
Conscientiousness	-.15	.63	-.28	.37
Industriousness (aspect)	-.44	.42	-.08	.21
Orderliness (aspect)	.22	.66	-.41	.43
Extraversion	-.44	-.03	.44	-.11
Assertiveness (aspect)	-.41	.02	.39	-.04
Enthusiasm (aspect)	-.35	-.07	.37	-.15
Neuroticism	.74	-.04	-.17	.10
Volatility (aspect)	.58	-.08	-.12	.16
Withdrawal (aspect)	.77	.02	-.19	.01
Agreeableness	-.01	.19	.02	-.33
Compassion (aspect)	-.04	.10	.23	-.37
Politeness (aspect)	.01	.22	-.22	-.18

*Note.* Correlations with absolute value > .10 are statistically significant at  $p < .05$ . CEI = Curiosity and Exploration Inventory-II; BSSS = Brief Sensation Seeking Scale; NCS = Need for Cognition Scale; EBI = Epistemic Beliefs Inventory; TOS = Threat Orientation Scale.

Table 1.4

*Correlations Between the Uncertainty Factors and Decision-Making Traits*

	UD	PNC	PS	CT
<b>US samples</b>				
Rational style (RIDSS)	.11	-.02	.70	-.03
Intuitive style (RIDSS)	.19	.19	-.18	.24
Hypervigilance (MDQ)	.80	-.17	.11	.29
Buck-passing (MDQ)	.60	-.18	-.13	.15
Procrastination (MDQ)	.57	.03	-.26	.01
Spontaneous style (GDMS)	-.02	.39	-.36	.12
Decision certainty (new)	-.29	.03	.18	.42
Desire for Decisiveness (NFCS-R)	.59	-.11	.08	.33
<b>Italian sample</b>				
Regret-based style (DMSI)*	.67	-.16	.13	.16
Rational style (DMSI)*	.32	-.14	.65	.22
Intuitive style (DMSI)*	-.18	.34	-.07	.15
Decisiveness (NFCS)*	-.54	-.15	-.09	-.08

*Note.* Correlations with absolute value  $> .10$  are sig. at  $p < .05$ . UD = Uncertainty Distress; PNC = Preference for Novelty/Complexity; PS = Preference for Structure; CT = Categorical Thinking GDMS = General Decision-Making Style; MDQ = Melbourne Decision Making Questionnaire; RIDSS = Rational and Intuitive Decision Styles Scale; DMSI = Decision Making Style Inventory; NFCS = Need for Closure Scale; NFCS-R = NFCS-Revised.

**Latent Correlations Among Uncertainty-Related Measures**

**Analysis.** The following CFA was conducted using SPSS Amos Version 23 (Arbuckle, 2014). For this analysis, the two US datasets were merged, and the Decisiveness-related (NFCS) facets were omitted (note: US and Italian participants were administered different versions of this subscale). Using CFA, each instrument was specified as a bifactor model, wherein a general factor explained the variance shared by the items, and additional factors explained the residual variance shared by items specific

to each facet. These bifactor models were, in turn, situated within a larger model, in which correlations were specified between the general factors and between the specific factors (see Figure 1.3). To my knowledge, a bifactor model has only previously been applied to one of the four measures (MAAS; Lauriola et al., 2015); nevertheless, its use was justified because the main objective of this analysis was to test the correlations among the general factors of each instrument (i.e., the individual fit of a bifactor model for each instrument was not of interest).

To reduce model complexity and improve fit, the items from each instrument were aggregated into three parcels per subscale, which supplanted the items as the factor indicators. Item parcels consisted of the average item scores of anywhere from 2 to 6 items, depending on the length of each subscale. Items from each subscale were placed into parcels in four different orders, and the CFA analysis was repeated for each method to verify that the results were consistent. The orders were sequential (e.g., 1, 2, 3; 4, 5, 6; 7, 8, 9), alternating (e.g., 1, 4, 7; 2, 5, 8; 3, 6, 9, etc.), semi-alternating (e.g., 1, 2, 7; 3, 4, 8; 5, 6, 9), and randomized (e.g., 1, 5, 6; 4, 2, 9; 8, 7, 3).

Goodness of fit statistics included the comparative fit index (CFI) and the root mean square error of approximation (RMSEA); CFI values  $> .90$  and RMSEA values  $< .08$  were interpreted as evidence of acceptable fit. Additionally, the probability of a close fit ( $p$ -close) was computed, which is a significance test of the null hypothesis that RMSEA equals  $.05$  ( $p$ -values greater than  $.05$  indicate a close-fitting model).

If any given correlation between the general factors exceeded  $.90$ , the correlation was fixed to 1 and a chi-square difference test was used to determine if the new model fit

was significantly worse. Constraints were added one at a time, starting with the highest correlation, and the new model fit was always compared to the baseline model.

Additionally, if any correlation exceeded 1 (e.g., 1.03), producing a Heywood case, the same procedure was followed (fixing the parameter to 1 and doing a chi-square difference test).

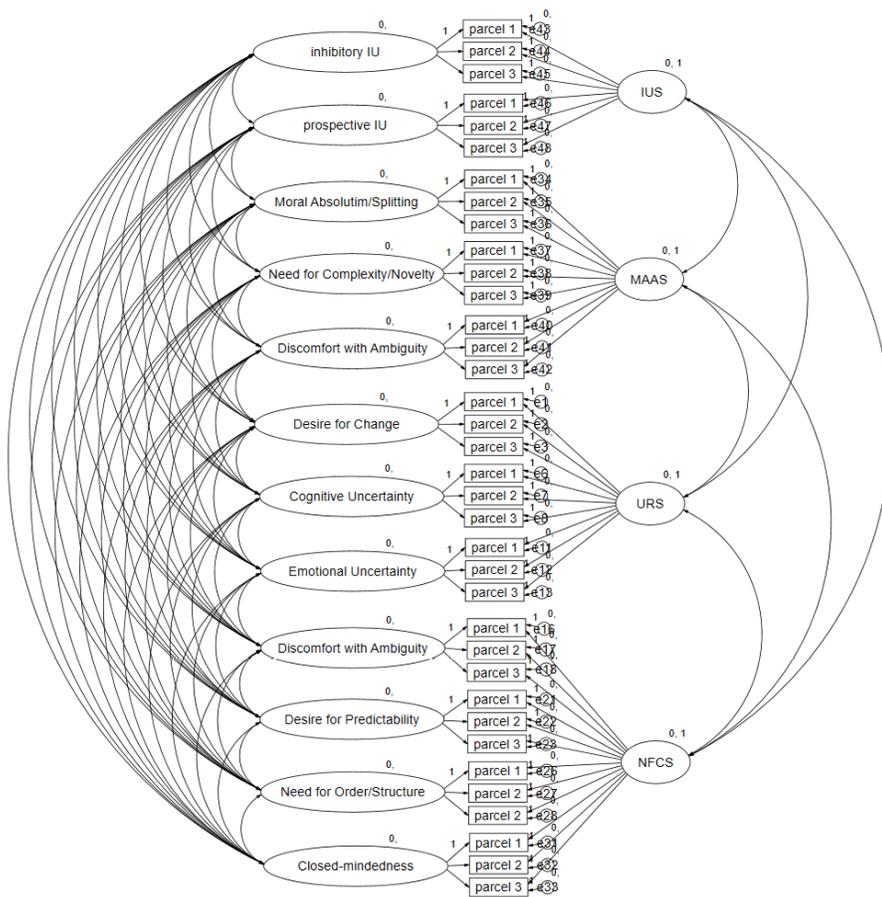


Figure 1.3. Bifactor model of IUS, MAAS, NFCS, and URS scales. Facet factors are on the left side and general factors (bifactors) are on the right side.

**Results.** Throughout the analysis, a few issues were encountered that are worth noting. First, as a general observation, the item parcels for some facets (namely, Prospective IU, Discomfort with Ambiguity, and Desire for Predictability) tended to have stronger loadings on a general factor than on their specific factor, and consequently, the specific factors of these facets did not always have significant variance. An opposite pattern was observed for the item parcels of Closed-mindedness (NFCS) and Need for Complexity and Novelty (MAAS), which tended to have weak or non-significant loadings on a general factor, especially in the Italian data. While unexpected, these patterns are consistent with the loadings that these facets had on the first unrotated factor in the facet EFA, which represented a general aversion to uncertainty (i.e., some facets were better indicators of this general factor).

Second, when the analysis was repeated with different item parceling methods, the model sometimes failed to converge, and to address this issue, starting values were specified for some of the item loadings on the general factors. In the Italian data, however, difficulties with model convergence persisted even after providing starting values. After some investigation, the difficulties appeared to be caused by the non-significant variance of one or more of the facet factors, and in particular, Discomfort with Ambiguity (MAAS). Removing this specific factor from the model reduced the fit somewhat, but it was necessary in order to help the model converge. I refer to this slightly altered model as Model 2 to distinguish it from the original model.

As shown in Table 1.5, both Models 1 and 2 provided a close fit to the data across all four methods of item parceling. In the US data, almost all of the correlations among

the general factors exceeded .90 and in many cases they were not significantly different from 1, implying that the general factors were indistinguishable. In the Italian data, by contrast, the correlations were more modest, with most falling in the range of  $r = .70$  to .90. The only notable exception to this pattern can be seen in the (Italian) results of Model 1 using the sequential item parceling method: some correlations exceeded .90 (see Table 1.5). I propose an explanation for the divergent results across the US and Italian data in the discussion.

Table 1.5

*Correlations Among the General Factors by Item Parceling Method, and Indices of Model Fit*

	Item parceling method	IUS MAAS	IUS URS	IUS NFCS	MAAS URS	MAAS NFCS	URS NFCS	<i>df</i>	$\chi^2$	CFI	RMSEA	<i>p</i> - close
<u>US</u>												
Model 1	sequential	.92	1.00	.95	1.00	1.00	1.02 <sub>a</sub>	488	1381.89	.943	.052	.159
Model 1	alternating	.93	1.00	1.00	.93	1.00	.96	489	1366.16	.943	.051	.234
Model 1	semi-alternating	.93	.97	.89	1.00	1.00	.94	488	1275.64	.950	.049	.730
Model 1	randomized	.83	.97	.91	.88	.93	.90	486	1265.73	.950	.049	.753
<u>Italian</u>												
Model 1*	sequential	.78	.73	.76	.93	.92	.94	486	736.72	.960	.038	1.000
Model 2	sequential	.72	.72	.77	.82	.86	.84	500	793.98	.953	.040	1.000
Model 2	alternating	.69	.77	.72	.71	.89	.71	500	801.46	.954	.041	1.000
Model 2	semi-alternating	.77	.83	.85	.74	.68	.63	500	731.48	.963	.036	1.000
Model 2	randomized	.82	1.00	.63	.87	.84	.68	500	815.69	.950	.042	1.000

*Note.* Coefficients of  $r=1$  represent constraints that were added to the model and did not reduce model fit. Model 2 was the same as Model 1 except that it lacked the facet factor for Discomfort with Ambiguity (MAAS). IUS = Intolerance of Uncertainty Scale; MAAS = Multidimensional Attitude toward Ambiguity Scale; NFCS = Need for Closure Scale; URS = Uncertainty Response Scale.

\* This row displays the results for Model 1 that converged only for the “sequential” item parceling method.

a. Heywood case.

## **Discussion**

The results of this study confirm that there is a high degree of overlap among measures of uncertainty constructs, and they shed new light on their structure. In hierarchical factor analyses of the items and facets of four different instruments, I found support for four factors that were replicated in both student and MTurk samples, and in both English- and Italian-speaking samples. While there were a few other factors that were confirmed in all three samples, they tended to emerge at different levels of the hierarchy across datasets and I would argue that they constituted aspects of the four factors, as noted in the factor descriptions below.

One interesting difference between datasets in the item EFA results is that, starting with Level 5, the items in the Italian data were more likely to sort themselves into factors resembling their instrument of origin. This was especially true of the IUS, Closed-mindedness (NFCS), and the Emotional and Cognitive Uncertainty subscales (URS). Differences in how the questionnaires were administered to each sample might account for these results. The instruments in the Italian study were administered in their original intact form, and, consequently, it is likely that within-measure correlations were artificially inflated by response sets. In the US survey, on the other hand, items from different instruments were all mixed together to eliminate the possibility that participants would complete each instrument under a different response set.

### **Uncertainty Distress**

Uncertainty Distress reflected the tendency to experience negative emotions (e.g., anxiety, frustration) and inhibition, cognitively and behaviorally, when uncertain. Its key facet indicators were Emotional Uncertainty (URS), Inhibitory IU, and Discomfort with Ambiguity (NFCS, MAAS), the last of which formed the basis of the Discomfort in Ambiguous Situations sub-factor that was observed all three datasets. Many of the items loading on this sub-factor implicitly described anxiety in social situations, stemming from uncertainty about other people's thoughts, intentions, or the meaning behind what they say, and it is likely that the "interpersonal" content of these items contributed in some degree to the factor's emergence.

An analysis of concurrent validity showed that Uncertainty Distress was strongly related to Withdrawal (aspect of Neuroticism) and an anxious style of coping with threat. Withdrawal encompasses individual differences in anxiety, depression, self-consciousness, as well as passive avoidance in response to threat and goal conflict, in contrast to the Volatility aspect, which entails irritability, emotional lability, and active defensive responses to threat (i.e., fight-flight-freeze) (Corr, DeYoung, & McNaughton, 2013). To confirm that Withdrawal was the aspect most relevant to Uncertainty Distress, I ran a follow-up regression with the two aspects as predictors of this factor, and indeed, found that Volatility explained only a small amount of unique variance compared to Withdrawal.

Uncertainty Distress was also characterized by its relationship to avoidant decision-making styles (e.g., shifting responsibility, procrastinating, etc.) and general indecisiveness, which is to say that distress-prone individuals have greater difficulty

making decisions. This relationship is consistent with the assumption that decisional conflict (i.e., uncertainty about which decision alternative to choose) engenders stress and anxiety regarding the potentially negative outcomes of each decision alternative (Janis & Mann, 1977).

### **Preference for Novelty/Complexity**

This factor described a desire to engage in new experiences and cognitively-challenging activities, as implied by the words ‘novelty’ and ‘complexity’. Indeed, at lower levels of the factor hierarchy (Levels 5 and 6 in the US data, and at Level 9 in the Italian data), two sub-factors emerged that were labeled Novelty Seeking and Preference for Complexity. Items loading on Novelty Seeking emphasized a desire for variety and change as opposed to routine, a willingness to take risks and try new things, and a tendency to embrace unpredictability and enjoy surprises. By contrast, Preference for Complexity described a general interest in stimuli that do not afford a simple or unambiguous interpretation, such as abstract poems and art, obscure symbolism, and complex problems, and a key source of this interest was the challenge of resolving the ambiguity inherent in these stimuli. The facets that were most representative of this factor were Desire for Change (URS), Need for Complexity and Novelty (MAAS), and Desire for Predictability (NFCS) (reversed).

It is safe to assume that Preference for Novelty/Complexity represents individual differences in curiosity/exploration, based on its correlation with the Curiosity and Exploration Inventory II ( $r = .88$ ). A follow-up analysis revealed that the two aspects of this factor mapped onto different varieties of curiosity/exploration in a predictable

manner: Novelty Seeking was strongly correlated with sensation-seeking but not Need for Cognition ( $r = .72$  vs.  $.33$ ), whereas the opposite was true of Preference for Complexity ( $r = .45$  vs.  $.77$ ). A similar pattern of discrimination was observed for Extraversion and Openness/Intellect: Novelty Seeking was more closely related to Extraversion ( $r = .46$  vs.  $.38$ ) and the Complexity factor was more closely related to Openness/Intellect ( $r = .60$  vs.  $.25$ ). The latter findings are noteworthy because Extraversion and Openness/Intellect share common variance that may represent a general exploratory tendency, with the former trait tapping behavioral exploration and the latter trait tapping cognitive exploration (DeYoung, 2014). That common variance is the basis for the Plasticity meta-trait in the Big Five hierarchical model (DeYoung, 2006).

In other findings, Preference for Novelty/Complexity was distinguishable from the other factors in its positive association with spontaneous decision-making, which can be interpreted within the context of the psychological benefits provided by such decision making. Spontaneous decisions, by definition, entail a lack of consideration of or preparation for their potential consequences, and this element of risk or unpredictability (i.e., with regards to the decision outcome) is likely to be exciting and interesting to individuals who are high in Preference for Novelty/Complexity.

### **Preference for Structure**

Preference for Structure represented the variance common to Preference for Order and Structure (NFCS) and Cognitive Uncertainty (URS), and to a lesser extent Prospective IU and Desire for Predictability (NFCS). Its content encompassed a variety of behaviors, including planning ahead and preparing for future events, following a daily

schedule or routine, gathering information towards reducing uncertainty, and maintaining an organized work and living environment. As these behaviors are confusingly diverse, I propose that they could be construed as strategies for minimizing risk or unpredictability in an effort to secure favorable outcomes. For instance, planning ahead rather than at the last minute allows one more time to consider the actions that could be taken to reach a goal and their potential outcomes, and having a schedule increases the chances that pre-planned actions will be executed in a timely manner. In turn, these behaviors provide a sense of security that valued goals will be accomplished.

Preference for Structure was strongly correlated with the Orderliness aspect of Conscientiousness, which encompasses perfectionism, tidiness, and routine-following. Taking into account the considerable content overlap among these two traits, their strong relationship is not surprising. In contrast to Uncertainty Distress and its association with anxious coping, Preference for Structure was also positively related to a measure of preventive coping in response to threat—a result that highlights the discriminability of these two factors. As it relates to decision-making, Preference for Structure was the strongest correlate of a rational style, which entails gathering evidence and thoroughly evaluating all decision options before making a decision. The latter two findings, in particular, are consistent with the suggestion that minimizing risk is part of what motivates the diverse behaviors that characterize this factor.

### **Categorical Thinking**

Categorical Thinking confirmed the Moral Absolutism/Splitting factor that was discovered by Lauriola and colleagues (2015; Study 1). While some items loading on this

factor alluded to evaluating people in terms of moral opposites (e.g., good/bad, strong/weak), the broader theme among the items was a tendency to think in black-and-white terms and the failure to consider or accept that there may be more than one valid answer or interpretation on any given issue. Some items also described negative attitudes and irritation toward things that are difficult to interpret as well as people who express disagreement or hold different opinions. Such attitudes were captured by items from the Discomfort with Ambiguity and Closed-mindedness (NFCS) facets.

Further insight into the nature of this factor can be gleaned from its close relationship to a measure of naïve epistemological beliefs, such as, the belief that people in authority know best, that knowledge is simple and fact-based, that learning should happen quickly and depends on innate potential, and that one's own beliefs are correct and will stand the test of time. This relationship suggests that the tendency to think in categorical terms may reflect a general lack of critical and skeptical thinking that manifests in various beliefs and thinking habits. In line with this interpretation, Categorical Thinking was positively related to a measure of unquestioning certainty when making decisions (e.g., "I rarely doubt my decisions.").

The replicability analysis suggested that Categorical Thinking was similar but not equivalent between the US and Italian datasets, a result that might be traced to the Closed-mindedness facet. In the Italian dataset, this facet was only weakly related to Moral Absolutism/Splitting, and consequently, the emergent Categorical Thinking factor shared more in common with Discomfort with Ambiguity (NFCS) than Closed-mindedness in this dataset compared to in the US dataset.

## **Evidence of Discriminant Construct Validity**

The second part of this study focused on the discriminant validity of the four instruments as measures of a single dimension. In the combined US data, I found evidence of unity or near-unity among the general factors of each instrument, and this result was replicated across four different methods of item parceling. In the Italian data, on the other hand, correlations generally fell below .90, which implies that the instruments were not interchangeable measures of the same trait. While it may be tempting to attribute these divergent results to cross-cultural or cross-linguistic differences, I think they are more convincingly explained by the differences in survey administration noted earlier. Namely, US participants answered the survey items as if they all belonged to one long questionnaire, whereas Italian participants completed each of the questionnaires in their original administrative format, which makes it likely that their data was contaminated by instrument-specific response sets. For this reason, I believe that the results for the US samples are more representative of the true relationships among the different instruments; nevertheless, it will be desirable to confirm them in other samples using the same administration procedures.

On a lesser note, it is worth highlighting that the URS, as a whole, appears to tap the same latent trait as the other instruments, despite the fact that it was developed to measure three different traits. To my knowledge, this is also the first study to confirm that there is a higher-order factor underlying the inter-correlations among its subscales.

## **Implications for Measurement of Uncertainty-Related Traits**

The present findings demonstrate that questionnaires of IA, IU, and NFC are lacking in discriminant validity, and moreover, they call into question whether these constructs can be psychometrically distinguished, as some researchers have suggested (Grenier et al., 2005; Rosen et al., 2015). In light of the present findings, I would argue that there are compelling reasons to consider supplanting existing measures (of NFC, etc.) with one based on the four factors uncovered in this study.

One of the attractive aspects of the four factors is that they are closely related to traits that already exist outside of the literature on attitudes toward uncertainty. Three of them roughly map onto traits from the Big Five hierarchy (DeYoung, 2006): Uncertainty Distress maps onto Withdrawal, Preference for Structure maps onto Orderliness, and Preference for Novelty and Complexity measures trait curiosity/exploration, which maps onto Plasticity<sup>6</sup> (i.e., the variance common to Extraversion and Openness/Intellect). The fourth factor, Categorical Thinking, does not appear to map onto any of the Big Five traits/aspects, but it can be interpreted within the context of the personality literature on epistemological beliefs, dogmatism, and rational thinking (e.g., Toplak, West, & Stanovich, 2014). The utility of mapping the four factors onto traits from the Big Five hierarchy or other personality models is that the existing body of knowledge on these traits can be applied to generate insights into the nature of each factor (e.g., their underlying psychological processes).

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<sup>6</sup> The hypothesis that Plasticity represents a general exploratory tendency (DeYoung, Peterson, & Higgins, 2002) has not yet been tested using trait measures of exploration. However, I should mention that the results of an informal CFA I conducted do appear to support it. Specifically, if curiosity/exploration is specified as a latent trait with three indicators from the present data, its latent correlation with Plasticity (indicated by Extraversion and Openness/Intellect) is greater than .90.

Another benefit is that the four factors are broad enough that they can be divided into additional facets (not yet fully identified), thus, providing a level of measurement specificity that can be useful in certain research contexts. Two of those facets that were identified in this study and should be distinguished include Novelty Seeking and Preference for Complexity. For research purposes, the former would be more relevant to predicting risk-taking or risk preferences, while the latter would be more useful to predicting behaviors on complex tasks or jobs, such as the ability to handle ambiguous information.

From a more philosophical standpoint, adopting a common structural model would promote greater scientific progress by allowing researchers to measure the same traits and thereby contribute to a unified body of knowledge regarding those traits, as opposed to contributing to fragmented literatures on highly overlapping traits (see Baliaetti, Mas, and Helbing [2015] for a discussion of the effects of disciplinary fragmentation on scientific progress). As a testament to this, much of the progress that is currently being made in the field of personality and allied fields (e.g., abnormal) can be arguably attributed to the widespread adoption of the Big Five model.

Lastly, I would emphasize that the four factors can be “averaged” to obtain a single measure of dispositional aversion to uncertainty, and they more or less confirm facets or subscales from existing instruments even though they have somewhat broader content. For example, the URS subscales provide an approximation of the first three factors (Uncertainty Distress, Preferences for Structure, and Preference for Novelty/Complexity), and the Moral Absolutism/Splitting facet of the MAAS

approximates Categorical Thinking. In other words, model I am proposing is not particularly novel, and taking into account that new models or measures of well-known personality traits are generally met with skepticism and resistance (for legitimate reasons), its familiarity should be seen as an advantage.

### **Additional thoughts on the four factors**

A thorny issue that needs to be addressed at this point is whether the four factors should be considered facets of a coherent overarching trait or as distinct traits that share some common variance. I would argue that the latter is more accurate because the factors appear to describe very different types of responses to uncertainty-eliciting stimuli or events. The following interpretations are informed not only by an analysis of the item content of the factors, but also evidence of their concurrent validity and theoretical considerations. A theoretical discussion of responses to uncertainty that provides useful context for these interpretations is provided in Chapter 4.

For the most part, Uncertainty Distress appears to describe passive avoidant responses to threat (i.e., uncertain punishment), including anxiety, worry, and cognitive and behavioral inhibition. Conceptually, these responses serve a common biological purpose, which is to stop and assess presently detected threats in order to avoid immediate punishment (McNaughton & Corr, 2004). By contrast, Preference for Structure describes what I would call “preventive” responses to (non-immediate) threat, as their purpose is to reduce the likelihood of future negative outcomes (i.e., risk) and thereby also reduce worry about such outcomes. According to this account, planning ahead and sticking to one’s plans or routines are like insurance policies—they make you

feel safe (that things will happen as you intend them to), and in the long-run they also reduce your exposure to harm (by steering you away from unfamiliar and hence risky courses of action). These interpretations are supported by findings related to the two styles of coping with threat that were measured in this study; Uncertainty Distress was correlated with an anxious coping style ( $r = .73$ ), while Preference for Structure was related to a preventive coping style ( $r = .69$ ).

Preference for Novelty/Complexity describes approach-oriented responses to novel, ambiguous, or unpredictable stimuli, including curiosity, excitement, and cognitive and behavioral exploration, as attested to by its relationship to measures of curiosity/exploration. Finally, Categorical Thinking appears to describe irritation, impatience, and closed-mindedness when confronted with conflicting information (e.g., multiple solutions, differences of opinion), suggestive of a dogmatic certainty in one's beliefs. If these responses were to be summed up in a statement of personal philosophy, they would read something like, "I'm right and everyone else is wrong; there are only a few types of people in this world; every question has a simple answer, and if I don't get it immediately, then it doesn't interest me."

The argument that the four factors reflect distinct dispositional responses to uncertainty is, needless to say, consistent with the origins of the items of the URS. As noted in the introductory chapter, these items were generated using individuals' statements of how they would respond to various hypothetical scenarios involving uncertainty, and accordingly, the end result was a three-factor model of coping styles or responses. I would dispute, however, the characterization of all three URS subscales as

measuring coping styles because most of the items of Desire for Change describe positive responses (e.g., “new experiences excite me”) that do not entail any stress to be coped with.

### **Limitations**

Inconsistent CFA results across US and Italian samples are one reason to exercise caution in concluding that the questionnaires examined in this study measure indistinguishable traits. While it is very likely that the inconsistencies stemmed from differences in survey administration, this explanation should be tested in future research by comparing the results of administering the NFCS and other measures as separate questionnaires with their own instructions, versus one big survey with all the items mixed and one set of instructions. Should the mixed-items procedure yield significantly stronger inter-correlations among the measures, it would confirm the present explanation.

The current findings are also limited in that they do not speak to whether or not NFC, IA, and IU scales are lacking in unique predictive utility. Given differences in the psychological phenomena each scale originally sought to measure (e.g., excessive worrying, epistemic motives, etc.), it is perhaps to be expected that each scale predicts certain behaviors better than others. However, I propose that their unique predictiveness is likely to be attributable to their coverage of the four factors. The IUS, for example, appears to tap Uncertainty Distress more than the other scales, while the MAAS is unique in its measurement of Categorical Thinking. Taking this point into account, any evidence of uniqueness would likely reinforce the benefit of differentiating the four factors rather than the constructs themselves.

### **Implications for dissertation research**

The results of this study provided direction for the rest of the dissertation research by suggesting the psychometric advantages of a four-factor model over existing measures. To further test the utility of this model, the next two studies (covered in Chapters 2 and 3) investigated whether the four factors have distinct behavioral correlates and are overall better predictors of uncertainty-related behaviors than NFC, IU, and IA.

## **Chapter 2: A Latent Variable Investigation of the Relationship Between Uncertainty-Related Traits and Data Gathering**

Study 1 revealed that the four emergent uncertainty-related factors were associated with very different personality traits and styles of decision-making. However, evidence of their discriminability was limited to self-report measures, and it is desirable to show that these factors are also predictive of different behaviors in the face of uncertainty. One particularly relevant type of behavior to examine in this context is how much evidence people gather (to reduce uncertainty) before making a decision, as measured by the popular “beads task” (Huq, Garety, & Hemsley, 1988; Philips & Edwards, 1966). In this task, participants are shown two jars containing beads of two colors in different ratios: one jar contains mostly beads of one color (e.g., 85 black and 15 white) and the second contains mostly beads in the other color (e.g., 15 black and 85 white). They are then told that beads will be drawn from one jar, and that they should monitor the sequence of beads until they are confident that they can identify from which jar they are being drawn. The number of beads drawn is therefore an indicator of how much evidence participants required in order to decide. Although not the only task of its kind, the beads task has been widely used in studies that seek to understand how NFC and IU moderate the gathering of evidence during decision-making.

Researchers have offered conflicting hypotheses regarding the relationship between IU and data gathering. Ladouceur, Talbot, and Dugas (1997), for instance, predicted that higher IU would lead to greater data gathering (e.g., drawing more beads) based on evidence that worriers require excessive amounts of evidence before making a

decision and take longer to decide (Metzger et al., 1990; Tallis et al., 1991). The explanation implied here is that people who are high in IU worry more about the decision outcome (i.e., making a regrettable decision), which leads them to consider more evidence in order to reduce uncertainty about the outcome. Others have hypothesized the opposite relationship (Broome et al., 2007; Fraser, Morrison, & Wells, 2006), with some suggesting that anxiety leads people to make hasty decisions after gathering only limited information, as it allows them to escape the anxiety sooner (Bensi & Giusberti, 2007; Fraser et al., 2006). This hasty decision-making bias has commonly been referred to as jumping to conclusions (JTC).

In contrast to the conflicting predictions made for IU, researchers have consistently drawn a theoretical connection between NFC and JTC in research employing the beads task (Colbert & Peters, 2002; Dudley & Over, 2003; Fraser, 2006). This connection is implied, for example, by Kruglanski and Webster's (1996) characterization of individuals with high NFC as impulsive or cognitively impatient and as having the tendency to "leap to judgment on the basis of inconclusive evidence" (p. 264). It is also supported by findings from the original publication of the NFCS (Webster & Kruglanski, 1994) that participants with high compared to low NFC requested less information before forming judgments, spent less time on tasks requiring a decision, and reported a higher degree of judgmental confidence and a stronger need to decide quickly.

Differences in the conceptualization of NFC and IU might explain the starkly different predictions that have been made regarding their influence on data gathering. IU is variably defined as the tendency to worry and experience anxiety and cognitive-

behavioral inhibition in the face of uncertainty about negative events, no matter how unlikely those events are. By comparison, NFC has been conceptualized as the desire to attain closure as soon as possible (labelled the urgency tendency) and the desire to maintain it for as long as possible (labelled the permanency tendency) (Kruglanski & Webster, 1996). Although both conceptualizations entail an aversion to uncertainty, they also suggest different means of coping with it. Within the context of decision-making, IU's definition suggests an inability to decide due to worry about the outcome, whereas NFC's definition entails an urgency to decide regardless of the outcome (e.g., to reach any conclusion, regardless of its accuracy). These conceptual distinctions are also reflected in some of their facets. For instance, Inhibitory IU measures the tendency to feel inhibited in uncertain situations, and Desire for Decisiveness (NFCS) describes the desire to make quick decisions, consistent with the urgency tendency.

Ironically, the overall body of literature on the beads task does not support either of the predictions for NFC and IU. While two studies do demonstrate a link between IU and excessive data gathering (EDG; Ladouceur et al., 1997; Rassin, Muris, Franken, Smit, & Wong, 2007), one supports the opposite relationship (i.e., a link to JTC; Broome et al., 2007) and others have failed to detect any significant relationship (Dudley et al., 2011; Freeman et al., 2014; Jacoby, Abramowitz, Reuman, & Blakey, 2016; White & Mansell, 2009). Likewise, studies have failed to confirm any empirical relationship between NFC and JTC (Colbert & Peters, 2002; Freeman et al., 2006; McKay, Langdon, & Coltheart, 2006; White et al., 2009).

## **Explaining the Lack of Findings**

One simple yet straightforward explanation for the lack of findings is that the beads task is lacking in validity and/or reliability. To start off with, most implementations of this task consist of no more than three pairs of jars, which means that the behavioral criterion (i.e., draws to decision) is measured only three times. Since reliability statistics for the beads task have never been reported (to my knowledge), it is unclear whether current measurement practices offer adequate reliability. From the perspective of construct validity, it is also problematic that the drawing of beads may be influenced by one's knowledge of how sample size (i.e., the number of beads drawn) affects the precision of one's estimates regarding the ratio of colored beads, as this knowledge is considered irrelevant to the construct of interest. In other words, persons who are savvy in basic statistics are likely to draw more beads, before concluding which ratio is correct, if only because they recognize the folly of relying on a smaller sample size to reach a conclusion.

Another concern regarding the measurement of data gathering is that it does not adequately discriminate between normal and extreme responses that constitute JTC or EDG. A lower (or higher) number of draws to decision has generally been taken as evidence of a JTC (or EDG) bias, yet the extreme ends of the distribution of draws are likely to be much more informative of these biases than the normal range of the distribution. As an illustrative example, if JTC is operationalized as the drawing of less than 5 beads out of 100, then the difference between drawing 40 and 50 beads would be meaningless (i.e., noise) relative to the difference between drawing 4 and 14 beads. It

stands to reason, therefore, that measuring these two tendencies separately by focusing on the ends of the distribution of draws may yield more meaningful results.

In addition to the measurement issues cited, it is possible that the relationship between data gathering and uncertainty-relevant traits exists at a lower-level of resolution than that of NFC and IU. Desire for Decisiveness and Inhibitory IU, in particular, appear to be much more relevant indicators of the JTC and EDG tendencies (respectively) than their parent constructs, and there is no indication as to whether or not these facets were analyzed in previous studies. Other relevant traits would include the four factors uncovered in Study 1, which are better differentiated than the facets of NFC and IU. Categorical Thinking may be associated with a JTC bias, as it appears to describe a tendency to reach black-and-white conclusions when confronted with ambiguity, and Uncertainty Distress encompasses Inhibitory IU and may have similar predictive validity to this facet.

### **The Present Study**

Given the noted shortcoming of previous studies, the purpose of the present study is to re-examine the relationship between uncertainty-relevant traits and data gathering using a more robust methodological design. First and foremost, I employed a latent variable approach to measure data gathering, using a modified beads task as well as two new analogous tasks. In one of the new tasks, blurry images had to be clarified in order to determine what they represented, and in the other, incomplete words were to be identified by requesting additional letters. Multi-task latent variables offer improvements in both the validity and reliability of the measurement over single-task variables, because they

exclude measurement error and task-specific variance that is extraneous to the behavior of interest (e.g., individual differences in statistical knowledge).

The present design also deviated from previous ones in two additional respects. The first is that EDG and JTC were measured and analyzed as separate variables, in addition to the total amount of evidence gathered, which earlier studies have looked at exclusively. Specifically, these variables represented how often individuals made a very high or low number of requests for information prior to making a decision. As mentioned earlier, focusing on extreme or rare responses is likely to provide more valid measurement of the two biases. However, I should note that this methodological decision was taken after the data collection, and the tasks were not tailored to measure extreme responses.

The other novel aspect of the design is that participants completed each task under two back-to-back conditions, with and without an incentive reward. In the incentive condition, correct decisions earned them points that were used to determine the winner of a cash prize, once data collection for the study ended. Although I did not expect to find different associations between personality and data gathering across the two conditions, the incentive condition was included to make task performance more “consequential”, in the event that participants might show indifference to being accurate in their decisions when no incentive was provided.

In the analysis for this study, the personality predictors I focused on were the four factors uncovered in Study 1 and the Desire for Decisiveness and Inhibitory IU facets. Behavioral variables of interest included the amount of data requested, the JTC and EDG

biases, decision accuracy, ratings of confidence in one's decisions, ratings of anxiety during decision-making, the rated importance of making accurate decisions (i.e., need for accuracy), and the average amount of time spent deciding.

I hypothesized the following based on the findings from Study 1 and the beads task literature: (1) Uncertainty Distress and Inhibitory IU will be positively and uniquely related to EDG, higher anxiety, and lengthier decision time, suggestive of indecisiveness; (2) Preference for Structure will be positively and uniquely related to a rational style that includes requesting more data, expressing a stronger need for accuracy, and achieving greater accuracy (3) Categorical Thinking and Desire for Decisiveness (NFCS) will be positively related to JTC, higher ratings of decision confidence, lower decision accuracy, and shorter decision time. Given the null findings of previous studies, I expected that NFC and IU will not be significantly related to any of the behavioral outcomes noted.

Finally, I also examined whether participants' level of engagement on other tasks during the study explained their behavior on the data gathering tasks, and tested whether this individual difference mediated any of the hypothesized findings. This portion of the analysis was not planned in advance, and its importance became evident due to the possibility that insufficient data gathering (i.e., JTC) might be part of a broader pattern of disengaged or disinterested participation.

## **Methods**

### **Participants and Procedure**

Participants were 357 University of Minnesota undergraduates ( $M_{\text{age}} = 20$ ,  $SD = 3.1$ , 70% female) who received course credit for their participation and were entered to

win one prize of \$50, based on their performance during the study. After excluding those who did not complete some parts of the study or whose data were unreliable (see Data Cleaning), 270 participants remained in the sample. The entire study was done online, using Inquisit 3 (2012) to collect behavioral data and Qualtrics research software to collect survey data. In addition to the data gathering tasks, participants also completed an intelligence test and five measures of perseverative behavior, which were originally purposed for a different study. These additional tasks became relevant in the course of analyzing the data, as they provided information regarding participants' engagement.

Participants were instructed to complete the study in a quiet location, where they would not be distracted. They were also informed that some tasks would involve winning and losing points, and that the top-scorer on one of these tasks will win a prize of \$50; yet, since the winner-determining task would be chosen randomly, they should try to do their best on each one in order to maximize their chances of winning. To make the study more interesting and less tedious, the behavioral tasks were interspersed and combined into three batches, and the personality survey was divided into two parts. These components were administered in the following order: batch 1, survey pt. 1, batch 2, survey pt. 2, batch 3, and each was accessed through a separate web-link that was provided at the end of the preceding component (i.e., upon completing one component, the link to the next one was provided). Participants were encouraged to take short break after each component or approximately every 30 minutes, as it was estimated that the study would take 2.5 hours to complete.

## **Questionnaires**

Questionnaire items from different instruments were administered in a mixed, pseudo-random order, using a 5-point Likert scale (“strongly disagree” to “strongly agree”). To assess whether or not participants paid sufficient attention during the survey, bogus items were included at random intervals, consisting of statements nobody would agree with (e.g., “I am a robot”) or statements everybody would agree with (e.g., “I am completing a questionnaire”). Participants were explicitly instructed to “strongly disagree” with false statements and “strongly agree” with true statements, and the letters “sd” (strongly disagree) and “sa” (strongly agree) were included within each statement to cue the appropriate response.

Uncertainty-related instruments included the revised Need for Closure Scale (NFCS; Roets & Van Hiel, 2007), 27-item Intolerance of Uncertainty Scale (IUS; Buhr & Dugas, 2002), the Cognitive Uncertainty subscale of the Uncertainty Response Scale (URS; Greco & Roger, 2001), and items from the Measurement of Ambiguity Tolerance (MAT; Norton, 1975), Multiple Stimulus Types Ambiguity Tolerance Scale-II (MSTAT-II; McLain, 2009), and Naemi, Beal, and Payne’s (2009) measures of IA and simplistic thinking. Also included were the Big Five Aspect Scale (DeYoung et al., 2007) and items from the Adventurousness and Excitement-Seeking subscales from the International Personality Item Pool (Goldberg et al., 2006) that measured trait curiosity/exploration. It is important to note here that some of the uncertainty instruments from Study 1 were not available in Study 2, namely, the Multidimensional Attitude Toward Ambiguity Scale (Lauriola et al., 2015) and the Emotional Uncertainty and Desire for Change subscales of

the URS, which affected the measurement of the four uncertainty factors, as described next.

Measuring the four factors took several steps. First, the EFA results from Study 1 were used to select items for each trait that had a loading greater than .30, which resulted in the selection of 14 to 25 items per trait (Note: only 14 items were deemed suitable for measuring Categorical Thinking, which is the narrowest of the four factors) (for items, see Appendix A-1).<sup>7</sup> Many of those items, however, were not available in Study 2 data; in particular, only 6 and 7 items were available for measuring Preference for Novelty and Complexity and Categorical Thinking. Thus, an initial set of trait scores were computed using the items that were available, and additional trait markers (i.e., items from other uncertainty-related instruments) were selected that were correlated ( $r > .30$ ) and consistent in content with each trait. The new set of items, consisting of the originals and the newly selected, was then subjected to a four-factor EFA (maximum likelihood and oblimin rotation) in order to verify that each item loads on its expected factor. At this stage, some of the newly selected items were removed and another EFA was run to verify the item loadings. This process resulted in a final selection of 14 to 19 items per trait that were used to compute a new set of trait scores (see Appendix A-2).

Correlations between the original and new trait scores were .93 (Uncertainty Distress), .99 (Preference for Structure), .76 (Preference for Novelty and Complexity), and .79 (Categorical Thinking). Due to the relative unavailability of items related to engaging with complexity, the Novelty/Complexity factor was more so descriptive of the

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<sup>7</sup> Categorical Thinking is narrower than the other factors, hence only 14 items were identified for measuring this factor.

tendency to seek new, exciting and unpredictable experiences, hence it was relabeled Novelty Seeking in this study. Categorical Thinking also differed slightly from the corresponding Study 1 factor in that it included more items tapping negative attitudes toward things that are difficult to comprehend.

## **Tasks**

All tasks were programmed in Inquisit 3 (2012).

**Data gathering tasks.** These consisted of a modified version of beads task (adapted from Huq et al., 1988) and two additional analogous tasks that involved identifying images and words.

**Beads task.** In the modified beads task, participants had to determine which of two colored beads (e.g., yellow, blue) had a higher proportion in a virtual jar of 40 beads. There were 6 jars to complete, and the ratio of proportions in each jar was either 38:62, 42:58, or 45:55, where 38:62 represented the easiest condition. Beads were drawn from each jar in a fixed, pseudo-randomized sequence, and the sequences and bead colors changes from one jar to the next. Throughout the task, the number of beads remaining in the jar and the number of beads drawn for each color were always on display, in integer format, and these numbers were updated with each new draw (for a screenshot see Figure 2.1). Alongside these numbers were also graphical displays of a jar, which always remained the same, and the two colored beads. Participants were instructed to click on the jar to draw beads (one per click) until they were confident about which color had a majority, and once they made a decision, they clicked on the bead of their choice.

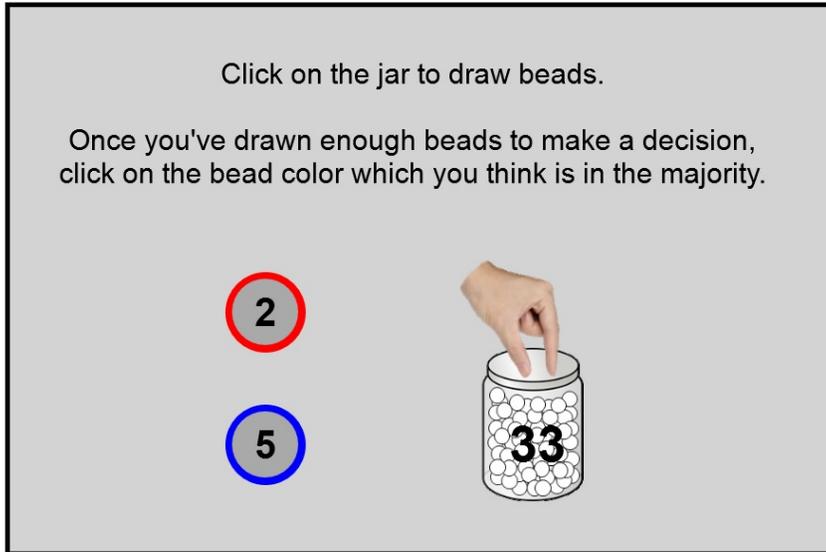


Figure 2.1. Screenshot of the beads task.

**Images task.** In this task, participants had to identify the item displayed in a blurred black-and-white image of either an object (e.g., backpack), location (e.g., classroom), or group of people (e.g., basketball players). Each image was presented along with 3 or 4 textual options as to what it may represent, which were always on display. Participants were instructed to click on the image to reduce its blur until they were confident that they could pick the correct option, and they repeated this process for 9 images. The level of blur could be reduced up to 13 times before it resulted in a clear image, but most images could be identified after much fewer than 13 clicks.

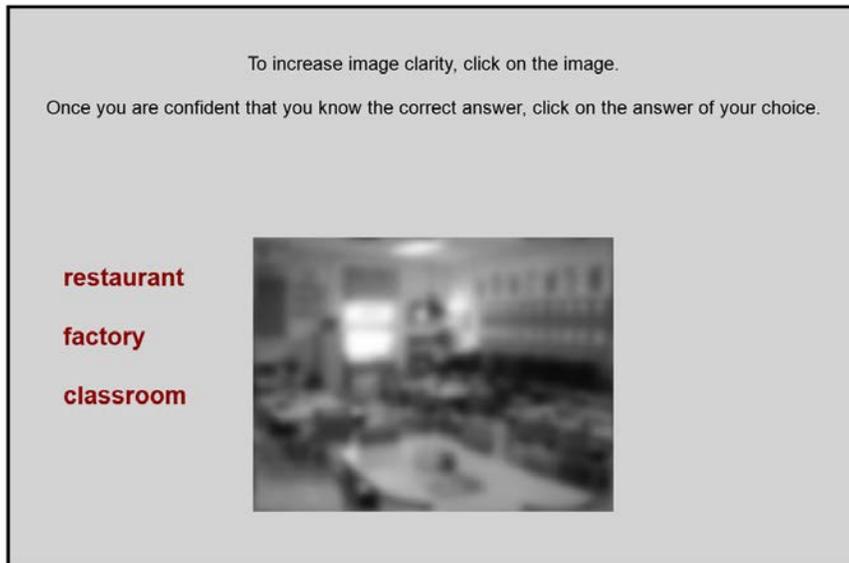


Figure 2.2. Screenshot of the images task.

**Words task.** Participants were tasked with identifying words with missing letters. Words were 10 to 11 letters long and were selected to be accessible to both native and non-native English speakers. Some examples include grandfather, intelligent, competition, popularity, confidence, and protection. Initially, only the first letter of a given word was shown with underscores for the missing letters (e.g., “g \_ \_ \_ \_ \_ \_ \_ \_ \_ \_”). Participants were asked to press a key to obtain another letter repeatedly until they felt confident that they knew what the word was, at which point they were asked to type the word into a textbox. This process was repeated for 10 words, and at the end of the task, participants were asked if they felt that their English skills were inadequate for performing this task.

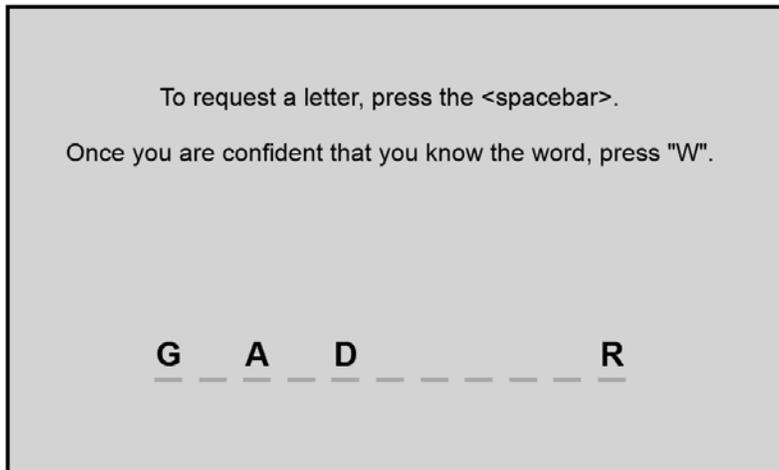


Figure 2.3. Screenshot of the words task.

**Task procedures.** Aside from their specific requirements, the three tasks had identical instructions and procedures. Instructions emphasized that participants should request additional information (e.g., draw beads) until they were *confident* that they could make an accurate decision, and they were explicitly asked not to guess so as to make it clear that this was not a guessing game. At the same time, it was communicated that they do not have to request all possible information (e.g., drawing all 40 beads). Each task began with a practice item to which participants were told exactly how to respond (e.g., draw X number of beads). At the end of each item, once they indicated their decision, they were also asked to rate how confident they were in their decision on a scale of 1 (“not at all”) to 9 (“completely”). However, they were not presented with any feedback. Lastly, at the end of the task, they rated how anxious they felt during the task and how important it was for them to make accurate decisions, both on a scale of 1 (“not at all”) to 4 (“very”). Outcome variables consisted of the average number of times information was requested, the proportion of items (e.g., jars, images, words) on which participants

jumped to conclusions and likewise the proportion of items on which they displayed an EDG bias (as described below), the average decision accuracy, average ratings of confidence, the ratings of anxiety and the importance of being accurate (need for accuracy), and the average amount of time they spent prior to making a decision.

JTC and EDG responses were counted as those that fell within the bottom 10% (for JTC) and top 10% (for EDG) of the response distribution for each item, and the cutoffs for each distribution were determined using frequency tables. For example, if the bottom 10% of responses for jar 1 corresponded to drawing fewer than 8 beads, than any response of 8 or below (i.e., the cutoff value) was counted as a JTC response and scored as 1, while any response above 8 was scored as 0. Responses were counted across all items and averaged, so the variables consisted of proportions. In essence, the JTC and EDG variables indicated how often participants responded in a statistically rare manner, by drawing either fewer or more beads than 90% of all participants.

The reason why I decided to use item-specific cutoffs to define JTC/EDG responses is that the items varied in difficulty and using a single, invariant cutoff was not a sensible option. However, since the cutoffs were based on the distributional criteria, this means that JTC/EDG are defined in a manner that is specific to the present sample. Also, a few items were not used to measure these biases because their distributions were highly concentrated at one tail; that is, they were either very easy (many people decided very early on) or very difficult (too many people decided at a late stage).

Participants completed two back-to-back conditions of each task, one as described, and another in which they would earn or lose points for each correct or

incorrect decision, thus competing for the chance to win the cash prize. The number of points they could earn for each correct decision was set to the maximum number of data requests that could be made, and the points they could lose was set to half of that amount. To ensure that participants did not request all available information (which would be a rational strategy for earning maximum points), each request also cost them a point from the potential earnings. To use a concrete example, in the beads task, one could earn a maximum of 40 points or they could lose 20 points, and so if one were to draw 16 beads before registering a decision, then 24 points could be earned. The potential earnings, potential losses, and total points earned were always displayed, and they were updated at the end of each decision, thus, notifying participants of whether or not they were correct.

**Additional tasks.** Participants also completed a measure of intelligence and five measures of perseverative behavior, which were administered for a different study. In an exploratory analysis, some of the performance variables from these tasks appeared to share common variance and were deemed useful for assessing participants' level of engagement throughout the study; therefore, the relevant tasks and the measurement of task engagement are described in more detail below. Two of the five perseveration tasks that were not used for this purpose and are not described further include the Einstellung water jar task (Greenberg, Reiner, & Meiran, 2012; Luchins, 1942) and the Door Opening Task (Matthys, Goozen, Vries, Cohen-Kettenis, & Engeland, 1998).

The *International Cognitive Ability Resource (ICAR; Condon & Revelle, 2014)* 16-item sample test is a public-domain measure of intelligence, consisting of four types of problems: verbal reasoning, letter and number series, matrix reasoning, and three-

dimensional rotation. It has been tested and normed on 97,000 participants ( $M_{\text{age}} = 26$ ,  $SD = 11$ ), has good reliability ( $\alpha = .81$ ), and has shown moderate to strong correlations with other measures of cognitive ability and achievement. The test was administered untimed.

***Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948)***. This task consists of sorting 128 cards with geometric shapes into four decks according to one of three dimensions (color, shape, number of shapes). Participants have to determine the correct sorting rule based on feedback they receive each trial, and they are also informed that the sorting rule may change during the task. After applying a rule correctly 10 consecutive times, the rule changes, and any further application of the old rule is counted as a perseverative error. I used a computerized version of the task (dated 9/16/2014) from the Millisecond Test Library (<https://www.millisecond.com/download/library>).

***Probabilistic reversal learning task (adapted from Waltz and Gold [2007])***. In this task, participants must learn to select one of two images based on response feedback. Choice of one image is reinforced 75% of the time, and choice of the other is reinforced 25% of the time. Participants are instructed to figure out which image is the ‘correct’ one (i.e., which selection is reinforced more often) and to continue selecting it, and they are made aware that its selection will not always be reinforced. They are also informed that at some point the correct image will change and that when that happens, they should begin choosing the other image. The target image changes after every 10 consecutive correct selections (1 error allowed), at which point every failure to select the new target is considered a perseverative error. However, unbeknownst to participants, the reversal of

the reinforcement rates is not instant but rather gradual; once the criterion is reached, the reinforcement rate for the target image (75%) decreases by 10% every ten trials, until it reaches 25%. There are three pairs of images in the task, and for each pair, participants must learn to reverse their selections 3 times within 70 trials (maximum allowed per reversal).

***Mystery card task.*** Similar to the WCST, this card task requires first learning to apply a rule, then learning to switch to a different rule based on response feedback. Participants are presented with four identical cards labeled with a question mark, one of which has a dollar sign (\$) located above it. Every time they pick a card, they earn either 1 or 0 points, and the \$ moves to a different card. Participants are told that the objective is to earn as many points as possible and that there are two rules they can follow, one of which will earn them more points than the other; however, they must discover the rules on their own. The optimal rule or strategy (reinforced 80% of the time) is to pick the card that is 2 cards away from the one below the \$, whereas the suboptimal rule (reinforced 25% of the time) is to pick the card below the \$. In order to help them discover the best rule, they are instructed to pay attention to the location of the \$ every time they win a point. Once the optimal rule is used 14 consecutive times, its reinforcement rate decreases by 10% every 10 uses until it is no longer reinforced, while the previously suboptimal rule is now reinforced at a rate of 80%. Participants are not notified that the optimal rule may change, and the behavior of interest is how long they persist in using the old rule once its reinforcement changes. Only one reversal takes place throughout the task.

***Measurement of task engagement.*** This individual difference was assessed as a latent variable using task-related variables that could be considered indicators of how much effort and attention participants applied to the task at hand. The variables (and their loading on a general factor) included the proportion of bogus survey items answered correctly (.71), the number of questions on the intelligence test that were answered in less than 5 seconds (-.61), total errors on the WCST (-.30), total errors on the reversal task (-.50), and the frequency of use of the sup-optimal (incorrect) rule during the mystery card task, prior to the reversal phase (-.29).

### **Data Cleaning**

For each task, unreliable participant data was removed based on task-specific criteria, as described next. Twenty participants failed to answer correctly 70% or more of the bogus questions during the survey, and two responded “neither agree nor disagree” to over 50% of all questions. For the word task, nine people provided responses that showed either lack of effort or inadequate English language skills. Five people did not understand or follow instructions for the images task (e.g., did not request any information on most images), as did 3 people for the beads task (e.g., drew all the beads or a set amount of beads for the entire task). For the WCST, 9 people responded in under 300ms on more than 15% of the trials, which suggested inadequate engagement in the task. With regards to the reversal learning task, 13 people either failed to reach the reversal phase of the task in 2 out of 3 blocks or they showed chance-level accuracy. Overall, the aforementioned criteria resulted in the removal of 7% of the survey data, and 1-5% of the task data.

Additionally, if a participant showed unreliable data on 3 or more study components, his or her data was removed in its entirety, and this applied to 14 people.

As this study was administered online and consisted of multiple separable parts, many participants did not complete the entire study and some experienced technical problems, which affected the rate of missing data. The dropout rate was 20% (72 participants) and this included participants who chose not to continue after doing only one task. Some task data (< 1%) was also lost due to technical issues that resulted in the data not being saved to online servers. The two most frequently-cited issues were lost internet connectivity and bugs in the Inquisit program that led participants to quit before their data could be saved. Rather than exclude anyone who did not finish the study, participants were retained in the sample as long as they had complete and reliable data for the personality survey and 2 of the 3 information sampling tasks.

### **Analysis**

Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) were conducted in SPSS Amos Version 23 (Arbuckle, 2014) using full-information maximum likelihood to handle missing data. First, to assess whether participants responded differently under the two task conditions (incentive/baseline), paired-sample *t*-tests were run for each of the data gathering task variables (DGVs), and the point biserial *r* equivalent of Cohen's *d* was computed to quantify the effect size differences. CFA was then used to examine the degree to which the variables from each condition measured the same tendencies. DGVs from each condition were modeled as separate factors with three indicators from the three tasks, and correlations were specified between all the factors.

Common-method variance was accounted for by specifying within-task correlations among the error terms of all the DGVs. Unless otherwise noted, the rest of the analysis was conducted using the data pooled from both conditions.

A CFA model was fitted to obtain the latent correlations among the DGVs, task engagement, and personality traits (see Figure 2.4). DGVs representing the data pooled from both conditions constituted factors with three indicators, task engagement constituted a factor with five indicators (as described earlier), and personality traits constituted observed variables for the four uncertainty factors, NFC, IU, and their facets. These variables were all allowed to correlate, and within-task (method) correlations were specified among the error terms of the task variables, as previously described. This model was also tested using the variables from each condition, separately, and any notable differences in the latent correlations were reported.

Next, the four uncertainty factors were treated as simultaneous predictors of each DGV in a series of SEM models. Regression paths were specified between each uncertainty trait and the dependent variable, and a general factor accounted for the variance shared among the traits. This analysis was also repeated with Inhibitory IU and Desire for Decisiveness supplanting Uncertainty Distress and Categorical Thinking, respectively, as predictors in each model, with Novelty Seeking and Preference for Structure retained as predictors.

Lastly, I tested whether task engagement mediated the effects of any personality traits found to be significant predictors of data gathering. Since this analysis was results-dependent, it is described in the results. Models were considered well-fitting if they had

CFI values greater than .90 and RMSEA values below .08, and the probability of a close fit ( $p$ -close; RMSEA=.05) was computed.

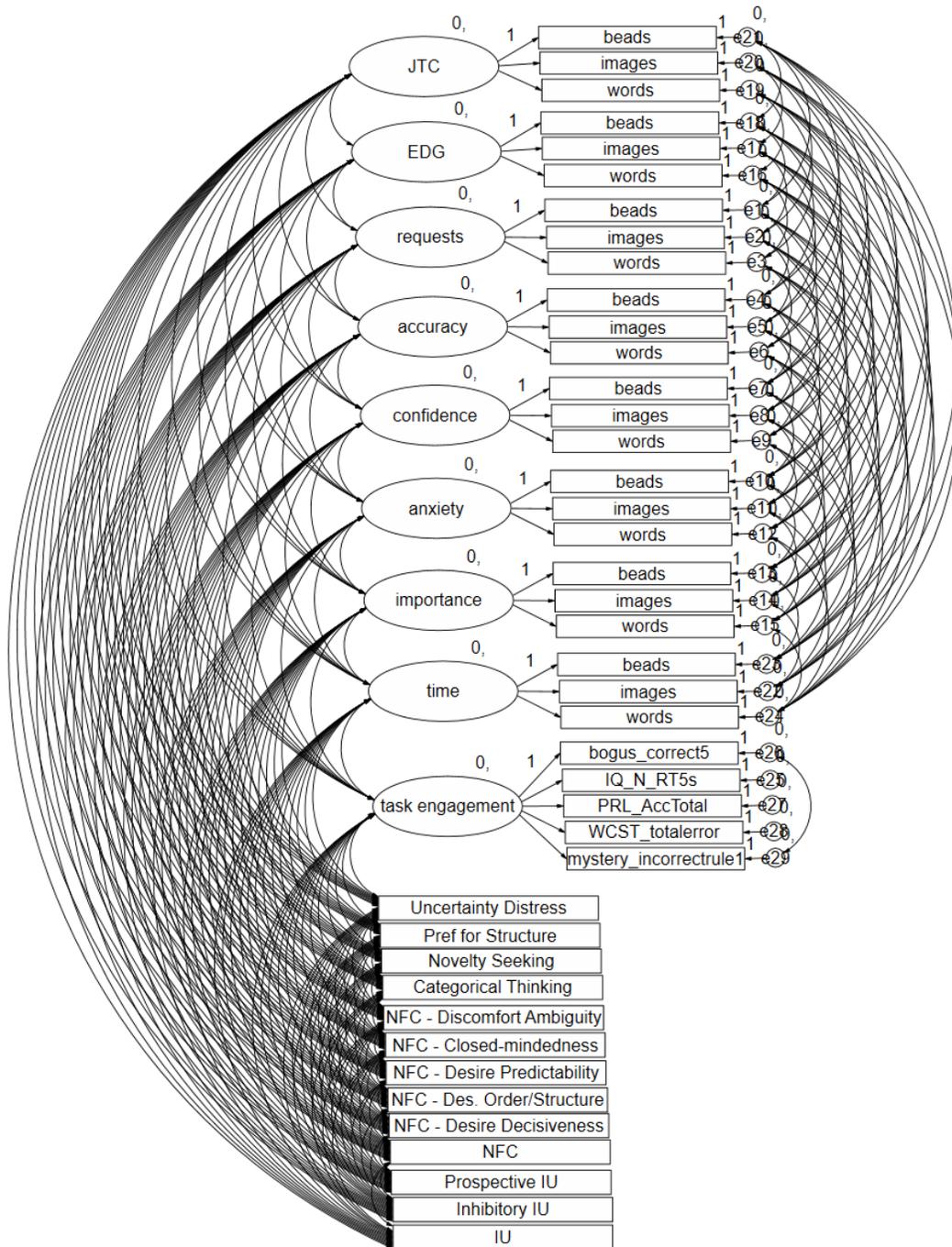


Figure 2.4. CFA model with correlations among data gathering variables, task engagement, and personality traits.

## Results and Discussion

### Descriptive Statistics

Table 2.1 displays descriptive statistics and alpha reliability estimates for the four uncertainty factors and the DGVs. Reliability estimates across the three tasks were generally adequate to excellent, with some exceptions. Alphas for measures of accuracy were quite low ( $< .70$ ), likely because the mean accuracy attained for many items was high ( $> .95$ ) and their variances were consequently very small (note: participants were encouraged not to guess). Differences in item score variance<sup>8</sup> may also explain differences in the alphas across the three tasks (beads  $>$  images  $>$  words) and the lower alphas for measures of EDG and JTC, whose items were binary scored (0/1). In the words task, variances were limited for several items due to ceiling effects (i.e., most people requested all available letters) and item difficulties were higher compared to the other tasks because participants were not presented with a set of answers to choose from. Despite the less-than-satisfactory alphas for some variables, all of the DGVs were significantly inter-correlated across the three tasks.

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<sup>8</sup> These differences stem from the fact that items in the beads task allowed for a greater range of responses in terms how much data could be requested (1-39), compared to the images task (1-13) and words task (1-10).

Table 2.1

*Descriptive Statistics and Reliability Estimates for Personality Traits and Data Gathering Variables*

	N	Mean	SD	Min	Max	Range	Skew	Kurt	$\alpha$
Uncertainty Distress	270	3.14	.59	1.19	4.67	3.48	.09	-.06	.90
Preference for Structure	270	3.55	.54	1.81	4.90	3.10	-.02	-.12	.90
Novelty Seeking	270	3.29	.50	1.57	4.57	3.00	-.07	.06	.79
Categorical Thinking	270	2.84	.52	1.42	4.21	2.79	.04	-.13	.84
Data requests (beads)	245	19.37	5.96	7.92	36.00	28.08	.59	-.06	.95
Data requests (images)	267	6.16	1.40	1.39	10.06	8.42	-.43	.24	.89
Data requests (words)	263	7.51	.73	4.75	9.35	5.03	-.60	.71	.81
JTC responses (beads)	245	.07	.14	.00	.83	.83	2.60	7.30	.79
JTC responses (images)	267	.07	.13	.00	.81	.81	2.60	8.44	.77
JTC responses (words)	263	.07	.11	.00	.75	.75	2.68	9.46	.75
EDG responses (beads)	245	.07	.18	.00	1.00	1.00	3.46	12.34	.90
EDG responses (images)	267	.05	.08	.00	.61	.61	2.71	11.05	.65
EDG responses (words)	263	.06	.09	.00	.71	.71	2.81	13.57	.53
Accuracy (beads)	245	.87	.13	.50	1.00	.50	-.90	-.05	.62
Accuracy (images)	267	.82	.12	.32	1.00	.68	-1.22	2.29	.59
Accuracy (words)	263	.54	.14	.06	.84	.78	-.44	.00	.57
Confidence (beads)	245	6.23	1.45	1.83	9.00	7.17	-.19	-.20	.94
Confidence (images)	267	7.47	1.08	4.22	9.00	4.93	-.65	-.11	.92
Confidence (words)	263	7.22	1.22	3.00	9.00	6.26	-.85	.31	.89
Time (beads)	242	23.65	8.61	6.82	52.00	73.18	.99	.88	-
Time (images)	267	10.37	4.76	2.80	30.00	35.24	1.34	2.14	-
Time (words)	263	12.32	7.88	2.93	45.00	42.07	1.69	3.17	-
Anxiety (beads)	245	2.31	.72	1.00	4.00	5.00	-.01	-.62	-
Anxiety (images)	266	1.92	.75	1.00	4.00	5.00	.52	-.59	-
Anxiety (words)	263	2.06	.81	1.00	4.00	3.00	.29	-.93	-
Need for accuracy (beads)	245	3.30	.65	1.00	4.00	5.00	-.94	.61	-
Need for accuracy (images)	266	3.02	.75	1.00	4.00	5.00	-.57	-.17	-
Need for accuracy (words)	263	2.79	.78	1.00	4.00	3.00	-.28	-.66	-

## Comparison of Task Conditions

T-test results comparing the two task conditions (baseline minus incentive) are displayed in Table 2.2. Compared to the baseline condition, in the incentive condition, participants gathered less data, they were less confident and accurate in their decisions, and they reported greater anxiety and need for accuracy. These results confirm that the incentive was effective in moderating behavior, specifically, by encouraging participants to accept a lower threshold for evidence in order to maximize points that could be earned for every correct decision. Although I expected the opposite effect (namely, participants gathering more evidence to ensure accuracy and not lose points), this finding is consistent with the fact that potential earnings were reduced with every data request.

A structural model with between-condition correlations among the DGVs showed a close fit to the data ( $\chi^2(225) = 259.54, p = .057, CFI = .986, RMSEA = .024, p\text{-close} = 1.0$ ). The latent correlations between conditions were .74 (data requested), .82 (JTC), .74 (EDG), .82 (decision accuracy), .92 (decision confidence), .86 (anxiety), and .79 (need for accuracy). If the two conditions measured the same individual differences, then one would expect to find correlations closer to unity, yet these findings suggest that there were significant differences in measurement. I therefore decided to examine whether the rest of the results differed across conditions.

Table 2.2

*T-test Results Comparing Behaviors Under the Baseline and Incentive Conditions (Baseline – Incentive)*

	<i>t</i>	<i>df</i>	<i>p</i>	95% C.I.		<i>M<sub>d</sub></i>	<i>M<sub>BC</sub></i>	<i>M<sub>IC</sub></i>	<i>d</i>	<i>r</i>
Data requests (beads)	14.300	242	.000	4.142	5.465	4.804	21.682	16.853	.92	.42
Data requests (images)	11.780	265	.000	.826	1.158	.992	6.646	5.648	.72	.34
Data requests (words)	1.658	262	.098	-.016	.187	.086	7.549	7.464	.10	.05
JTC responses (beads)	-.805	242	.422	-.035	.015	-.010	.062	.072	.05	.03
JTC responses (images)	-.225	265	.822	-.018	.015	-.002	.074	.076	.01	.01
JTC responses (words)	.593	262	.554	-.010	.019	.004	.069	.064	.04	.02
EDG responses (beads)	.861	242	.390	-.013	.034	.010	.076	.062	.06	.03
EDG responses (images)	-1.145	265	.253	-.024	.006	-.009	.046	.054	.07	.04
EDG responses (words)	-3.840	262	.000	-.048	-.016	-.032	.049	.080	.24	.12
Decision accuracy (beads)	8.064	242	.000	.072	.118	.095	.917	.822	.52	.25
Decision accuracy (images)	13.453	265	.000	.124	.166	.145	.887	.742	.82	.38
Decision accuracy (words)	6.835	262	.000	.061	.110	.085	.588	.503	.42	.21
Confidence (beads)	10.149	242	.000	.662	.981	.821	6.628	5.803	.65	.31
Confidence (images)	7.740	265	.000	.374	.630	.502	7.721	7.223	.47	.23
Confidence (words)	7.732	262	.000	.418	.703	.560	7.501	6.941	.48	.23
Anxiety (beads)	-13.602	244	.000	-.804	-.600	-.702	1.955	2.657	.87	.40
Anxiety (images)	-13.524	264	.000	-.709	-.529	-.619	1.609	2.230	.83	.38
Anxiety (words)	-13.061	262	.000	-.866	-.639	-.753	1.688	2.441	.81	.37
Need for accuracy (beads)	-5.787	244	.000	-.377	-.186	-.282	3.159	3.441	.37	.18
Need for accuracy (images)	-4.830	264	.000	-.303	-.127	-.215	2.917	3.128	.30	.15
Need for accuracy (words)	-.584	262	.560	-.150	.081	-.034	2.772	2.806	.04	.02

*Note.* *M<sub>d</sub>* = mean difference; *M<sub>BC</sub>* = mean for baseline condition; *M<sub>IC</sub>* = mean for incentive condition; *d* = Cohen's *d*; *r* = point biserial *r* equivalent of *d*.

## Correlations Among Data Gathering Variables

The CFA model specifying correlations among the DGVs, task engagement, and personality traits was close-fitting ( $\chi^2(496) = 595.29, p = .001, CFI = .983, RMSEA = .027, p\text{-close} = 1.0$ ). Latent correlations among the data gathering variables and task engagement are displayed in Table 2.3. As this table displays, JTC and EDG were only moderately correlated with one another and their correlations with data requests were below .85, providing evidence of divergent validity among these variables. Decision accuracy was very strongly correlated with JTC ( $r = .93$ ) but not EDG ( $r = .40$ ), which suggests that inaccurate decisions were mostly the result of requesting very little information. Decision time was a moderate-to-strong indicator of JTC and decision accuracy, but it was not a significant indicator of EDG, implying that people who took longer to decide were not necessarily more extreme in their evidentiary requirements.

As indicated by the weak relationship between decision confidence and data requests, people who requested more evidence were only somewhat more confident about their decisions than those who gathered less. In turn, moderate correlations among ratings of anxiety and the need for accuracy suggest that those who cared more about being accurate were more anxious about the making wrong decisions. Anxiety was also positively correlated with the JTC but not EDG, which lends credibility to the idea that anxiety propels people to make quick decisions in a bid to end the unpleasant uncertainty (Bensi & Giusberti, 2007; Fraser et al., 2006).

Task engagement was positively correlated with decision time, decision accuracy, and need for accuracy, and it was negatively correlated with the JTC bias but not total

data requests. In other words, individuals who were diligent in carrying out other tasks also showed diligence during the data gathering tasks by taking their time and not jumping to conclusions (perhaps because they were more likely to heed the instruction not to guess). Surprisingly, they were also marginally less likely to show EDG ( $r = -.20$ ,  $p = .06$ ), which would make the EDG bias a negative indicator of task engagement.

In general, the correlations varied in strength across the two conditions, but it is unclear whether those variations were meaningful. Specifically, in the incentive condition compared to the baseline condition, there were stronger inter-correlations among the JTC/EDG biases, the total amount of data gathered, and decision accuracy, which implies less differentiation in what they were measuring.

Table 2.3

*Latent Correlations Among Data Gathering Variables and Task Engagement*

	1	2	3	4	5	6	7	8
1. Decision time	–							
2. JTC	-.51	–						
3. EDG	-.04	-.38	–					
4. Data requests	.35	-.81	.72	–				
5. Decision accuracy	.56	-.93	.40	.88	–			
6. Need for accuracy	.14	.05	-.11	-.04	.06	–		
7. Anxiety	.02	.22	-.10	-.19	-.14	.42	–	
8. Confidence	.00	-.01	-.08	.10	.01	.15	-.01	–
9. Task engagement	.46	-.57	-.20	.14	.46	.22	.14	-.13

*Note.* Correlations with absolute value  $> .15$  are significant at  $p < .05$ .

## **Associations Between Personality Traits and Data Gathering**

All SEM regression models showed a close fit to the data ( $p$ -close > .05). Table 2.4 displays the regression coefficients from all models and is divided into two sections: “Analysis A” corresponds to the analysis conducted with the four factors, and “Analysis B” corresponds to the analysis conducted with Inhibitory IU and Desire for Decisiveness. This table also displays results from the models with task engagement as a mediating variable, which are described in the next section. The following results concern the models without mediation (Step 1 in Table 2.4).

Contrary to my first set of hypotheses, Uncertainty Distress and Inhibitory IU were not positively associated with EDG and decision time, but they were predictive of anxiety, as expected. Second, Preference for Structure was positively associated with need for accuracy (ratings), as predicted, but it was not related to decision accuracy nor the amount of data requested. Third, Categorical Thinking was positively associated with JTC and negatively associated with accuracy and decision time, confirming that those who are prone to thinking in black-and-white terms are more likely to make hasty and inaccurate decisions based on limited evidence. I made the same predictions for Desire for Decisiveness, but the only prediction confirmed was its negative association with accuracy.

Novelty Seeking emerged as a unique, positive predictor of JTC and decision inaccuracy, yet these results were not predicted. In one respect, they are counterintuitive because one would expect individuals scoring high on this trait to show greater interest in acquiring information. On the other hand, given their tendency to embrace uncertainty, it

is possible that these individuals felt more comfortable deciding without all available information, which would be consistent with the positive association found between Preference for Novelty/Complexity and spontaneous decision-making (Study 1). Note too that Novelty Seeking, in this study, measured only one of the two aspects of the Novelty/Complexity factor and it is possible that these aspects have different effects on data gathering.

In other unplanned analyses, I examined whether the general factor indicated by the four uncertainty factors explained unique variance in data gathering behavior when it was added as a predictor. Doing so, however, meant excluding Uncertainty Distress as a predictor because it had a strong loading on the general factor (.87), so only three of the four factors were retained. Like Uncertainty Distress, the general factor was only predictive of anxiety.

Table 2.5 displays the latent correlations between all personality traits and DGVs. Consistent with the results of previous studies, NFC and IU were not related to the amount of evidence gathered. The only variables they were significantly correlated with (negatively) were decision time and task engagement.

A comparison of the results across conditions revealed that correlations were noticeably weaker and less significant in the incentive condition, but their direction did not change. It appears then that the gamification of the tasks (i.e., possibility of winning and losing points, and competing for a cash prize) altered participants' behavior such that it reduced the predictiveness or diagnosticity of the personality traits.

Table 2.4

*Regression Coefficients from the SEM Analyses*

	Requests		JTC		EDG		Accuracy		Time		Confidence		Anxiety		NeedAccuracy		TE
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	
<b>Analysis A</b>																	
Uncertainty Distress	-.03	-.03	.08	.07	.07	.06	.03	.05	.04	.05	.00	.00	<b>.24</b>	<b>.24</b>	-.01	-.01	-.04
Preference for Structure	.03	.02	-.11	-.08	-.07	-.07	-.01	-.04	-.02	-.04	.11	.11	.05	.04	<b>.24</b>	<b>.23</b>	.09
Novelty Seeking	<b>-.25</b>	<b>-.25</b>	<b>.36</b>	<b>.29</b>	-.10	-.13	<b>-.37</b>	<b>-.33</b>	.03	.09	.08	.06	.11	.12	.08	.12	-.16
Categorical Thinking	<b>-.20</b>	<b>-.19</b>	<b>.49</b>	<b>.26</b>	.03	-.06	<b>-.50</b>	<b>-.36</b>	<b>-.27</b>	-.06	.14	.09	-.14	-.08	-.04	.11	<b>-.50</b>
Task engagement		.02		<b>-.44</b>		<b>-.18</b>		<b>.27</b>		<b>.42</b>		-.09		.15		<b>.30</b>	
<b>Analysis B</b>																	
Inhibitory IU	-.04	-.03	.14	.07	.07	.04	.02	.08	-.02	.04	-.01	-.02	<b>.17</b>	<b>.21</b>	-.04	.00	<b>-.22</b>
Preference for Structure	-.04	.04	-.03	-.03	-.05	-.06	-.11	-.13	-.05	-.05	.13	.13	.05	.05	<b>.23</b>	<b>.23</b>	.00
Novelty Seeking	<b>-.22</b>	<b>-.21</b>	<b>.30</b>	<b>.25</b>	-.11	-.13	<b>-.28</b>	<b>-.26</b>	.08	.11	.06	.05	.11	.13	.08	.10	-.13
Desire for Decisiveness	-.04	-.02	.16	.05	-.01	-.04	<b>-.20</b>	-.13	-.07	-.01	.10	.08	.01	.04	.02	.07	<b>-.15</b>
Task engagement		.11		<b>-.51</b>		<b>-.17</b>		<b>.40</b>		<b>.39</b>		-.12		<b>.19</b>		<b>.26</b>	

*Note.* Coefficients in bold are significant at  $p < .05$ . Analysis A = regression with four uncertainty factor as predictors; Analysis B = regression with Inhibitory IU and Desire for Decisiveness. S1 = Step 1 (no mediation). S2 = Step 2 with task engagement added as mediator. TE = task engagement.

Table 2.5

## Latent Correlations Between Personality Traits, Data Gathering, and Task Engagement

	DR	JTC	EDG	TIM	ACC	nACC	ANX	CON	TE
Uncertainty Distress	.00	.10	.09	-.14	-.08	.05	.13	.07	-.18
Preference for Structure	-.02	.01	-.07	-.12	-.06	.18	.07	.12	-.07
Novelty Seeking	-.18	.19	-.12	.10	-.19	.00	.00	.00	.01
Categorical Thinking	-.13	.35	.04	-.27	-.39	.03	-.04	.16	-.43
Need for Closure	.00	.09	.04	-.20	-.09	.11	.02	.13	-.19
Desire for Decisiveness	-.04	.14	.03	-.13	-.19	.05	.07	.11	-.22
Closed-mindedness	-.05	.13	.04	-.18	-.09	-.05	-.10	.03	-.23
Desire for Predictability	.05	-.02	.08	-.15	-.01	.06	.00	.08	-.05
Desire for Order/Structure	.02	-.03	-.04	-.08	.05	.19	.09	.12	-.06
Discomfort with Ambiguity	.02	.07	.06	-.15	-.09	.13	.02	.12	-.14
Intolerance of Uncertainty	.05	.07	.14	-.17	-.07	.08	.12	.07	-.26
Prospective IU	.05	.07	.14	-.20	-.14	.13	.09	.08	-.25
Inhibitory IU	.04	.04	.11	-.12	.00	.03	.14	.05	-.22

*Note.* Correlations with absolute value > .15 are significant at  $p < .05$ . DR = data requests; JTC = jumping to conclusions; EDG = excessive data gathering; TIM = decision time; ACC = decision accuracy; nACC = need for accuracy; ANX = anxiety; CON = decision confidence; TE = task engagement.

## Tests of Mediation by Task Engagement

Evidence that task engagement was uniquely predicted by both Categorical Thinking ( $\beta = -.50, p < .01$ ) and Novelty Seeking ( $\beta = -.16, p < .06$ ) raised the possibility that this variable mediated at least some of their effects on data gathering. To test for mediation, the SEM analyses were repeated with task engagement added as a predictor of each DGV, and regression paths were specified from Categorical Thinking and Novelty Seeking to the engagement factor, as shown in Figure 2.5. All mediation models were close-fitting ( $p\text{-close} > .05$ ), and the results displayed in Table 2.4 (Step 2) show that task engagement partially mediated the effects of both traits on JTC and decision accuracy, and it fully mediated the effects of Categorical Thinking on decision time.

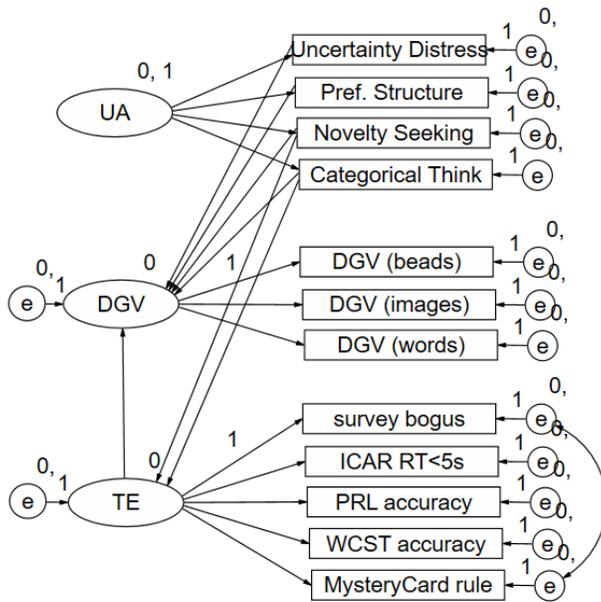


Figure 2.5. Structural model with task engagement as a mediator. UA = uncertainty aversion; DGV = data gathering variable; TE = task engagement.

This mediation analysis was then re-done with the Inhibitory IU and Desire for Decisiveness facets as predictors of data gathering and task engagement, with Novelty Seeking also a predictor of task engagement. Here, the results showed that task engagement partially mediated the effects of Desire for Decisiveness on decision accuracy, which no longer remained significant (see Table 2.4, Analysis B, Step 2).

### **Follow-up Analysis**

Due to the zero-inflated, non-normal distributions of the EDG and JTC observed variables (most people did not respond extremely and thus had zero values), there were concerns that modeling the JTC/EDG latent variables using linear regression equations led to biased estimates of their relationship to personality traits and potentially misleading findings. To confirm that the results were robust to the severe non-normality of those variables, the SEM analyses were rerun, in which JTC/EDG were modeled using logistic regression and their factor indicators were treated as ordered categorical variables rather than continuous variables. Specifically, JTC/EDG scores from each task were rescored using 4 ordered categories corresponding to the number of extreme responses: category 1 = 0; category 2 = 1-2; category 3 = 3-5; category 4 = 6+. These analyses were conducted in MPlus version 8 (Muthén & Muthén, 1998-2017).

Overall, the initial results reported were confirmed—namely, that Categorical Thinking and Novelty Seeking were significant predictors of JTC (including after controlling for task engagement), and there were no significant personality predictors of EDG.

## General Discussion

This study introduced novel measures of data gathering to reassess its inconclusive relationship with uncertainty-related traits. Only some of the hypotheses put forth were supported: Uncertainty Distress and Inhibitory IU predicted greater anxiety during decision-making, Preference for Structure predicted a stronger need for accuracy, and Categorical Thinking predicted JTC, lower accuracy (as did Desire for Decisiveness), shorter decision time, and reduced data gathering. In turn, NFC and IU were not predictive of data gathering, which is consistent with earlier results. Although limited in nature, these findings support the discriminant predictive validity of the four uncertainty factors and reveal their usefulness compared to constructs like NFC and IU.

One of the more surprising non-findings of this study is that none of the personality traits examined were positive predictors of data gathering, despite the strong theoretical rationales for Preference for Structure and Inhibitory IU. These lack of findings among others lead me to suspect that the beads paradigm, on which all the present tasks were based, may be lacking in ecological validity, as it oversimplifies the nature of real-life decision-making. In essence, the paradigm involves deciding between a given set of hypotheses, using the click of a button to obtain more information that has incremental value for reaching the correct decision. In everyday decision-making, people generally grapple with many other sources of uncertainty, such as where to obtain relevant information, how to weigh the information based on its credibility and relevance, and how to resolve conflicting information. A decision-making task that involves more of these uncertainties would likely be more ecologically valid.



### **Task Engagement Findings**

Task engagement only partially mediated the effects of Categorical Thinking and Novelty Seeking on the DGVs, which suggests that there is a unique relationship between these traits and data gathering that is not explained by a general lack of motivation to perform. It should be highlighted though that the mediation analysis was conducted post-hoc and there is some ambiguity as to what the task engagement factor actually measures in terms of psychological processes. The existence of a general factor underlying indicators of engagement from multiple tasks was discovered in an exploratory analysis, and it became relevant to the study once I had observed that it was correlated with JTC. The label for the factor was chosen because one of its indicators reflected participants' willingness to perform rather than their performance per se—specifically, their willingness to spend a reasonable amount of time working through the problems on the ICAR test. It is most likely the case, however, that both ability and motivation were at play, because even after controlling for the tendency to skip problems on the ICAR test, there remained a modest positive association between this factor and intelligence. Furthermore, participants' performance probably also reflected how well they understood the task instructions, as certain tasks were particularly challenging and had lengthy instructions.

### **Task Condition Findings**

Relative to the baseline condition, the incentive condition introduced in this study generally yielded weaker associations between personality and data gathering, which is to say that it weakened the effects of personality. Although, as intended, the reward

incentive did lead individuals to express a stronger need for accuracy, it also led them to consider less evidence as a strategy for maximizing their points for each correct decision, which was not expected. It is not difficult to imagine real-life scenarios where this kind of tradeoff occurs, namely, the reward for making a quick decision outweighs the costs of making the wrong decision (e.g., rejecting a job applicant among a large list of applicants). The problem is that this tradeoff is not particularly relevant to the criterion of interest in the beads paradigm, which is individuals' evidentiary requirements during decision-making. Thus, I would give less weight to the results from this condition.

### **Limitations**

The results of this study should be viewed with some caution due to the study length and the online method of administration. Many tasks were administered, which collectively took over 2 hours to complete, and it is likely that the study length diminished at least some participants' motivation to perform as expected, despite the allowance for brief breaks after each task. The online nature of the study also may have influenced their behavior in ways that would not otherwise have influenced them in a laboratory setting. Therefore, it is unclear if the current results would replicate in a laboratory session wherein only the three data gathering tasks were to be administered.

Another caveat is that many participants either dropped out of the study at various stages or had their data for certain tasks removed due to its unreliability. Although these issues are common, especially in online studies where people feel more comfortable quitting at any point, the pattern of missing data cannot be considered random, as confirmed in a post-hoc analysis: the number of tasks for which participants had missing

data was negatively associated with task engagement, which shows that non-random factors contributed to the missingness. Importantly though, I accounted for one of these factors by controlling for the effects of task engagement.

### **Implications**

With regards to the measurement of data gathering, this study highlights the benefit of measuring the JTC bias as an aggregate of extreme responses. In a post-hoc analysis, I found that JTC fully explained the negative relationship between Novelty Seeking and data requests, and it partially explained the same relationship for Categorical Thinking. The use of percentile cutoffs to measure JTC (and EDG), however, resulted in non-normally distributed variables, and so other measurement alternatives should be looked into in future research. In contrast to the positive findings for JTC, no evidence was found linking EDG to any personality traits, and it questionable whether this variable provided any uniquely useful information (not already provided by total data requests). Allowing participants to gather more evidence (i.e., raising the ceiling on the amount of evidence that can be requested) perhaps would have enabled me to better differentiate normal from extreme responses.

The present findings also provide new clues regarding the possible motivational nature of Categorical Thinking. People who scored high on this trait showed much less engagement throughout the study and they also evaluated the tasks more negatively,<sup>9</sup> as revealed in a post-hoc analysis, which leads me to speculate that they are particularly averse to cognitively demanding tasks. The idea that cognitive effort is costly and that

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<sup>9</sup> At the end of each task, participants were asked evaluate the task on a 5-point Likert scale (“hate it” to “love it”). This feedback was collected to gain insight into the user experience.

people generally seek the least effortful means to accomplish their goals is explored in detail by Kool, McGuire, Rosen, and Botvinick (2010), and it serves as part of the theoretical backdrop for Study 3.

### **Chapter 3: Distinguishing Between Threat and Cognitive Demand as Sources of Ambiguity Aversion**

At the broadest level of description, IA, IU, and NFC all represent a dispositional aversion to ambiguity, yet there is no consensus among their supportive theories as to what makes ambiguity aversive. Theories of IU (Freeston et al., 1994) and IA (Budner, 1962; McClain, 2015) have both assumed that the “intolerance” entails a heightened sensitivity to threat, expressed in the tendency to perceive stimuli of ambiguous significance (i.e., positive, negative, or neutral) as threatening, as well as the tendency to worry about uncertain negative outcomes. Indeed, several studies have demonstrated that IU is associated with greater self-reported worry in response to ambiguous situations, and that the level of worry reported is, in turn, explained by perceptions of threat (Bredemier & Berenbaum, 2008; Byrne, Hunt, & Chang, 2015; Dugas et al., 2005; Koerner & Dugas, 2008).

NFC theory, on the other hand, has made no assumptions as to what underlies the aversion in question, as it has focused instead on the consequences of NFC on social-cognitive phenomena. Further, NFC was initially formulated as a basic epistemic motive (i.e., desire to settle on any answer to a question) and this conceptualization precluded references to more biologically significant motives that might explain why people are averse to ambiguity. Nevertheless, insight into the motivational nature of this construct can be gleaned from studies that have investigated the effects of situational and dispositional NFC on information processing and decision-making. A bulk of these studies have shown, for example, that NFC is related to less extensive search for

information, greater use of heuristics, a desire to make quick decisions, consideration of fewer hypotheses, and a reliance on early cues to make judgments (for an overview, see Roets, Kruglanski, Kossowska, Pierro, & Hong, 2015). Altogether, this evidence has been taken to suggest that NFC involves a reluctance to invest cognitive effort in decision-making—a notion that is currently disputed by some researchers (Roets et al., 2015; Sunkaran, Szumowska, & Kossowska, 2017).

Although intuitive in nature, the idea that cognitive effort is aversive and costly has only recently been formally tested. In a series of experiments, using the demand selection task (DST; Rosen, McGuire, & Botvinick, 2007), Kool et al. (2010) demonstrated that when asked to choose between two conditions of the same cognitive task, one more demanding than the other, people learn over time to select the less demanding condition in the absence of any explicit awareness regarding such differences. In short, the authors confirmed that “all else being equal, actions tend to be selected to minimize cognitive demand” (Kool et al., 2010, p. 668), a finding that has since been replicated and extended to show that individual differences in demand avoidance are related to a variety of traits, including self-control, attentional control, delay discounting, intelligence, and Need for Cognition (Gold et al., 2015; Juvina et al., 2018; Kool, McGuire, Wang, & Botvinick, 2013).

Extending this research to the discussion of ambiguity aversion leads first to the straightforward prediction that people generally seek to resolve ambiguity by the least effortful means available, and correspondingly, those who are more averse to ambiguity are more likely do so. This prediction is, indeed, supported by the large body of work

associating NFC with the use of effort minimizing strategies to attain closure (as noted earlier), and it is also consistent with human reliance on heuristics or mental shortcuts (e.g., rules of thumb, stereotypes, educated guesses) to make judgments and decisions under uncertainty (Tversky & Kahneman, 1974).

Secondly, it can be predicted that, all else being equal, actions are chosen that entail less *exposure* to ambiguity insofar as it places greater demands on information processing. To my knowledge, this idea has not been explicitly tested, but one can find real-life, mundane examples where it applies. People, for instance, prefer sources of information (e.g., textbooks, teachers, etc.) that present information in a manner that is clear, easy-to-understand, and free of inconsistencies, and they generally prefer to visit or work in countries where their language is spoken, since learning or translating another language poses a significant time and effort investment. While it is true that people also actively seek to be challenged, for example, by learning a new language or by working on ambiguous problems, the expected reward of such activities must always be weighed against the expected cost of information processing (more formally, the cost of implementing cognitive control; see Shenhav, Botvinick, & Cohen, 2013). Accordingly, if the anticipated rewards of two problem-solving activities are equal, one would still be expected to choose the less effortful activity, based on the findings of Kool et al. (2010).

In short, the literatures on IU, IA, and NFC independently suggest at least two distinct sources of aversion to ambiguity—threat and cognitive demand. From an economic perspective, one can also think of these sources as having to do with two kinds of costs: threat entails the potential loss of reward or failure to attain a goal more

generally, along with the emotional costs of pain, sadness, or regret, whereas, cognitive demand is costly in that the human capacity for effortful cognition is limited (e.g., by limited energetic resources; Christie & Schrater, 2015), and engaging in demanding tasks precludes the pursuit of other, potentially more rewarding goals (Kurzban, 2016).

### **The Present Study**

In this study, I examine whether the threatening and demanding aspects of ambiguity are relevant to discriminating between the four uncertainty factors uncovered in this work, as well as the NFC, IU, and IA constructs. Study 1 established that Uncertainty Distress was the strongest indicator of threat sensitivity, based on its relationship to Neuroticism, anxious coping, and avoidant decision-making. In turn, the results of Study 2 showed that Categorical Thinking was the best predictor of cursory information gathering and task disengagement, and one plausible motive for such behaviors is a reluctance to invest effort in cognitive tasks. These two uncertainty factors are therefore the main candidates I sought to connect to the two aspects of ambiguity.

Aversion to ambiguity was measured using two novel tasks wherein participants had the opportunity to avoid stimuli that were very difficult to discriminate (i.e., ambiguous). In the first task, the ambiguous stimuli, relative to the rest of the stimuli, were more likely to result in errors punished by an unpleasant noise, but they were no more complex in features, whereas, in the second task, ambiguous stimuli were more complex, hence more difficult to process than the rest, but no punishment was administered. Essentially, one task was designed to elicit avoidance due to the threat

posed by the ambiguous stimuli (hence “threat avoidance”), and the other due to their higher cognitive demands (hence “effort avoidance”).

Although the intention was to manipulate threat and cognitive demand using different tasks, in reality, the effects of each incentive could not be “contained” to one task or the other. Regardless of the presence of external punishment, participants were expected to feel threatened by the possibility of committing errors, and the discrimination difficulty of the ambiguous stimuli guaranteed that, regardless of their complexity, they would more demanding to process. What the current tasks set to accomplish then is to *maximize* the motivational salience of either the demanding or threatening aspects of ambiguity.

Within each task, two separate procedures were employed to measure behavioral avoidance. During one procedure, participants were allowed to withhold response to stimuli by pressing a key, which enabled them to strategically avoid the more ambiguous stimuli. Then, in another procedure based on the DST (Kool et al., 2010), participants were instructed to repeatedly select between two patterns, which led to high- and low-ambiguity task conditions (i.e., one condition presented a higher proportion of ambiguous stimuli). To the extent that they became aware of the difference between patterns, they could choose to avoid the more difficult condition.

A significant flaw in the DST that I sought to address in this study is the confounding of effort avoidance with effort detection—the ability to detect differences in the effort requirements of different strategies. A recent study by Gold and colleagues (2015) reported that some individuals fail to notice differences in difficulty between task

conditions in the DST even after being explicitly informed of such differences, and more importantly, it found that effort avoidance was positively predicted by effort detection and IQ. (Notably, these predictors were significant individually but not simultaneously, which implies shared effects.) These findings suggest, problematically, that the effort avoidance demonstrated by the DST is not merely a product of an underlying aversion to effort, but also a product of cognitive ability.

To control for the confounding influence of IQ and effort detection in this study, I measured intelligence and had participants complete the DST procedures under both implicit and explicit instructions. Implicit instructions (which are the standard in the DST) provided only vague hints that there was some difference between the two patterns participants were to choose from, and they were used to measure ambiguity avoidance, whereas explicit instructions revealed that one pattern made the task easier and that participants should find and select it, and they were used to measure detection ability. IQ and detection ability were, thus, used as control variables in the analyses.

I hypothesized that, among the four uncertainty factors, Categorical Thinking would be the only unique predictor of effort avoidance, and Uncertainty Distress would be the sole predictor of threat avoidance. Based on the evident lack of discrimination among measures of NFC, IA, and IU, I did not expect that these traits would be differentially related to the two measures of avoidance. Additionally, I looked at other traits that were likely to be related to threat avoidance (Neuroticism) and effort avoidance (Intellect, Need for Cognition, self-control, and a new self-report measure of aversion to cognitive effort).

## Methods

### Participants

Participants were 249 undergraduates, ages 17 to 47 ( $M_{\text{age}} = 20$ ,  $SD = 2.3$ ), 64% female, who participated for course credit. Of these, three participants were removed from the dataset due to evidence of random responding (see Data Cleaning and Transformations), leaving 246 in the sample. Participants first completed an online a personality survey, followed by a brief intelligence test, which altogether took approximately 75 minutes to do. Then, they arrived for a scheduled laboratory session to perform the behavioral tasks, which lasted approximately 1.5 hours.

### Questionnaires

As in the previous studies, items from different questionnaires were pseudo-randomly mixed and administered using a 5-point Likert scale (“strongly disagree” to “strongly agree”), and bogus items were interspersed within the survey to catch those who did not pay sufficient attention. The Big Five Aspect Scale (BFAS; DeYoung et al., 2007) was used to measure the Big Five traits. Uncertainty-related questionnaires included the revised Need for Closure Scale (NFCS; Roets & Van Hiel, 2007), 12-item Intolerance of Uncertainty Scale (IUS; Carleton, et al., 2007), and the Cognitive Uncertainty subscale (URS; Greco & Roger, 2001). IA was measured using a selection of 15 items from the Measurement of Ambiguity Tolerance (Norton, 1975) and the Naemi et al. (2009) measure of IA and simplistic thinking,<sup>10</sup> and 9 items from the Discomfort with Ambiguity subscale of the NFCS (see Appendix A-3). Compared to the Multidimensional

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<sup>10</sup> Some of the items also appear in the Multidimensional Attitude Toward Ambiguity Scale (MAAS).

Attitude Toward Ambiguity Scale (Lauriola et al., 2015), which covers three facets of IA, the present measure of IA had less coverage of the Complexity/Novelty facet. The alpha reliability of the 24 items was .85.

Since more than a few items from Study 1 instruments were not available to measure the four uncertainty factors, analogous items were used in order to improve measurement. I followed the procedures described in Study 2, whereby the factors were initially scored using all of the available items selected in Study 1, and additional items from this study were selected based on their correlations with the scores for each factor. Of special note, measurement of Preference for Novelty/Complexity was supplemented by items from the Curiosity and Exploration Inventory-II (Kashdan et al., 2009), the Epistemic Curiosity Inventory (Litman & Spielberger, 2003), and the Adventurousness and Excitement-Seeking subscales of the International Personality Item Pool (Goldberg et al., 2006). The items for the four factors are included in Appendix A-3.

**Traits hypothesized to predict effort avoidance.** Aversion to cognitive effort (labeled Effort Aversion) was measured with 8 item statements that were written by me for this study based on personal experience and the literature on cognitive effort and stress. These items showed a high internal consistency ( $\alpha = .86$ ) and described a variety of avoidant responses to situations requiring mental effort: losing interest, feeling stressed, feeling tired, having difficulty sustaining effort, and avoiding such situations (e.g., “I try to avoid activities that demand a lot of mental effort.”) (for more items, see Appendix A-3). Need for Cognition was measured with the Short Form of the Need for

Cognition Scale (Cacioppo, Petty, and Kao, 1984), and self-control was measured with 8 items from the Self-Control Scale ( $\alpha = .75$ ) (SCS; Tangney, Baumeister, & Boon, 2004).

## Tasks

**Intelligence.** The 16-item sample test from the International Cognitive Ability Resource (Condon & Revelle, 2014) was used to measure intelligence.

**Brightness task.** In this task (adapted from Lommen, Engelhard, & van den Hout, 2010), one had to learn to categorize grey circles of varying brightness as either “light” or “dark” with the help of error feedback. The red, green, and blue (RGB) values of the circles ranged from 100-100-100 to 230-230-230 (in short, 100 to 230) with intervals of 10, thus producing 14 shades or levels of brightness. To simplify the task of discriminating between shades, I divided them into dark (values 100 to 160) and light (values 180 to 240) categories based on the results of an informal pilot, wherein participants indicated how they would intuitively label each shade. Unlike other shades, those with a value of 170 were designated as light on 50% of trials and dark on the other 50%, hence their correct category was completely ambiguous, and participants were not made aware of this. Table 3.1 displays items statistics for the 14 shades (by RGB value), which indicate, among other things, the difficulty and rate of avoidance for each item, based on the present sample. By those two metrics, shades 160 to 180 could be described as moderately to highly ambiguous, but note that the ambiguity extended to other items too.

During the practice phase of this task, participants were told to use their best judgment as to which category each shade belongs to, using the left arrow key for “dark” and right arrow key for “light”. On each trial, a fixation cross appeared foveally for 600ms, followed by the presentation of the target stimulus (circle), and the trial ended

upon a response, followed by a post-trial interval of 200ms. Below the target, a black, left-facing arrow and a white, right-facing arrow were always displayed as a reminder of the stimulus-response mapping. Whenever participants made an error, the word ‘dark’ or ‘light’ was shown, and they had to respond again correctly. After the practice phase, this textual feedback was discontinued and incorrect responses were punished with a loud noise on one third of all error trials. The noise stimulus consisted of a combined 1000 Hz tone and white noise, and it was delivered via noise-isolating headphones at 85 decibels, over a duration of 600ms. These stimulus properties were selected based on previous research (Levita et al., 2009) and an informal pilot test to ensure that the stimulus was not too loud and unpleasant in duration.

Table 3.1

*Item Statistics for the Brightness Task*

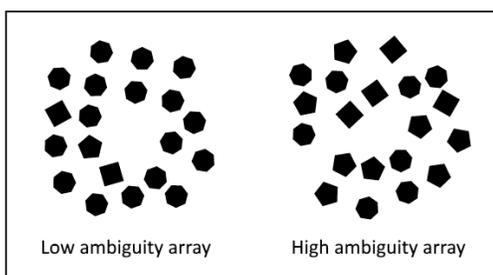
Item	Diff	Latency	Pass rate
100	.99	654	.01
110	.99	649	.02
120	.99	622	.02
130	.98	673	.04
140	.96	765	.07
150	.91	874	.14
160	.71	1070	.23
170	.52	1043	.27
180	.83	1017	.22
190	.95	809	.14
200	.98	738	.07
210	.98	680	.04
220	.99	672	.01
230	.99	708	.02

*Note.* Grey-filled rows highlight the most ambiguous items. Item column represents the RGB values of each shade (higher values indicate lighter shades); Diff = item difficulty; Latency = mean latency (ms); pass rate = proportion of trials avoided (see task procedures).

**Majority task.** Inspired by the majority function task (Fan, Guise, Liu, & Wang, 2008), this task involved determining which of three shapes—squares, pentagons, and heptagons—has a majority in an array of 20 figures. In any given array, the figures were pseudo-randomly dispersed and rotated, and the most frequent shape had a numerical advantage of anywhere from 1 to 15 over the second most-frequent shape. The larger the advantage, the easier it was to tell which shape had a majority; thus, easier items had a more uneven ratio of shapes (e.g., 17:2:1) and harder ones had a more even ratio (e.g., 10:9:1; see Figure 3.1 for examples). Additionally, some items were completely

ambiguous in that they had an even number of two of the three shapes. Item statistics for the arrays, grouped by the numerical advantage of the shape with a majority, are displayed in Table 3.2.

To ensure that all participants followed the same strategy, they were instructed to focus on the whole array by maintaining their gaze on the fixation cross at its center, and conversely they were asked not to count the individual figures. (These instructions also served to prevent them from becoming aware of the inherent ambiguity of some items.) The fixation cross remained at the center of the screen throughout the task, and an array appeared 600ms into each trial until a response was recorded, followed by a 200ms post-trial interval. Participants used the left, down, and right arrow keys to respond to a majority of squares, pentagons, or heptagons, respectively, and the stimulus-response mappings were cued at the bottom of each array. The cue consisted of an outline of each shape, adjacent to one another, with the corresponding arrow enclosed within each shape. During the practice phase only, a red 'X' appeared for 600ms whenever an error was committed.



*Figure 3.1.* Examples of low and high ambiguity arrays from the majority task.

Table 3.2

*Item Statistics for the Majority Task*

Item	Diff	Latency	Pass rate
0	.48	1895	.17
1	.60	1813	.15
2	.63	1795	.16
3	.73	1579	.09
4	.80	1606	.09
5	.80	1503	.06
6	.89	1334	.05
7	.81	1404	.05
8	.86	1348	.06
9	.88	1318	.03
10	.92	1131	.02
11	.92	1134	.01
12	.90	1170	.03
13	.94	1042	.02
14	.91	1175	.02

*Note.* Grey-filled rows highlight the most ambiguous items. Item column represents the numerical advantage of the shape with a majority (higher values indicate easier items); Diff = item difficulty; Latency = mean latency (ms); pass rate = proportion of trials avoided (see task procedures).

**Task procedures.** The order of the two tasks was counterbalanced and participants were randomly assigned to one of two orders. As described below, each task had multiple phases. Participants completed phases 1-4 of the first task, then the second task. Then, after receiving a new set of instructions, they completed the fifth phase per task. At the end of the study, they were asked to rate which task was more mentally demanding, required more effort, was more frustrating, provoked greater anxiety/worry, and was more difficult overall. This data provided partial evidence for the effectiveness of the different task designs.

**1-2. Practice and test phases.** After practicing the task for a set number of trials (40 in the majority task and 72 in the brightness task), participants did a test block of 120 trials, which assessed their response accuracy. The test block ended with five questions asking them to rate the extent to which the task was mentally demanding (1) and stressful (2), the extent to which they worked hard to attain their level of performance (3), and lastly the extent to which they experienced frustration (4) and anxiety/worry about responding incorrectly (4). Ratings were provided using 5 Likert options, from “very low degree” to “very high degree”.

**3. Pass phase.** Next, participants completed another test block of 120 trials, only this time they were given the option to “pass” or withhold response on any given trial by pressing the spacebar, thus enabling them to avoid the more ambiguous stimuli. They were told that it is up to them to decide when and how often to pass, and that they could do so as many times as they wanted as long as they did so strategically rather than indiscriminately.

**4. Selection phase with implicit instructions.** In this phase, participants were asked to select repeatedly between two squared patterns, described simply as “two options” (see Figure 3.2). Each selection initiated a 6-trial run of the task without the option to pass. The main difference between the two squared patterns is that one resulted in a task condition that had a much higher proportion of ambiguous stimuli, hence was more difficult (item proportions for each condition are displayed in Table 3.3). Participants were implicitly informed that there was a difference between the two options, but they were not told what it was, as it was important that they base their

selections on their personal experience with each one. Specifically, they were told the following:

“Since you won't know initially how these two options differ, you should try them both. After selecting each of them a couple of times, you may notice that you prefer doing the task when one of them is selected. Feel free to select whichever option you prefer.

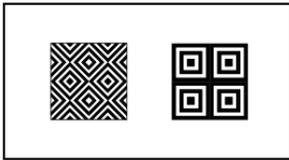
Try not to pay attention to details such as the appearance of the patterns or their location; the patterns don't serve any purpose other than to visually represent the two options you are given. This also means that you should not base your selections on which pattern you regard as more attractive.”

This portion of the task consisted of 5 blocks, each with a unique pair of patterns, and in each of these blocks participants made 10 selections over a total of 60 trials. To ensure that they were exposed to each condition, they were initially instructed to choose one pattern, then the other, and the next 8 selections were made freely. They pressed ‘1’ for the pattern appearing on the left, and ‘2’ for the pattern on the right, and the location of the patterns corresponding to each condition was pseudo-randomized, such that there was no correlation between location or response key and condition.

After having completed *both* tasks, participants were asked the following questions regarding the selection blocks for each task: “Before you began this task, what expectations (if any) did you have about how the two options would differ?”; “Did you expect that one option would make the task more difficult than the other?”; “How did you choose between the two options?”; “By the end of each run, did you find yourself

preferring one option over the other? If so, what was this preference based on?". If they answered "yes" to the last question, they were also asked to rate the degree to which the following reasons led them to prefer one task condition: "the task seemed to be *less mentally demanding*; the task seemed to require *less effort*"; "the task seemed to be *less frustrating*"; "I felt *less worried* about committing errors"; and "I thought I could finish the task in *less time*". Finally, participants were informed about the difference in difficulty between conditions and they were asked if they noticed this difference.

**5. Selection phase with explicit instructions.** In this phase, participants completed another set of 5 selection blocks under the explicit instruction that they were to determine which pattern made the task easier, and then they were to continue selecting the pattern.



*Figure 3.2.* Example of one pair of patterns presented during the selection phase.

Table 3.3

*Item Proportions for Low and High Ambiguity Task Conditions*

	CA	MA	UA
<b>Majority task</b>			
Low ambiguity condition	.03	.03	.94
High ambiguity condition	.20	.74	.06
<b>Brightness task</b>			
Low ambiguity condition	.00	.08	.92
High ambiguity condition	.18	.23	.59

*Note.* CA = completely ambiguous stimuli; MA = moderately ambiguous stimuli; UA = relatively unambiguous stimuli. For majority task: item 0 was CA; items 2-6 were MA, and items 7-14 were UA. For brightness task: item 170 was CA, items 160 and 180 were MA, and items 100-150 and 190-230 were UA. See Tables 3.1 and 3.2 for items.

**Measures of ambiguity avoidance and detection accuracy, and task ratings.**

Ambiguity avoidance was indicated by two variables: the proportion of trials on which participants used the pass option (“pass rate”), and the mean proportion of selections for the low-ambiguity condition in the implicit instruction phase (“implicit choice rate”). In turn, the ability to detect a difference in difficulty between conditions (i.e., detection accuracy) was indicated by the corresponding low-ambiguity choice rate in the explicit instruction phase (“explicit choice rate”).

As noted earlier, participants also provided ratings on three occasions throughout each task: individual ratings of each task at the end of the test phase, ratings of the motives for preferring one task condition over the other during the first selection phase, and comparative ratings of the two tasks at the end of the study. The identifiers

“individual”, “motive”, and “comparative” will be used to distinguish these ratings throughout this chapter.

**Summary of the task procedures and measures.** Due to the complexity of the design and procedures, the reader may benefit from the following summary:

A. Task 1:

1. *Practice phase*
2. *Test phase*: measured task accuracy, followed by individual task ratings
3. *Pass phase*: measured the rate of withholding response to stimuli (pass rate)
4. *Selection phase with implicit instructions*: measured preference for the low-ambiguity condition (implicit choice rate).

B. Task 2: same procedures as Task 1

C. Debrief: participants provided motive ratings for each task

D. Task 1: *Selection phase with explicit instructions*: measured the ability to detect differences in the task conditions (explicit choice rate)

C. Task 2: same procedure as Task 1

D. End of study: participants provided comparative ratings of the two tasks

**Data Cleaning, Scoring, and Transformations**

Instead of scoring the choice rate data as the average proportion of low-ambiguity selections, I determined that reliability can be improved by replacing any proportions falling below .50 with .50, as this is the proportion corresponding to lack of preference for the low-ambiguity condition. Therefore, this alternative scoring method was used (for more details about the rationale, see Appendix B).

In regards to the “pass” phase of each task, a large percentage of participants did not use of the pass option (30-38%), and consequently the pass rate variables had zero-inflated distributions, with values of 0 representing non-use. These zeros were problematic from a measurement standpoint because it was unclear whether any given zero entailed indifference to ambiguity, or something quite different, such as, a failure to heed instructions, or a decision to not use the pass option out of convenience. As a result, I decided to split each variable into binary and continuous variables; the binary variable (“pass use”) reflected whether or not the pass option was used (coded as 0/1), and the continuous one (retaining the label “pass rate”) represented how often it was used, excluding cases of non-use. While both variables were included in the analysis, the binary one was sidelined due its ambiguous nature, hence only the continuous variable was treated as a measure of avoidance.

For the purpose of removing unreliable data, I determined that the lowest rate of response accuracy that is reliably different from chance is .43 for the majority task (chance-level = .33) and .60 for the brightness task (chance-level = .50). Since there were several independent parts to each task, only partial data that failed to meet the accuracy cutoff was deleted (e.g., if a participant’s accuracy during the test block fell below the cutoff, the rest of his or her data was not affected). This resulted in the deletion of 3-5% of the majority task data and less than 1% of the brightness task data. Additionally, three participants failed to meet the accuracy cutoffs throughout the entire study, and one failed to pass the attention checks during the survey, and therefore they were excluded from the dataset.

## Analysis

All statistical analyses were conducted in R version 4.3.4 (R Core Team, 2017).

Due to evidence of non-normal distributions among the pass rate and choice rate variables, two non-parametric statistics were employed to analyze these variables: Spearman's Rho was used for correlations, and the Wilcoxon signed rank-test was used for hypothesis testing.

I first tested whether there was a sample-wide preference for the low-ambiguity condition in each task by running a Wilcoxon signed-rank test under the hypothesis that the choice rates are greater than a chance rate of .50. Next, I examined whether ratings related to cognitive effort (mental demand, work requirement, and task difficulty) and threat (stress and anxiety/worry about committing errors) were significantly different across the two tasks, consistent with their designs. Paired-sample t-tests were conducted to compare individual and motive ratings, and a one-sample t-test was used for the comparative task ratings. Additionally, multiple regression was used to clarify which of the (rated) motives uniquely contributed to the selection of the low-ambiguity condition in each task.

Bivariate correlations were, subsequently, run to examine the convergent validity among the avoidance measures, and divergent validity between measures of avoidance and detection accuracy. Their correlations with intelligence and task accuracy were also observed. A multiple regression analysis was then performed to assess the effects of the four uncertainty factor on ambiguity avoidance and other task variables of interest. Then,

bivariate correlations between all personality traits (including NFC, IA, IU) and task variables of interest were examined.

Finally, I used correlational and regression analyses to explore associations between personality traits and task ratings. These analyses were not originally planned, but they provided additional context for the behavioral results.

## **Results**

### **Descriptive Statistics**

Descriptive statistics and reliability estimates are displayed in Table 3.4. Under implicit instructions, participants selected the low-ambiguity condition 71% (majority task) and 64% (brightness task) of the time, and Wilcoxon signed-rank tests confirmed that these rates were significantly different from chance ( $p < .001$ ). It appears from these results that the designed contrast between conditions was effective in getting individuals to avoid the high ambiguity condition.

One surprising result is that reliability of the explicit choice rates were much lower than those for the implicit choice rates, despite the fact that the only major difference between these measures were the task instructions. A possible but not too convincing explanation is that participants did not perform as consistently as they did under implicit instructions, because they had already spent close to an hour doing both tasks and were less motivated.

Table 3.4

*Descriptive Statistics and Reliability Estimates for Task Variables and Personality Traits*

	N	Mean	SD	Min	Max	Range	Skew	Kurt	$\alpha$
<b>Majority task</b>									
1. Implicit choice rate	236	.75	.17	.50	1.00	.50	.01	-1.47	.88
2. Explicit choice rate	230	.86	.12	.52	1.00	.48	-.93	.35	.64
3. Pass rate	148	.11	.08	.01	.42	.41	.84	.40	–
4. Pass use	237	.62	.49	.00	1.00	1.00	-.51	-1.75	–
5. Response accuracy	236	.82	.08	.46	.94	.48	-1.36	2.76	–
6. Reaction time	236	1347	322	763	2710	1947	.87	1.08	–
<b>Brightness task</b>									
1. Implicit choice rate	235	.69	.14	.50	1.00	.50	.18	-1.25	.78
2. Explicit choice rate	230	.81	.13	.50	1.00	.50	-.60	-.47	.66
3. Pass rate	167	.12	.11	.01	.45	.44	.98	.34	–
4. Pass use	235	.51	.50	.00	1.00	1.00	-.06	-2.00	–
5. Response accuracy	241	.92	.03	.77	.99	.22	-.87	1.14	–
6. Reaction time	241	763	130	457	1227	770	.76	.68	–
<b>Personality traits</b>									
1. Uncertainty Distress	246	3.14	.58	1.50	5.00	3.50	-.05	.28	.89
2. Pref. for Structure	246	3.55	.51	2.28	4.94	2.67	-.07	-.06	.88
3. Novelty/Complexity	246	3.43	.48	2.06	4.88	2.82	-.06	.45	.84
4. Categorical Thinking	246	2.47	.44	1.24	3.79	2.55	.39	-.11	.80
5. NFC	246	3.06	.34	2.05	4.15	2.10	.11	.21	.84
6. IU	246	2.97	.53	1.43	4.93	3.50	.35	.46	.67
7. IA	246	3.05	.43	1.92	4.79	2.88	.47	.96	.85
9. Need for Cognition	246	3.25	.51	1.73	4.73	3.00	-.23	.15	.82
10. Effort Aversion	246	2.67	.70	1.00	4.63	3.63	.33	-.53	.86
11. Industriousness	246	3.12	.57	1.60	4.70	3.10	.07	-.36	–
12. Neuroticism	246	2.82	.64	1.25	4.80	3.55	.20	-.22	–
13. Intellect	246	3.52	.61	1.60	5.00	3.40	-.36	.11	–

### **Comparison of Task Ratings**

For both individual and comparative task ratings, participants rated the brightness task as significantly more anxiety-provoking and stressful than the majority task, which, in turn, they rated as more mentally demanding (see Table 3.5 for individual ratings and Table 3.6 for comparative ratings). Consistent with these results, when asked to rate a number of motives for their preferences during the first selection phase, participants rated their anxiety/worry higher (i.e., more relevant) during the brightness task, whereas they rated effort-related concerns higher during the majority task (see Table 3.5, second half).

The differences in effort-related ratings, however, were surprisingly small in effect size, and the mean ratings for the majority task suggest that it was not as effortful as I had anticipated (e.g., mean ratings for “mentally demanding” and “worked hard” fell within the low-to-moderate values of the 5-point Likert scale [2-3]). Some lack of differentiation was also observed among the motivational predictors of ambiguity avoidance: the implicit choice rate in the majority task was predicted solely by perceived effort requirements, yet, for the brightness task, it was uniquely predicted by both anxiety- and effort-related concerns (see Table 3.7).

Table 3.5

*T-test Results of Individual Task Ratings and Motive Ratings*

	<i>t</i>	<i>df</i>	<i>p</i>	95% C.I.		<i>M<sub>d</sub></i>	<i>M<sub>Maj</sub></i>	<i>M<sub>Br</sub></i>	<i>d</i>	<i>r</i>
<b>Individual task ratings and hypotheses</b>										
1. Mentally demanding (M > B)	5.628	230	.000	.288	Inf	.407	2.725	2.290	.37	.18
2. Worked hard (M > B)	2.017	230	.022	.027	Inf	.147	2.780	2.614	.13	.07
3. Anxious/worried about errors (B > M)	-16.276	230	.000	-Inf	-1.241	-1.381	1.928	3.295	1.07	.47
4. Frustrating	-.731	230	.233	-Inf	.076	-.061	2.148	2.220	.05	.02
5. Stressful (B > M)	-11.314	230	.000	-Inf	-.780	-.913	1.983	2.880	.74	.35
<b>Motive ratings and hypotheses</b>										
6. Task was less mentally demanding (M > B)	1.923	120	.028	.136	Inf	.983	15.444	14.500	.17	.09
7. Task required less effort (M > B)	3.609	120	.000	1.090	Inf	2.017	14.960	12.820	.33	.16
8. I was less worried about errors (B > M)	-2.816	120	.003	-Inf	-.755	-1.835	13.629	14.967	.26	.13
9. Task was less frustrating	-1.325	120	.094	-Inf	.170	-.678	13.861	14.240	.12	.06
10. Task took less time to finish	1.531	120	.128	-.213	1.668	.727	11.629	10.787	.14	.07

*Note.* Motive ratings were provided in response to, “When I chose one pattern...”. *M<sub>d</sub>*= mean difference in ratings. *M<sub>Maj</sub>* = mean rating (majority task); *M<sub>Br</sub>* = mean rating (brightness task). The number of respondents for the 'reasons' ratings is lower because only those who confirmed having a preference were asked to provide ratings.

Table 3.6

*T-test Results of Comparative Task Ratings*

	<i>t</i>	<i>df</i>	<i>p</i>	95% C.I.		$M_d$	<i>d</i>	<i>r</i>
Which of the two tasks...								
1. ...was more mentally demanding (M > B)	3.41	233	.00	.75	Inf	1.46	.22	.11
2. ...required more effort (M > B)	1.70	233	.05	.02	Inf	.72	.11	.06
3. ...was more difficult (M > B)	1.63	233	.05	-.01	Inf	.71	.11	.05
4. ...made you feel greater anxiety/worry (B > M)	-19.63	233	.00	-Inf	-5.70	-6.22	1.28	.54
5. ...was more frustrating	-9.03	233	.00	-Inf	-2.93	-3.58	.59	.28

*Note.* Positive differences mean higher ratings for the majority task. M = majority task; B = brightness task.  $M_d$  = mean difference. *d* = Cohen's *d*.

Table 3.7

*Standardized Coefficients of Implicit Choice Rates Regressed on Motive Ratings*

	ICR-B	ICR-M
1. Task was less demanding/required less effort*	<b>.31</b>	<b>.23</b>
2. I was less worried about committing errors	<b>.25</b>	-.04
3. Task was less frustrating	<b>-.23</b>	-.03
4. Task took less time to finish	<b>-.20</b>	-.02

Note. Coefficients in bold are significant at  $p < .05$ . ICR-B = Implicit choice rate for brightness task. ICR-M = Implicit choice rate for majority task.

\*Ratings of mental demand and effort requirements were averaged.

### Correlations Among Task Variables and Intelligence

As displayed in Table 3.8, measures of avoidance (implicit choice rate and pass rates) were moderately inter-correlated, and the between-task correlation among measures of avoidance (implicit choice rates) was stronger than the within-task correlations between measures of avoidance and detection (i.e., implicit and explicit choice rates), providing evidence of both convergent and discriminant validity. Note however that the relative unreliability of the explicit choice rates may also explain their relatively weaker correlations with the rest of the variables.

Explicit choice rates were distinguished from their implicit counterparts by their positive correlations with intelligence and response accuracy (n.s. for brightness task). The correlation with intelligence is consistent with past findings that intelligent individuals are better at detecting differences in effort requirements (Gold et al., 2015), and the correlation with response accuracy suggests rather intuitively that those who paid more attention to each task were more likely to detect differences between the conditions.

Table 3.8

*Correlations Among Task Variables and IQ*

	1	2	3	4	5	6	7	8	9	10
<b>Majority task</b>										
1. Implicit choice rate	–									
2. Explicit choice rate	.33	–								
3. Pass rate	.27	-.08	–							
4. Pass use	.21	.09	NA	–						
5. Response accuracy	.11	.19	-.08	.05	–					
<b>Brightness task</b>										
6. Implicit choice rate	.57	.26	.15	.19	.10	–				
7. Explicit choice rate	.32	.21	.03	.10	.12	.36	–			
8. Pass rate	.24	.09	.31	.15	-.02	.47	.25	–		
9. Pass use	.22	.04	.27	.53	-.02	.23	-.04	NA	–	
10. Response accuracy	.03	.07	.04	-.06	.17	.06	.12	.03	-.05	–
Intelligence	.04	.17	.01	-.06	.23	.04	.16	-.08	-.06	-.04

*Note.* Correlations with absolute value  $> .15$  are significant at  $p < .05$ .

**Associations Between Task Variables and Personality Traits**

Linear regression results revealed that Uncertainty Distress was a unique predictor of avoidance in the brightness task, as hypothesized (see Table 3.9). Categorical Thinking, on the other hand, was not predictive of avoidance in any task. No other significant predictors were found, and controlling for response accuracy, detection accuracy, and intelligence did not alter the effects of the uncertainty factors on measures of avoidance.

At the zero-order level (see Table 3.10), Uncertainty Distress and Neuroticism were positively correlated with avoidance across both tasks (some correlations were n.s.), which overall highlights the relevance of negative affectivity traits. NFC, IU, and IA also

tended to be positively correlated with avoidance, but most of their correlations did not reach significance at the .05 level, with the exception of IA.

In general, traits that were hypothesized to be related to effort avoidance, which included Categorical Thinking, Intellect, Need for Cognition, Effort Aversion, and self-control, were not found to be significantly correlated with any measures from the majority task. Some of these traits (Need for Cognition, Intellect, and self-control) were negatively correlated with pass rates in the brightness task only, but the specificity of these results suggests that they may be unreliable.

Table 3.9

*Standardized Coefficients of Uncertainty Factors as Predictors of Task Variables*

	UD	PS	PNC	CT
<u>Majority task</u>				
1. Implicit choice rate	.11	-.01	-.11	-.07
2. Explicit choice rate	.01	.03	-.05	-.12
3. Pass rate	.13	-.03	-.10	.09
4. Pass use	-.07	.04	.05	.03
<u>Brightness task</u>				
1. Implicit choice rate	<b>.18</b>	-.04	-.08	-.06
2. Explicit choice rate	-.02	-.01	-.11	-.06
3. Pass rate	<b>.21</b>	-.07	-.03	.00
4. Pass use	.02	.06	.01	.03

*Note.* Bolded coefficients are significant at  $p < .05$ . UD = Uncertainty Distress; PS = Preference for Structure; PNC = Preference for Novelty/Complexity; CT = Categorical Thinking.

Table 3.10

*Correlations Between Task Variables and Personality Traits*

	UD	PS	PNC	CT	NFC	IU	IA	EA	NCog	SC	Intel	Neur
<b>Majority task</b>												
1. Implicit choice rate	.18	.09	-.13	-.03	.11	.12	.16	.09	-.10	.00	-.01	.12
2. Explicit choice rate	.05	.00	-.03	-.10	-.03	-.01	-.01	.04	-.02	.05	.01	.10
3. Pass rate	.17	.07	-.18	.09	.16	.13	.18	.06	-.05	-.02	-.08	.15
4. Pass use	-.07	-.01	.03	-.01	-.05	-.03	-.08	-.06	.14	.04	.12	-.03
<b>Brightness task</b>												
1. Implicit choice rate	.17	.06	-.10	-.03	.07	.07	.07	.00	-.04	.07	-.06	.13
2. Explicit choice rate	-.02	.00	-.06	-.01	-.01	-.06	.05	-.03	.02	-.03	.09	-.02
3. Pass rate	.21	.02	-.12	.03	.14	.12	.14	.10	-.15	-.15	-.14	.21
4. Pass use	.04	.08	-.05	.03	.03	.04	-.01	.05	.07	-.03	.07	.10

*Note.* Correlations with absolute value  $> .15$  are significant at  $p < .05$ . UD = Uncertainty Distress; PS = Preference for Structure; PNC = Preference for Novelty/Complexity; CT = Categorical Thinking; NFC = Need for Closure; IA = Intolerance of Ambiguity; EA = effort aversion; NCog = Need for Cognition; SC = self-control; Intel = Intellect; Neur = Neuroticism.

## **Associations Between Task Ratings and Personality Traits**

In this part of the analysis, some task rating variables were aggregated, as they were highly correlated with one another. These included the individual task ratings of stress and anxiety/worry, on the one hand, and ratings of mental demand and effort investment on the other. Effort-related motive ratings were also aggregated.

In a linear regression, Uncertainty Distress was the only consistent predictor of task ratings related to negative affect (i.e., stress, worry and frustration), as one would expect, and this extended to both tasks and both individual and motive ratings (see Table 3.11). Interestingly, Preference for Novelty/Complexity predicted higher ratings of reduced frustration and reduced cognitive demand as a reason for avoiding ambiguity in one or both tasks. One might interpret the latter results to suggest that individuals who are drawn to novelty and complexity were more likely to detect that one condition was less frustrating and demanding, yet, there was no evidence that they were better at detection or that they preferred the easier condition.

To explore the unique relationships between task ratings and personality (since the ratings were all inter-correlated), I conducted a linear regression of each personality traits on the individual and motive ratings, separately. The results of this analysis revealed that, for the brightness task, individual task ratings of stress and worry were positively associated with Uncertainty Distress, NFC, IA, and Neuroticism, and ratings of frustration were positively associated with Categorical Thinking and Effort Aversion (see Table 3.12). By contrast, for the majority task, only the individual task ratings of frustration were associated with personality (Uncertainty Distress, NFC, and IA).

Importantly, these results show that worry-related ratings were only predictive of personality in the brightness task, as is expected.

Table 3.11

*Standardized Coefficients of Uncertainty Factors as Predictors of Task Ratings*

	UD	PS	PNC	CT
<b>Majority task</b>				
<i>Individual task ratings</i>				
1. Mentally demanding/worked hard	-.05	<b>.20</b>	.13	.05
2. Stressful/worried about committing errors	.17	.00	.14	.05
3. Frustrating	<b>.24</b>	-.10	.07	.10
<i>Motive ratings</i>				
4. Task was less demanding/required less effort	.11	.05	.12	-.03
5. I was less worried about committing errors	<b>.19</b>	-.05	.10	<b>.19</b>
6. Task was less frustrating	.17	.00	<b>.19</b>	.11
7. Task took less time to finish	.04	.13	<b>.21</b>	.07
<b>Brightness task</b>				
<i>Individual task ratings</i>				
1. Mentally demanding/worked hard	<b>.21</b>	.00	-.03	.12
2. Stressful/worried about committing errors	<b>.31</b>	-.06	-.14	.04
3. Frustrating	<b>.27</b>	-.13	-.09	<b>.20</b>
<i>Motive ratings</i>				
4. Task was less demanding/required less effort	.16	.15	<b>.27</b>	.11
5. I was less worried about committing errors	<b>.24</b>	.01	.17	-.07
6. Task was less frustrating	.17	.11	<b>.30</b>	.07
7. Task took less time to finish	.09	.16	<b>.28</b>	.16

*Note.* Bolded coefficients are significant at  $p < .05$ . UD = Uncertainty Distress; PS = Preference for Structure; PNC = Preference for Novelty/Complexity; CT = Categorical Thinking.

Table 3.12

*Standardized Coefficients of Personality Traits Regressed on Task Ratings (Majority Task)*

	UD	PS	PNC	CT	NFC	IU	IA	NCog	EA	SC	Neur	Intel
<hr/> Individual task ratings <hr/>												
1. Mentally demanding/worked hard	-.11	.15	.04	.04	.07	-.04	-.01	.09	-.04	.03	-.12	.09
2. Stressful/worried about errors	.03	-.01	.08	-.03	-.14	.06	-.14	.14	-.08	.09	.09	.00
3. Frustrating	<b>.22</b>	-.05	-.09	.09	<b>.19</b>	.12	<b>.26</b>	-.18	.12	-.11	.06	-.14
<hr/> Motive ratings <hr/>												
4. Task was less demanding/less effort required	.02	-.01	-.01	-.12	-.03	-.08	.03	-.09	-.01	.19	-.06	-.02
5. I was less worried about committing errors	.14	.04	-.05	<b>.19</b>	.11	.17	<b>.22</b>	-.04	.00	-.13	.09	.01
6. Task was less frustrating	.05	-.02	.08	.05	.02	-.03	.06	.12	.01	.12	.01	.00
7. Task took less time to finish	-.04	.06	.10	.07	-.01	.04	-.05	.04	-.05	-.17	-.08	.02

*Note.* Bolded coefficients are significant at  $p < .05$ . UD = Uncertainty Distress; PS = Preference for Structure; PNC = Preference for Novelty/Complexity; CT = Categorical Thinking; NFC = Need for Closure; IA = Intolerance of Ambiguity; EA = effort aversion; NCog = Need for Cognition; SC = self-control; Intel = Intellect; Neur = Neuroticism.

Table 3.13

*Standardized Coefficients of Personality Traits Regressed on Task Ratings (Brightness Task)*

	UD	PS	PNC	CT	NFC	IU	IA	NCog	EA	SC	Neur	Intel
<b>Individual task ratings</b>												
1. Mentally demanding/worked hard	.01	.08	.03	.08	.09	.08	-.02	-.07	.08	.01	-.02	-.14
2. Stressful/worried about errors	<b>.27</b>	.12	<b>-.23</b>	-.02	<b>.21</b>	.14	.15	-.09	.06	-.06	<b>.30</b>	-.07
3. Frustrating	.15	.00	-.11	<b>.21</b>	.06	<b>.20</b>	.15	-.13	<b>.26</b>	-.16	.05	<b>-.18</b>
<b>Motive ratings</b>												
4. Task was less demanding/less effort required	.09	.06	-.03	.04	.07	<b>.18</b>	.06	-.05	.01	.09	-.12	.02
5. I was less worried about committing errors	.17	-.05	-.03	-.17	-.06	.07	-.07	.03	-.02	.04	.10	-.12
6. Task was less frustrating	-.06	.01	.16	.08	-.03	-.11	.07	.07	.00	.06	.00	.05
7. Task took less time to finish	-.01	.07	.09	.14	.09	.01	.04	.13	-.10	-.12	-.01	.09

*Note.* Bolded coefficients are significant at  $p < .05$ . UD = Uncertainty Distress; PS = Preference for Structure; PNC = Preference for Novelty/Complexity; CT = Categorical Thinking; NFC = Need for Closure; IA = Intolerance of Ambiguity; EA = effort aversion; NCog = Need for Cognition; SC = self-control; Intel = Intellect; Neur = Neuroticism.

## Discussion

This study represents an initial attempt to validate the distinction between effort avoidance and threat avoidance as motivational bases for aversion to ambiguity. The two tasks designed to measure these tendencies were generally effective in eliciting avoidance of ambiguous stimuli; most participants preferred the low-ambiguity condition in each task, and the pass option was predominantly used to avoid responding to the most ambiguous stimuli. More importantly, there was evidence that each task elicited different motives. In the majority task, the easier condition was preferred due to reduced cognitive demand, whereas, in the brightness task, preferences were partially explained by reduced cognitive demand but also partially explained by greater worry over making incorrect responses. Consistent with these findings, the majority task was perceived to be more demanding and less anxiety-provoking than the brightness task, although differences in perceived demand were small in magnitude.

These relatively small differences suggest that the brightness task was perhaps more demanding than I had intended by design, despite the simplicity of the stimuli and the underlying task. Alternatively, it is possible that the threat of being administered unpleasant noise led individuals to expend greater effort (e.g., greater vigilance and alertness to stimuli) in order to respond accurately and avoid being punished, which would imply a contingent relationship between the two incentives used in this study (i.e., when under threat, people invest more effort). Moreover, such a relationship could mean that it is not feasible to manipulate threat and cognitive demand separately, as I attempted to do in this study.

At the same time, there is also reason to believe that the majority task was not as demanding as I had planned. For one, the absence of any response feedback after the practice phase was meant to minimize any anxiety participants might have about responding incorrectly, but it is likely that this had the unintended consequence of decreasing overall investment of effort in the task. Secondly, it is questionable to what extent the more complex (ambiguous) arrays were subjectively more demanding given that the discrimination task itself was not very challenging and most response latencies were under 1.5s, meaning that participants spent little time processing each array.

### **Trait Predictors of Ambiguity Avoidance**

Hypotheses regarding the uncertainty factors and other related traits were only partially confirmed. As predicted, Uncertainty Distress was the only significant predictor of ambiguity avoidance after controlling for the other uncertainty traits and relevant covariates (IQ, task accuracy, and detection accuracy), and this predictive relationship held significance only for the brightness task. Moreover, after controlling for other brightness task ratings, only ratings of stress/worry were associated with Uncertainty Distress, confirming the threatening nature of this task. Most of these results also extended to Neuroticism, consistent with the fact that these two traits are highly correlated with one another. Zero-order correlations, however, suggested that Uncertainty Distress and Neuroticism were correlated with ambiguity avoidance across both tasks, and this suggests that the relationships were not driven by threat sensitivity per se but rather a general avoidance motivation underlying these traits.

Contrary to the proposal that Categorical Thinking entails a reluctance to invest effort into cognitive activities, no relationship was observed between this trait and measures of avoidance, nor was it related to ratings of cognitive demand in either task. This result is unsurprising as neither were trait measures of cognitive engagement and effort aversion (e.g., Need for Cognition) related to indicators of effort avoidance, despite their clear relevance in this context. In the absence of evidence of external concurrent validity for effort avoidance, the current results could mean that the majority task was not very effective in measuring this tendency, or they may reflect inherent flaws in the DST paradigm (see Limitations).

To look further into the proposed relationship between Categorical Thinking and effort investment, I performed a follow-up multiple regression of Effort Aversion (i.e., the self-report measure) on the four uncertainty factors. Although Categorical Thinking was indeed a significant positive predictor ( $\beta = .34$ ) of Effort Aversion, the strongest predictor turned out to be Uncertainty Distress ( $\beta = .43$ ). This finding appears to suggest that effort avoidance is not *uniquely* relevant to explaining individual differences in Categorical Thinking, and it also suggests that Uncertainty Distress may reflect sensitivity to both threat and cognitive demand.

### **Limitations**

As noted, there were indications that the majority task was not sufficiently demanding, and this may have weakened the measurement of effort avoidance, thereby also suppressing associations with personality traits. Another caveat to note is that the N for the pass rate variables excluded participants who did not use the pass option (30-38%

across the two tasks), and consequently the results for those variables are not representative of the larger sample.

One of the more serious issues encountered in this study is that a quarter to a third of participants did not show a preference for the low-ambiguity condition during the task phases with implicit instructions, which suggests that some of them had difficulty distinguishing the two conditions (and a few preferred the more difficult condition). This difficulty could mean that the contrast between conditions was not salient enough, but it could also mean that the implicit instructions were too “implicit” and did not go far enough in drawing participants’ attention to the existence of meaningful differences between conditions. The latter is evident in that only 10% to 14% of participants did not show a preference under explicit instructions. I should mention however that the rates of non-preference under implicit instructions were comparable to those observed in the original experiments of Kool et al. (2010); therefore, this issue does not appear to be specific to my implementations of the DST design.

Participants’ failure to distinguish between conditions highlights a deeper problem with the DST paradigm, which is that effort avoidance is to a certain extent confounded with effort detection. While I did attempt to control for detection ability using the explicit choice rates, this methodological approach is far from ideal as it involves two separate measurements under different instructions, and it is unlikely that the explicit choice rate is purely a measure of effort detection. A much more promising approach is demonstrated by Juvina et al. (2018), whose method involves estimating the trial number where detection occurred (within a given block) and counting only the

choices that were made after this detection point. Using this new approach, the authors found negative correlations between effort avoidance and trait measures of executive control (e.g., self-control, attentional control, Need for Cognition, and grit) that they did not find using the standard method of computing the mean proportion of low-demand selections. Unfortunately, their approach could not be applied to the present data due to the manner in which the DST trials were structured (participants made a new selection every 6 trials rather than every trial).

One final caveat: this study focused on only one of several expressions that ambiguity can take in a research setting, namely, the difficulty of discriminating between stimuli. To the extent, however, that different expressions of ambiguity elicit the same responses (e.g., threat avoidance), the current results should generalize to other research settings.

### **Concluding Thoughts**

While the results of this study provide some evidence that threat and cognitive demand operate as distinct incentives for avoiding ambiguity, the two tasks designed to measure avoidance were not very effective in separately manipulating these incentives. As a result, the purported measures of effort and threat avoidance showed greater convergence than divergence in their associations with personality traits. Of the four uncertainty factors, Uncertainty Distress appears to be the best predictor of avoidance of ambiguity, especially under conditions of threat. Given the noted flaws in task design, some of which may be inherent to the DST paradigm, the questions in this study should

be addressed in future research with an improved design (the details of which remain to be worked out).

## **Chapter 4: A Framework for Understanding Responses to Uncertainty**

In this chapter, I present a synthetic framework that seeks to account for the most common responses to uncertainty by drawing upon the literatures on emotion, motivation, and coping. Note that this framework is a work in progress and does not aim to cover an exhaustive list of responses. In particular, it omits discussion of how people respond to social threats and threats to one's beliefs, which will be important to incorporate in further revisions.

### **Defining Uncertainty**

Uncertainty is challenging to define given the diversity of its expressions, and it will be necessary to unpack its complexity in several steps. Hirsh, Mar, and Peterson (2012) propose that perception and action represent the two primary domains in which people feel uncertain, and they conceptualize uncertainty as a psychological state of conflict between competing perceptions or goals (or goal strategies). Perceptions may be construed broadly to include predictions, hypotheses, beliefs, etc.; thus, perceptual conflict may consist of two or more mutually exclusive hypotheses regarding an object (Is that a bird or some other flying object?) or an event (Will it be rainy or sunny tomorrow?). Goals, in turn, can be defined as desired or undesired future states one is motivated to approach or avoid, and goal conflict may stem from having to decide between several strategies to achieve the same goal (e.g., repaying a favor by either buying a gift or writing a thank you note) or between two or more incompatible goals (e.g., eating junk food and losing weight). Since experiences of goal conflict generally

occur within the context of decision-making, “decisional conflict” is another term that can be used to describe them.

In addition to conflict, there are other expressions of uncertainty that can be distinguished, including ignorance, confidence (doubt), and precision (imprecision). A state of ignorance can be thought of as the inability to conceive of any possible hypothesis or strategy in response to a question; confidence refers to the subjective probability that a perception is correct or that a goal strategy (action) will result in a desired outcome; and precision refers to the subjective margin of error around an estimate (e.g., “I paid somewhere between \$5 to \$10.”). The diversity of these expressions demonstrates why defining uncertainty in an all-inclusive manner is difficult if not impossible.

### **Other Terms Related to Uncertainty**

Several terms used throughout this chapter can be understood as the properties of stimuli (or events) that entail a state of uncertainty. Ambiguous stimuli are those that can be perceived in more than one way, thereby generating perceptual conflict.

Unpredictability refers to the nature of events whose occurrence or timing cannot be predicted with 100% accuracy, hence, a person can be uncertain as to whether or when an event will happen. Related to unpredictability is the concept of risk, defined as “the probability of a negative outcome” in everyday vernacular, or “the variance of a set of possible outcomes with known probabilities” in the decision sciences and economics

(Knight, 1921; Markowitz, 1952).<sup>11</sup> Table 4.1 presents a summary of the most important terms describing uncertainty (important for the purposes of this discussion).

Surprise, novelty, and complexity are experiences or attributes that generally contribute to but do not describe uncertainty. Surprise refers to the experience of an unpredicted event and reflects how subjectively rare the event is given one's prior expectations (for a formal definition, see Itti and Baldi [2009]), and novelty reflects the degree to which current representations (e.g., of the environment) do not match those stored in memory (Barto, Mirolli, & Baldassarre, 2013). Novel and surprising stimuli often elicit uncertainty when they cannot be neatly assimilated into existing categories for representation. Lastly, complexity has been defined as the amount of diversity in a stimulus pattern (Berlyne, 1960), or the degree to which stimuli contain discernable patterns that are compressible—that is, patterns that can be encoded into compressed representations (from this view, complex stimuli are less compressible and require more memory to encode) (Chater & Vitanyi, 2003). Complex stimuli generally take longer to process and interpret than simpler ones, hence, they may prolong a state of uncertainty, and they may also invite a greater number of competing interpretations.

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<sup>11</sup> Although these definitions both refer to the unpredictability of outcomes, it is worth noting that they diverge with respect to the measurement of risk. For example, in the latter conception, a pair of outcomes with probabilities of 50/50 (e.g., winning/losing \$10) entail more risk (have a higher variance) than a set of outcomes with probabilities of 10/90 (winning/losing); whereas, in the vernacular sense the opposite is true, i.e., a 90% chance of losing is riskier.

Table 4.1

*Terms Describing Uncertainty*

Domain	Subdomain	Terms	Questions
Action		goal conflict, decisional conflict	What can I do? Should I do this or that?
Perception	stimulus- related	perceptual conflict, ambiguity	What is it? Is it this or that?
	event- related	risk, unpredictability	Will it happen? When will it happen? How likely is it to happen?

**Responses to Uncertainty**

All responses to uncertainty can be construed one way or another as responses to stimuli that have some potential motivational significance. Four major classes of motivational stimuli that may be distinguished include rewards and incentive rewards (cues of reward) on the one hand, and punishments and threats (cues of punishment) on the other hand. Rewards and punishments can be understood as stimuli that either satisfy or detract from the goals and needs of an individual. (From this point of view, the successful attainment of a goal is rewarding, whereas the failure to attain a goal is punishing). By contrast, threats and incentive rewards are stimuli that signal that a rewarding or punishing event may occur in the near or distant future. Importantly, any event that has not yet occurred is also one that is at least to some degree unpredictable, even if there is a strong expectation that it will occur, which is why these motivational cues elicit uncertainty regarding reward and punishment. The one exception to the aforementioned classes are stimuli that are ambiguous in significance and thus could be perceived as either threatening (it could be bad) or promising (it could be good).

## Responses to Uncertain Punishment

**Immediate responses.** Most people would describe uncertainty as an aversive psychological state, as evident from the fact that to “feel uncertain” colloquially means to feel anxious, worried, nervous, apprehensive, etc., all of which are terms used to describe the phenomenology of anxiety. Psychologists have often defined anxiety in relation to fear, noting that it is an emotional response to potential, rather than clear and present threat (Estes & Skinner, 1941; Freud, 1930). Some have suggested that fear and anxiety can be distinguished according to how much uncertainty there is regarding the source and nature of a threat, the likelihood that it will lead to punishment, and the appropriate defensive response to it (Blanchard & Blanchard, 2008; Grupe & Nitschke, 2013; Lazarus & Averill, 1972; LeDoux, 2015). According to this perspective, fear is a response to an imminent, identifiable threat, signaling that “something bad will *definitely* happen unless I get out of here” and where the only means of defense is active avoidance (e.g., escape), whereas anxiety arises when the threat is ambiguous in nature or distant enough psychologically that it does not evoke any clear defensive strategy, hence punishment remains uncertain.

Yet another perspective assumes that anxiety is a response to goal conflict rather than threat per se (Gray & McNaughton, 2000). According to Gray and McNaughton’s revised Reinforcement Sensitivity Theory, anxiety is produced by a neuropsychological system called the Behavioral Inhibition System (BIS), which has an inhibitory input to two other systems—the Fight-Flight-Freeze System (FFFS) and the Behavioral Approach System (BAS). The FFFS is activated by the detection of threat and it produces the

motivation or readiness to avoid punishment through escape, defensive attack, or immobility, whereas the BAS is activated by incentive rewards and it produces the motivation to approach reward. Situations that are not sufficiently threatening to elicit fearful avoidance (e.g., escape) usually generate conflict between the motivation to approach a goal and the motivation to avoid punishment. The BIS responds to this conflict by producing a cautious state of passive avoidance whereby any potentially conflicting behaviors are suppressed, pending further analysis of the threat. Additionally, the BIS produces anxious arousal and increases in attention (or vigilance), directed towards scanning the environment and/or memory for any information that may help to reduce uncertainties about the threat and the appropriate defensive action to be taken.

Importantly, the BIS is conceived of as a system that responds to conflict not only between approach and avoidance motivations, but also between alternative means of avoidance (e.g., fight or flee) or approach (e.g., deciding between two medical treatments); in other words, it responds to any goal conflict. Corr and colleagues (2013) explain that deciding between alternatives, even those that are purely approach-oriented, can be anxiety-provoking due to the possibility of making the wrong decision, thereby incurring a loss (i.e., a worse outcome) relative to making the right decision. This explanation however would suggest that the anxiety in such conflicts stems precisely from the possibility of a negative outcome rather than the conflict itself. For this reason, I follow the more widely accepted interpretation that anxiety stems from the perception of threat and specifically the uncertain anticipation of punishment.

**Coping responses.** Once a threat has been assessed as significant, there are several ways it can be coped with. Coping is a construct that refers to the management of stress and its underlying causes (stressors), including threats, losses, and challenges (Lazarus & Folkman, 1984). At the broadest level of categorization, researchers have distinguished between approach or engagement coping, aimed at dealing with a stressor or its emotions, and avoidance or disengagement coping, aimed at escaping the stressor or related emotions (Connor-Smith & Flachsbart, 2007; Moos & Schaefer, 1993; Tobin, Holroyd, Reynolds, & Wigal, 1989). One can also distinguish between strategies that focus on the underlying problem (stressor), and those that focus on the symptoms of the problem, namely, the emotions (Lazarus & Folkman, 1984). When these distinctions are crossed, they suggest rather intuitively that one can either approach or avoid dealing with a problem or its symptoms.

How then are these coping strategies expressed in a threatening context? Having identified a threat that doesn't require a fight or flight response, the first question one must ask is what if anything can be done to prevent a negative outcome. In some cases, the answer will be immediately clear if it entails a conditioned response—for example, if a piece of electronic equipment gets unusually hot, shut it off. In all other cases, there will be some initial uncertainty as to how the threat may be addressed; therefore, some degree of planning will be required to generate and evaluate potential solutions, which may also entail gathering information relevant to solving the problem. Problem-focused coping encompasses all steps taken to diminish the likelihood and impact of a negative outcome, including the seeking of instrumental support such as the help or advice of

others (Connor-Smith & Flachsbart, 2007). Taking these steps, naturally, should alleviate anxiety and reduce uncertainty regarding undesired outcomes.

Recognizing that there is a threat that can be controlled, however, does not guarantee that one will muster the motivation to approach the problem at hand. An obvious barrier lies in the fact that confronting a threat can be stressful and anxiety-provoking (in the immediate term), and such negative affect is in and of itself something people wish to avoid or diminish. Problem-focused coping also incurs a cost in terms of cognitive and physical demands that can be substantial depending on the nature of the threat. For example, saving a failing marriage will require a great deal of work compared to mending a more casual relationship. Altogether, these emotional, cognitive, and/or physical costs in part explain why people sometimes cope in an avoidant manner.

Avoidance coping includes not only passively avoiding the problem, for instance, by procrastinating or ignoring it, but also actively avoiding any upsetting thoughts and reminders about it, and in extreme cases, even denying that the problem exists (Connor-Smith & Flachsbart, 2007). These strategies can be described as emotion-focused because their sole benefit is to provide temporary relief from stress, and they are dysfunctional in that they do not address the underlying problem, hence are ineffective in reducing distress in the long run (Carver & Connor-Smith, 2010; Roth & Lawrence, 1986). This is not to say, however, that all emotion-focused strategies are avoidant and maladaptive; approach strategies include, for instance, active attempts to regulate emotions (e.g., relaxation, exercise), seeking emotional support from others, accepting or coming to terms with the

reality of a negative situation, and finding more positive ways to think about it (Connor-Smith & Flachsbart, 2007).

### **Responses to Uncertain Reward**

The fact that people sometimes feel optimistic about an uncertain future suggests that not all states of uncertainty are unpleasant. Emotions such as optimism and excitement reflect the anticipation of future desired events (Baumgartner, Pieters, & Bagozzi, 2008), whether they constitute a reward (e.g., getting a job offer) or the absence of punishment (e.g., not losing one's job). Hope, eagerness, and desire, by contrast, reflect motivational states of 'wanting', which serve to energize behavior towards approaching reward, insofar as it is attainable (Corr et al., 2013). Although all anticipatory emotions entail some uncertainty regarding the future occurrence of an event (Baumgartner et al., 2008), some emotions appear to do so more than others. In particular, it has been shown that hope and desire are elicited in anticipation of events that are appraised as much more uncertain than those that elicit optimism, joy, and excitement (Bruininks & Malle, 2005; Frijda, 1987; Roseman, 1991; Smith & Ellsworth, 1985).

In contrast to the positive anticipatory emotions mentioned, anticipatory frustration conveys the emotional reaction to events signaling the potential omission of an expected reward (Amsel, 1992). Within the context of goal-directed behavior, these events are appraised as obstacles or challenges, which may instill doubt as to whether or not a goal can be attained. Interestingly, Gray and McNaughton (2000) propose that the anticipated absence of an expected reward is a key source of anxiety based on

experimental evidence that anxiolytic drugs have the effect of weakening this state (Gray, 1977). This suggests that anxiety may in fact reflect the anticipation of any uncertain negative outcome, regardless of whether it entails punishment or the omission of reward.

While both may elicit anxiety, threats and challenges are generally considered distinct stressors<sup>12</sup> (Lazarus & Folkman, 1984; Schwarzer & Taubert, 2002), which call for different types of approach coping. The difference can best be described through the lens of Regulatory Focus Theory (RFT; Higgins, 1998), which posits that all goal-directed behavior can be characterized by one of two self-regulatory orientations—promotion focus and prevention focus. Working to overcome challenges entails a promotion focus as it involves approaching a goal that is framed as a reward (e.g., eating healthy to look good), while tackling a threat entails prevention focus, as one is approaching a goal framed as the absence of punishment (e.g., eating healthy to not gain weight). These coping styles have also been referred to as “proactive” and “preventive” (Schwarzer & Taubert, 2002; Gan, Yang, Zhou, & Zhang, 2007).

### **Responses to Uncertainty about Perception and Action<sup>13</sup>**

Attaining a goal generally involves several steps, including selecting and initiating a goal strategy, inferring goal-relevant information from the environment (or from memory), employing that information to update predictions about goal-relevant outcomes, and adjusting behavior as needed. Any uncertainty that undermines the

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<sup>12</sup> In the coping literature, challenge has been distinguished from threat on the basis that it entails “an opportunity for growth, mastery or gain” (Lazarus & Folkman, 1984, p. 840) as well as the expectation that one is able to successfully cope with the challenging stressor (Tomaka, Blascovich, Kelsey, & Leitten, 1993).

<sup>13</sup> For lack of a better descriptor, ‘uncertainty about perception and action’ is used in distinction from uncertainty about reward or punishment.

execution of these steps can make goal progress more difficult, leading to apprehension about the goal outcome. To use an illustrative example, a driver who is rapidly approaching a traffic light and cannot determine its status (e.g., has it turned yellow or is it a reflection of the sun?) will consequently be conflicted as to whether to apply the breaks or accelerate, which in turn will raise the specter of running a red light and getting a traffic ticket. What this example purports to demonstrate is that a state of uncertainty about perception/action can be an obstacle or a threat, just like other more concrete obstacles or threats in the environment.

Naturally, one of the ways in which people cope with uncertainty is to try to reduce it by gathering additional information or by making inferences based on available information (Dawes, 1988; Janis & Mann, 1977; Lipshitz & Strauss, 1997). Information has obvious value for ending a state of ignorance or conflict, particularly when it consists of evidence that strongly or irrefutably supports a hypothesis or a particular course of action. Traditionally, information seeking behaviors have been studied under the rubric of curiosity and exploration (e.g., Keller, Schneider, & Henderson, 1994; Pisula, 2009). Curiosity, also referred to as interest, has been described as an emotion that arises from the appraisal of stimuli as novel, complex, ambiguous, or surprising (Silvia, 2005), all of which are attributes that signal the opportunity to acquire new information. Whereas curiosity is an emotion, cognitive exploration is the means by which information is sought and manipulated to different ends. More recently, neuropsychological evidence has been presented in support of the idea that any behavior motivated by the possibility of gaining information is exploratory in nature (DeYoung, 2013).

Compared to other instances of problem-focused coping, resolving uncertainty can be much more cognitively demanding, to the extent that it involves effortful cognitive processes, and there is evidence that people generally seek to minimize such demands (Rosen et al., 2007; Kool et al., 2010). One way they may do so is by gathering and processing the minimum information needed to arrive at a decision or conclusion on a topic. For some people, this could mean terminating the exploratory process early by settling on the first answer that satisfies a question, thus not giving consideration to other alternatives (Kruglanski & Webster, 1996). Alternatively, one can altogether avoid situations that are likely to elicit uncertainty, such as reading difficult books, mingling with people who do not share one's beliefs, and taking on complex jobs (cf., Neuberg & Newsom, 1993). Insofar as these behaviors seek to avoid or minimize the demands of coping with uncertainty, they might also be construed as a form of avoidance coping.

As outlined in this section, exploratory (information-seeking) behaviors serve an instrumental role in resolving uncertainty about perception and action. It would be inaccurate, however, to characterize exploration exclusively as a coping response, as it is well documented that both humans and non-human animals like to explore even when there are no obvious, practical benefits to doing so (Berlyne, 1966; Harlow, 1950; Thistlethwaite, 1951). This anomalous finding has led to the proposed distinction between intrinsic and extrinsic exploration (Berlyne, 1960), the former motivated by the "intrinsic" enjoyment of exploring and the latter motivated by its "extrinsic" instrumental value (e.g., exploring job websites to find a job). Although this distinction remains underdeveloped, there is some agreement that the not-so-obvious benefit of intrinsic

exploration is that it leads to the acquisition of skills and knowledge that have latent value, even if they are not presently useful, because they may be exploited in the future (DeYoung, 2013; Mirolli & Baldassarre, 2013; Polizzi di Sorrentino et al., 2014).

### **Summary**

In short, responses to uncertainty can be meaningfully organized around different types of motivational stimuli and they can further be divided into approach and avoidance-oriented responses, as summarized in Table 4.2 (note: some details are omitted for brevity).

Table 4.2

*Summary of Responses to Uncertainty*

Uncertainty	Stimuli	Goal	Approach-oriented responses	Avoidance-oriented responses
Uncertainty about reward	Incentive reward	Gain reward	Hope, excitement, behavioral approach	
	Threat (challenge)	Gain reward	Frustrative anxiety, proactive coping	Avoidance coping
Uncertainty about punishment	Threat	Absence of punishment	Preventive coping	Anxiety, inhibition, avoidance coping
Uncertainty about perception/action	Ambiguous, novel, complex stimuli	Gain information	Curiosity, exploration	

## **Conclusion**

### **Summary of Findings**

Throughout this work, I have sought to develop a model of uncertainty-related traits that is more structurally sound than current measures of IA, IU, and NFC. The four factors in this model were suggested by the results of Study 1, and I have made the case that they should be conceptualized as markers of distinct types of responses to uncertainty-eliciting stimuli, as opposed to interchangeable indicators of a dispositional aversion to uncertainty. Specifically, I proposed that Uncertainty Distress and Preference for Structure describe avoidant and preventive responses to threat, respectively; Preference for Novelty/Complexity describes exploratory responses to ambiguous, novel, and complex stimuli; and Categorical Thinking describes closed-minded responses to conflicting or belief-inconsistent information.

Study 1 laid the groundwork for this dissertation by demonstrating a lack of discriminant validity among the NFCS, MAAS, IUS, and URS scales. A CFA revealed that the general factors measured by these scales were equivalent or near-equivalent to one another (in the US samples), and EFA showed that most of the covariation among their items and facets was explained by four factors that were replicated across US and Italian samples. Furthermore, these four factors were shown to have strong concurrent validity with other traits, namely, Withdrawal, Orderliness, curiosity/exploration, and naïve epistemic beliefs.

The next two studies, in turn, yielded evidence that the four factors predict different outcomes and have, altogether, more predictive utility than NFC and its

counterparts (IA, IU). Study 2 employed a latent variable approach to measure data gathering behavior and it highlighted the usefulness of separately analyzing excessive and limited data gathering (i.e., EDG and JTC). Results confirmed that Categorical Thinking is positively associated with a tendency to jump to conclusions on the basis of little evidence, and they revealed that this association was in large part mediated by a general lack of task engagement. NFC and IU, on the other hand, were not significantly associated with the JTC and EDG biases (respectively), consistent with the null findings of previous studies.

Inspired in part by Study 2 findings, Study 3 investigated whether the threatening and cognitively demanding aspects of ambiguity could be used to distinguish between Uncertainty Distress and Categorical Thinking. Results did not support the hypothesized relationship between Categorical Thinking and effort avoidance at the behavioral level (i.e., as measured by the majority task), but they did reveal a relationship with a self-report measure. Uncertainty Distress was the only factor significantly associated with avoidance of ambiguity, and this extended to both measures of threat and effort avoidance. Although not entirely expected, the latter results reinforced the special relevance of avoidance motivation to this factor.

Overall, the results of the three studies support the discriminability of the four factors as correlates/predictors of different personality traits and decision-making styles (Study 1) and different behavioral outcomes of relevance (Studies 2 and 3). In view of the fact that the factors are constructed from existing measures, their discriminability demonstrates that there are meaningful relationships that are presently obscured by

measures of a general aversion to uncertainty. This point may also be construed as an argument for analyzing the facets within existing measures, except that most of the facets are not adequately different across measures, as Study 1 showed. Thus, the continued use of these uncertainty-relates scales cannot be recommended for any level of analysis.

### **Measurement of the Four Factors**

Interested parties could measure the four factors using a selection of items from current scales, such as the selection presented in Appendix A-1. As it stands, the URS also provides well-differentiated scales measuring Uncertainty Distress (Emotional Uncertainty), Preference for Structure (Cognitive Uncertainty), and Preference for Novelty/Complexity (Desire for Change), and the Moral Absolutism/Splitting facet of the MAAS provides adequate coverage of Categorical Thinking. In future work, however, it would be preferable to develop a new scale using more rigorous methods of item selection, such as an item response analysis.

### **Future Directions**

Given the relatively limited scope of Studies 2 and 3, additional work is needed to clarify the uniqueness of each of the four factors. In particular, this work should focus on substantiating the interpretation that they entail distinct types of responses to uncertainty. The proposal that Uncertainty Distress and Preference for Structure tap avoidant and preventive responses to threat, for example, is supported by the correlations between these two factors and self-report measures of coping (Study 1), but it needs to be further tested using other methods. In the rest of this section, I describe two future directions that are presently being investigated using data from Studies 1-3.

**The four factors and political conservatism.** Uncertainty constructs have been employed in the study of political conservatism from as early as IA was first proposed, in search of an explanation for the behaviors of ethnically-prejudiced individuals (Frenkel-Brunswik, 1949). It is only more recently, however, that these constructs gained a firm foothold in the field of political psychology with the influential theory that political conservatism is motivated by needs to manage uncertainty and threat (Jost, Glaser, Kruglanski, & Sulloway, 2003). In their meta-analysis of 88 samples spanning 12 countries, Jost and colleagues (2003) identified “dogmatism—intolerance of ambiguity”, “uncertainty tolerance”, and “needs for order, structure, and closure”, as some of the key personality variables that predict conservatism. Could we learn more about the relationship between conservatism and the need to manage uncertainty by examining the independent effects of the four uncertainty factors? Based on the preliminary results described in Appendix C, the answer appears to be “yes”.

**Orderliness and aversion to uncertainty.** The idea that Orderliness entails some aversion to uncertainty may seem rather uninteresting in the present context, since it is directly implied by the strong relationship between Orderliness and Preference for Structure. Yet, this insight is quite useful in view of the fact that Orderliness is one of the two main aspects of Conscientiousness (DeYoung et al., 2007)—a trait predictor of important life outcomes, such as physical health, marital satisfaction, and job performance, to name a few (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007). Orderliness characterizes people who are tidy, schedule-oriented, perfectionistic, cautious, and rule-oriented, whereas, the other aspect of Conscientiousness—

Industriousness—describes people who are achievement-driven, self-confident, hard-working, and self-disciplined. Clarifying how these two aspects are different beyond their descriptive summaries is essential to understanding how each contributes to the range of outcomes that are predicted by Conscientiousness. A natural question to ask then is whether aversion to uncertainty is what differentiates these two aspects. In Appendix C, I describe preliminary results showing that the variation that is unique to Orderliness, controlling for Industriousness, is no different from the variation shared among the uncertainty-related scales used in Study 1.

### **Unresolved Questions**

This work leaves several questions unresolved, which I turned to next.

#### **What does the general factor underlying uncertainty-related scales measure?**

EFA results from Study 1 suggested that the first unrotated factor was quite similar to Uncertainty Distress, which emerged later, and this is also confirmed when we examine the loadings of the four factors (measured as observed variables) on a single factor—Uncertainty Distress has the highest loading ( $>.80$ ), and the loadings of the other factors are significantly lower ( $<.70$ ). It seems appropriate therefore to consider this undifferentiated trait as simply a measure of aversion to uncertainty, but further insight into its psychological nature is needed. One might point out that the literatures on NFC, IU, and IA already provide a vast amount of information on the nature of this trait, and that is perhaps most accurate of the NFC literature, as the NFC scale has a more even coverage of the four factors than other scales. A more interesting question to explore then is whether the general factor does a better job at predicting certain outcomes than its

constituent factors. The research presented in this work does not provide evidence to that effect, but the question should nevertheless be examined.

**Are there other important factors?** Needless to say, the four-factor model presented is empirically derived from instruments that purport to measure a single construct, with the exception of the URS. It does not seek to encompass all important individual differences in responses to uncertainty (yet one could argue that it does cover the major ones). What then would a more comprehensive model of uncertainty-related traits look like, and what other traits would it include that are absent from the current model? These questions are worth exploring because the current model is, to some extent, the by-product of arbitrary decisions about the relevant psychological expressions of each construct (e.g., need for order and structure).

One approach that might be taken to answer these questions would involve selecting a much wider range of trait measures than the ones I investigated, based on theoretical criteria as to (1) what can be construed as measuring an attitude or response to uncertainty, and (2) which terms can be construed as having a similar meaning or other important conceptual ties to “uncertainty” (e.g., confusion, ignorance, risk, ambiguity, unpredictability, etc.). The selection of measures could then be subjected to a joint factor analysis.

An alternative approach would be to catalogue a comprehensive list of responses to uncertainty based on theoretical considerations and/or based on a conceptual analysis of the items of existing scales, as demonstrated in the recent work of Hillen and colleagues (2017). Using this list, one could then generate a sufficient set of new items

for each response, and these items would be factor analyzed to determine which of the responses identified belong to similar traits.

A third approach has already been demonstrated in the construction of the URS (Greco & Roger, 2001). It involves generating a series of hypothetical scenarios involving uncertainty, collecting data from a sample of participants as to how they would respond in these situations, then using their responses to generate items that can be factor analyzed.

Perhaps the most logical and fruitful approach is to build upon the four-factor model by identifying other potentially relevant traits and measures. Some candidates to consider include trait measures of perception of a dangerous world and responses to social threats, such as authoritarian aggression. The relevance of authoritarianism, in particular, is suggested by not only the historical roots of IA in research on the authoritarian personality (Adrono et al., 1950), but also its inclusion in the measurement of Uncertainty Orientation (Sorrentino & Short, 1986)—a construct that was not covered in the present work.

**Should decision-making traits be considered part of a larger family of uncertainty-related traits?** NFC theorists consider decisiveness or the desire for decisiveness (i.e., making quick decisions) relevant to measuring aversion to ambiguity, and more specifically, the urgency to attain closure. Yet, when we focus on the four factors underlying the NFCS and other scales (Study 1), we find that other decision-making traits become relevant as well. Study 1 found that the decision-making facets of the NFC correlated mainly with Uncertainty Distress, while the rest of the factors were

correlated with other styles of decision-making: Preference for Structure was characterized by a rational style, Preference for Novelty/Complexity was characterized by a spontaneous style, and Categorical Thinking was related to decisional certainty.

These findings reinforce the point that decision-making is a reflection of how people cope with uncertainty, which raises an interesting question—should decision-making traits be considered part of a larger family of uncertainty-related traits? A conceptual integration that acknowledges the relationships between the two types of traits (and why they are coherent with one another) would likely be useful as it would promote, among other things, greater cross-talk between two different areas of research. However, it is less clear what benefits would come from combining the measurement of the two, beyond incorporating some decision-making items into the measurement of the uncertainty factors.

**How can the diverse theories and conceptualizations of uncertainty constructs be reconciled?** The present work focused primarily on addressing the psychometric rather than the conceptual overlap among uncertainty-related constructs. If a unified structural model is to be adopted as an alternative to these constructs, then it will be necessary to explore how their supportive theories and conceptualizations might be reconciled and integrated, while also taking into account existing bodies of empirical work on each construct. Hillen and colleagues (2017) have recently proposed a conceptual model that integrates multiple perspectives on IU and IA, which marks an important step in this direction. The push toward conceptual integration should also be extended to NFC and other similar constructs like Uncertainty Orientation and Personal

Need for Structure. Ultimately, a unifying theoretical and conceptual model must accommodate the existence of not only a general, dispositional aversion to uncertainty but also the four specific factors that appear to tap different responses to uncertainty.

## References

- Adorno, T. W., Frenkel-Brunswik, E., Levinson, D. J., & Sanford, R. N. (1950). *The authoritarian personality*. New York: Harper & Brothers.
- Altemeyer, B. (2002). Dogmatic behavior among students: Testing a new measure of dogmatism. *The Journal of Social Psychology, 142*(6), 713–721.
- Amsel, A. (1992). *Frustration theory*. Cambridge: Cambridge University Press.
- Balietti, S., Mäs, M., & Helbing, D. (2015). On disciplinary fragmentation and scientific progress. *PloS One, 10*(3), e0118747.
- Baumgartner, H., Pieters, R., & Bagozzi, R. P. (2008). Future-oriented emotions: Conceptualization and behavioral effects. *European Journal of Social Psychology, 38*(4), 685–696.
- Berlyne D. E. (1960). *Conflict, arousal, and curiosity*. New York: McGraw–Hill.
- Berlyne, D. E. (1966). Curiosity and exploration. *Science, 153*, 25–33.
- Birrell, J., Meares, K., Wilkinson, A., & Freeston, M. (2011). Toward a definition of intolerance of uncertainty: A review of factor analytical studies of the Intolerance of Uncertainty Scale. *Clinical Psychology Review, 31*(7), 1198–1208.
- Blanchard, D. C., & Blanchard, R. J. (2008). Defensive behaviors, fear, and anxiety. In R. J. Blanchard, D. C. Blanchard, G. Griebel, & D. J. Nutt (Eds.), *Handbook of anxiety and fear* (pp. 63–79). San Diego, CA: Elsevier.
- Bredemeier, K., & Berenbaum, H. (2008). Intolerance of uncertainty and perceived threat. *Behaviour Research and Therapy, 46*(1), 28–38.

- Bruininks, P., & Malle, B. F. (2005). Distinguishing hope from optimism and related affective states. *Motivation and Emotion, 29*(4), 324–352.
- Budner, S. (1962). Intolerance of ambiguity as a personality variable. *Journal of Personality, 30*(1), 29–50.
- Byrne, S. P., Hunt, C. J., & Chang, B. P. I. (2015). Comparing the roles of ambiguity and unpredictability in intolerance of uncertainty. *Behaviour Change, 32*(1), 26–34.
- Cacioppo, J. T., Petty, R. E., & Feng Kao, C. (1984). The efficient assessment of need for cognition. *Journal of Personality Assessment, 48*(3), 306–307.
- Carleton, R. N., Norton, M. P. J., & Asmundson, G. J. (2007). Fearing the unknown: A short version of the Intolerance of Uncertainty Scale. *Journal of Anxiety Disorders, 21*(1), 105–117.
- Carleton, R. N., Weeks, J. W., Howell, A. N., Asmundson, G. J., Antony, M. M., & McCabe, R. E. (2012). Assessing the latent structure of the intolerance of uncertainty construct: An initial taxometric analysis. *Journal of Anxiety Disorders, 26*(1), 150–157.
- Carver, C. S., & Connor-Smith, J. (2010). Personality and coping. *Annual Review of Psychology, 61*, 679–704.
- Chater, N., & Vitányi, P. (2003). Simplicity: A unifying principle in cognitive science?. *Trends in Cognitive Sciences, 7*(1), 19–22.
- Christie, S. T., & Schrater, P. (2015). Cognitive cost as dynamic allocation of energetic resources. *Frontiers in Neuroscience, 24*(9), 289–289.

- Condon, D. M., & Revelle, W. (2014). The International Cognitive Ability Resource: Development and initial validation of a public-domain measure. *Intelligence, 43*, 52–64.
- Connor-Smith, J. K., & Flachsbart, C. (2007). Relations between personality and coping: A meta-analysis. *Journal of Personality and Social Psychology, 93*(6), 1080–1107.
- Corr, P. J., DeYoung, C. G., & McNaughton, N. (2013). Motivation and personality: A neuropsychological perspective. *Social and Personality Psychology Compass, 7*(3), 158–175.
- Dawes, R. M. (1988). *Rational choice in an uncertain world*. New York: Harcourt Brace Jovanovich.
- DeYoung, C. G. (2006). Higher-order factors of the Big Five in a multi-informant sample. *Journal of Personality and Social Psychology, 91*(6), 1138–1151.
- DeYoung, C. G. (2013). The neuromodulator of exploration: A unifying theory of the role of dopamine in personality. *Frontiers in Human Neuroscience, 7*, 1–26.
- DeYoung, C. G. (2014). Openness/intellect: A dimension of personality reflecting cognitive exploration. In M. L. Cooper & R. J. Larsen (Eds.), *APA handbook of personality and social psychology: Personality processes and individual differences* (Vol. 4, pp. 369–399). Washington, DC: American Psychological Association.

- DeYoung, C. G., Quilty, L. C., & Peterson, J. B. (2007). Between facets and domains: 10 aspects of the big five. *Journal of Personality and Social Psychology, 93*(5), 880–896.
- Dugas, M. J., Hedayati, M., Karavidas, A., Buhr, K., Francis, K., & Phillips, N. A. (2005). Intolerance of uncertainty and information processing: Evidence of biased recall and interpretations. *Cognitive Therapy and Research, 29*(1), 57–70.
- Estes, W. K., & Skinner, B. F. (1941). Some quantitative properties of anxiety. *Journal of Experimental Psychology, 29*(5), 390–400.
- Eysenck, H. J. (1954). *The psychology of politics*. New York: Praeger.
- Eysenck, S. B., Eysenck, H. J., & Barrett, P. (1985). A revised version of the psychoticism scale. *Personality and Individual Differences, 6*(1), 21–29.
- Fan, J., Guise, K. G., Liu, X., & Wang, H. (2008). Searching for the majority: Algorithms of voluntary control. *PLoS One, 3*(10), e3522.
- Freeston, M. H., Rhéaume, J., Letarte, H., Dugas, M. J., & Ladouceur, R. (1994). Why do people worry? *Personality and Individual Differences, 17*(6), 791–802.
- Frenkel-Brunswik, E. (1949). Intolerance of ambiguity as an emotional and perceptual personality variable. *Journal of Personality, 18*(1), 108–143.
- Freud, S. (1930). *Inhibitions, symptoms and anxiety*. London: Hogarth Press.
- Frijda, N. H. (1987). Emotion, cognitive structure, and action tendency. *Cognition and Emotion, 1*(2), 115–143.

- Furnham, A. (1994). A content, correlational and factor analytic study of four tolerance of ambiguity questionnaires. *Personality and Individual Differences, 16*(3), 403–410.
- Gallagher, N. G., South, S. C., & Oltmanns, T. F. (2003). Attentional coping style in obsessive-compulsive personality disorder: a test of the intolerance of uncertainty hypothesis. *Personality and Individual Differences, 34*(1), 41–57.
- Gan, Y., Yang, M., Zhou, Y., & Zhang, Y. (2007). The two-factor structure of future-oriented coping and its mediating role in student engagement. *Personality and Individual Differences, 43*(4), 851–863.
- Gold, J. M., Kool, W., Botvinick, M. M., Hubzin, L., August, S., & Waltz, J. A. (2015). Cognitive effort avoidance and detection in people with schizophrenia. *Cognitive, Affective, & Behavioral Neuroscience, 15*(1), 145–154.
- Goldberg, L. R. (2006). Doing it all bass-ackwards: The development of hierarchical factor structures from the top down. *Journal of Research in Personality, 40*(4), 347–358.
- Goldberg, L. R., Johnson, J. A., Eber, H. W., Hogan, R., Ashton, M. C., Cloninger, C. R., & Gough, H. G. (2006). The international personality item pool and the future of public-domain personality measures. *Journal of Research in Personality, 40*(1), 84–96.
- Gray, J. A. (1977). Drug effects on fear and frustration: Possible limbic site of action of minor tranquilizers. In L. L. Iversen, S. D. Iversen, & S. H. Snyder (Eds.),

- Handbook of psychopharmacology, volume 8. Drugs, neurotransmitters and behaviour* (pp. 433–529). New York: Plenum Press.
- Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety*. New York: Oxford University Press.
- Greco, V., & Roger, D. (2001). Coping with uncertainty: The construction and validation of a new measure. *Personality and Individual Differences, 31*(4), 519–534.
- Grenier, S., Barrette, A. M., & Ladouceur, R. (2005). Intolerance of uncertainty and intolerance of ambiguity: Similarities and differences. *Personality and Individual Differences, 39*(3), 593–600.
- Grupe, D. W., & Nitschke, J. B. (2013). Uncertainty and anticipation in anxiety: An integrated neurobiological and psychological perspective. *Nature Reviews Neuroscience, 14*(7), 488–501.
- Hamilton, K., Shih, S. I., & Mohammed, S. (2016). The development and validation of the rational and intuitive decision styles scale. *Journal of Personality Assessment, 98*(5), 523–535.
- Harlow, H. F. (1950). Learning and satiation of response in intrinsically motivated complex puzzle performance by monkeys. *Journal of Comparative and Physiological Psychology, 43*(4), 289–294.
- Hillen, M. A., Gutheil, C. M., Strout, T. D., Smets, E. M., & Han, P. K. (2017). Tolerance of uncertainty: Conceptual analysis, integrative model, and implications for healthcare. *Social Science & Medicine, 180*(C), 62–75.

- Hirsh, J. B., Mar, R. A., & Peterson, J. B. (2012). Psychological entropy: A framework for understanding uncertainty-related anxiety. *Psychological Review*, *119*(2), 304.
- Hoyle, R. H., Stephenson, M. T., Palmgreen, P., Lorch, E. P., & Donohew, R. L. (2002). Reliability and validity of a brief measure of sensation seeking. *Personality and Individual Differences*, *32*(3), 401–414.
- Inquisit 3 [Computer software]. (2012). Retrieved from <https://www.millisecond.com>.
- Itti, L., & Baldi, P. (2009). Bayesian surprise attracts human attention. *Vision Research*, *49*(10), 1295–1306.
- Janis, I. L., & Mann, L. (1977). *Decision making: A psychological analysis of conflict, choice, and commitment*. New York: The Free Press.
- Jost, J. T., Glaser, J., Kruglanski, A. W., & Sulloway, F. J. (2003). Political Conservatism as Motivated Social Cognition. *Psychological Bulletin*, *129*(3), 339–375.
- Jost, J. T., Sterling, J., & Stern, C. (2017). Getting closure on conservatism, or the politics of epistemic and existential motivation. In C. Kopetz & A. Fishbach (Eds.), *The motivation-cognition interface; From the lab to the real world: A Festschrift in honor of Arie W. Kruglanski*. New York, NY: Psychology Press.
- Jovina, I., Nador, J., Larue, O., Green, R., Harel, A., & Minnery, B. (2018). *Measuring individual differences in cognitive effort avoidance*. Poster presented at the Annual Meeting of the Cognitive Science Society, Madison, WI.
- Kashdan, T. B., Gallagher, M. W., Silvia, P. J., Winterstein, B. P., Breen, W. E., Terhar, D., & Steger, M. F. (2009). The curiosity and exploration inventory-II:

- Development, factor structure, and psychometrics. *Journal of Research in Personality*, 43(6), 987–998.
- Keller, H., Schneider, K., & Henderson, B. (Eds.). (1994). *Curiosity and exploration*. Heidelberg, Germany: Springer.
- Kenny, D. T., & Ginsberg, R. (1958). The specificity of intolerance of ambiguity measures. *Journal of Abnormal Psychology*, 56(3), 300–304.
- Knight, F. H. (1921). *Risk, uncertainty and profit*. Boston, MA: Houghton Mifflin Company.
- Koerner, N., & Dugas, M. J. (2008). An investigation of appraisals in individuals vulnerable to excessive worry: The role of intolerance of uncertainty. *Cognitive Therapy and Research*, 32(5), 619–638.
- Kool, W., McGuire, J. T., Rosen, Z. B., & Botvinick, M. M. (2010). Decision making and the avoidance of cognitive demand. *Journal of Experimental Psychology: General*, 139(4), 665–682.
- Kool, W., McGuire, J. T., Wang, G. J., & Botvinick, M. M. (2013). Neural and behavioral evidence for an intrinsic cost of self-control. *PloS One*, 8(8), e72626.
- Kruglanski, A. W. (1989). *Lay epistemic and human knowledge: Cognitive and motivational bases*. New York: Plenum Press.
- Kruglanski, A. W., & Freund, T. (1983). The freezing and unfreezing of lay-inferences: Effects of impression primacy, ethnic stereotyping and numerical anchoring. *Journal of Experimental Social Psychology*, 19, 448–468.

- Kruglanski, A. W., & Webster, D. M. (1996). Motivated closing of the mind: “Seizing” and “freezing”. *Psychological Review*, *103*(2), 263–283.
- Kruglanski, A. W., Atash, M., & DeGrada, E. (1997). Psychological theory testing versus psychometric nay-saying: comment on Neuberg et al.'s (1997) critique of the Need for Closure Scale. *Journal of Personality and Social Psychology*, *73*(5), 1005–1016.
- Kruglanski, A. W., Webster, D. M., & Klem, A. (1993). Motivated resistance and openness to persuasion in the presence or absence of prior information. *Journal of Personality and Social Psychology*, *65*, 861–877.
- Kurzban, R. (2016). The sense of effort. *Current Opinion in Psychology*, *7*, 67–70.
- Lauriola, M., Foschi, R., Mosca, O., & Weller, J. (2015). Attitude toward ambiguity: empirically robust factors in self-report personality scales. *Assessment*, 1–21.
- Lazarus, R. S., & Averill, J. R. (1972). Emotion and cognition: With special reference to anxiety. In C. D. Spielberger (Ed.), *Anxiety: Current trends in theory and research*. New York: Academic Press.
- Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal and coping*. New York: Springer.
- LeDoux, J. (2015). *Anxious: Using the brain to understand and treat fear and anxiety*. New York: Viking.
- Levita, L., Hare, T. A., Voss, H. U., Glover, G., Ballon, D. J., & Casey, B. J. (2009). The bivalent side of the nucleus accumbens. *Neuroimage*, *44*(3), 1178–1187.
- Levitin, D. J., Schaaf, A. & Goldberg, L. R. (2005). Factor diagrammer (Version 1.1b) [computer software]. Montreal: McGill University.

- Lipshitz, R., & Strauss, O. (1997). Coping with uncertainty: A naturalistic decision-making analysis. *Organizational Behavior and Human Decision Processes*, 69(2), 149–163.
- Litman, J. A., & Spielberger, C. D. (2003). Measuring epistemic curiosity and its diversive and specific components. *Journal of Personality Assessment*, 80(1), 75–86.
- Lommen, M. J. J. J., Engelhard, I. M., & van den Hout, M. A. (2010). Neuroticism and avoidance of ambiguous stimuli: Better safe than sorry? *Personality and Individual Differences*, 49(8), 1001–1006.
- Lorenzo-Seva, U., & Ten Berge, J. M. (2006). Tucker's congruence coefficient as a meaningful index of factor similarity. *Methodology*, 2(2), 57–64.
- Luchins, A. S. (1942). mechanization in Problem Solving: The Effect of Einstellung. *Psychological Monographs: General and Applied*, 54(6), i–95.
- Mann, L., Burnett, P., Radford, M., & Ford, S. (1997). The Melbourne Decision Making Questionnaire: An instrument for measuring patterns for coping with decisional conflict. *Journal of Behavioral Decision Making*, 10(1), 1-19.
- Mannetti, L., Pierro, A., Kruglanski, A., Taris, T., & Bezinovic, P. (2002). A cross-cultural study of the Need for Cognitive Closure Scale: Comparing its structure in Croatia, Italy, USA and The Netherlands. *British Journal of Social Psychology*, 41(1), 139–156.
- Markowitz, H. (1952). Portfolio Selection. *Journal of Finance*, 7(1), 77–91.

- Matthys, W., van Goozen, S. H., de Vries, H., Cohen-Kettenis, P. T., & van Engeland, H. (1998). The dominance of behavioural activation over behavioural inhibition in conduct disordered boys with or without attention deficit hyperactivity disorder. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, 39(5), 643-651.
- McLain, D. L. (2009). Evidence of the properties of an ambiguity tolerance measure: The Multiple Stimulus Types Ambiguity Tolerance Scale-II (MSTAT-II). *Psychological Reports*, 105(3), 975-988.
- McLain, D. L., Kefallonitis, E., & Armani, K. (2015). Ambiguity tolerance in organizations: definitional clarification and perspectives on future research. *Frontiers in Psychology*, 6(344), 1–7.
- McNaughton, N., & Corr, P. J. (2004). A two-dimensional neuropsychology of defense: fear/anxiety and defensive distance. *Neuroscience & Biobehavioral Reviews*, 28(3), 285–305.
- Mirolli, M., Baldassarre, G. (2013). Functions and mechanisms of intrinsic motivations: The knowledge versus competence distinction. In G. Baldassarre, & M. Mirolli (Eds.). *Intrinsically motivated learning in natural and artificial systems* (pp. 49–72). Berlin: Springer-Verlag.
- Moos, R. H., & Schaefer, J. A. (1993). Coping resources and processes: Current concepts and measures. In L. Goldberger, & S. Breznitz (Eds.), *Handbook of stress: Theoretical and clinical aspects* (2<sup>nd</sup> ed., pp. 234–57). New York: Free Press.

- Muthén, L.K. and Muthén, B.O. (1998-2017). *Mplus User's Guide. Eighth Edition*. Los Angeles, CA: Muthén & Muthén.
- Naemi, B. D., Beal, D. J., & Payne, S. C. (2009). Personality predictors of extreme response style. *Journal of Personality*, 77(1), 261–286.
- Neuberg, S. L., & Newsom, J. T. (1993). Personal need for structure: Individual differences in the desire for simple structure. *Journal of Personality and Social Psychology*, 65(1), 113–131.
- Neuberg, S. L., Judice, T. N., & West, S. G. (1997). What the Need for Closure Scale measures and what it does not: Toward differentiating among related epistemic motives. *Journal of Personality and Social Psychology*, 72(6), 1396–1412.
- Norton, R. W. (1975). Measurement of ambiguity tolerance. *Journal of Personality Assessment*, 39(6), 607–619.
- Nygren, T. E. (2000). Development of a measure of decision making styles to predict performance in a dynamic J/DM task. Paper presented at the meeting of the Psychonomic Society, New Orleans, LA.
- Ostendorf, F. (1990). *Sprache und persönlichkeitsstruktur: Zur validität des fünf-faktoren-modells der persönlichkeit* [Language and personality structure: Toward the validation of the five-factor model of personality]. Regensburg, Germany: S. Roderer Verlag.
- Pisula, W. (2009). *Curiosity and information seeking in animal and human behavior*. Boca Raton, FL: Brown Walker Press.

- Polizzi di Sorrentino, E., Sabbatini, G., Truppa, V., Bordonali, A., Taffoni, F., Formica, D., ... Visalberghi, E. (2014). Exploration and learning in capuchin monkeys (*Sapajus* spp.): the role of action-outcome contingencies. *Animal Cognition*, *17*(5), 1081–1088.
- R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>.
- Rautu, A., & DeYoung, C. G. (2017). *Uncovering the factor structure of uncertainty related questionnaires*. Poster presented at the biennial meeting of the Association for Research in Personality, Sacramento, CA.
- Revelle, W. (2018). psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, USA, <https://CRAN.R-project.org/package=psych> Version = 1.8.4.
- Roberts, B. W., Kuncel, N. R., Shiner, R., Caspi, A., & Goldberg, L. R. (2007). The power of personality: The comparative validity of personality traits, socioeconomic status, and cognitive ability for predicting important life outcomes. *Perspectives on Psychological Science*, *2*(4), 313–345.
- Roets, A., & Van Hiel, A. (2007). Separating ability from need: Clarifying the dimensional structure of the need for closure scale. *Personality and Social Psychology Bulletin*, *33*, 266–280.

- Roets, A., Kruglanski, A. W., Kossowska, M., Pierro, A., & Hong, Y. Y. (2015). The motivated gatekeeper of our minds: New directions in need for closure theory and research. *Advances in Experimental Social Psychology*, 52, 221–283.
- Roseman, I. J. (1991). Appraisal determinants of discrete emotions. *Cognition and Emotion*, 5(3), 161–200.
- Rosen, N. O., Ivanova, E., & Knäuper, B. (2014). Differentiating intolerance of uncertainty from three related but distinct constructs. *Anxiety, Stress & Coping*, 27(1), 55–73.
- Rosen, Z. V., McGuire, J., & Botvinick, M. M. (2007). *Is mental effort aversive? Some behavioral and psychophysiological evidence*. Poster presented at the Annual Meeting of the Cognitive Neuroscience Society, New York.
- Roth, S., & J. Lawrance, C. (1986). Approach avoidance and coping with stress. *American Psychologist*, 4(7), 813–819.
- Samuels, J., Bienvenu, O. J., Krasnow, J., Wang, Y., Grados, M. A., Cullen, B., ... & Rasmussen, S. A. (2017). An investigation of doubt in obsessive–compulsive disorder. *Comprehensive Psychiatry*, 75, 117–124.
- Sankaran, S., Szumowska, E., & Kossowska, M. (2017). “When the going gets tough, the tough get going”: Motivation towards closure and effort investment in the performance of cognitive tasks. *Motivation and Emotion*, 41(3), 308–321.
- Saucier G. (1997). Effect of variable selection on the factor structure of person descriptors. *Journal of Personality and Social Psychology*, 73, 1296–1312.

- Schraw, G., Bendixen, L. D., and Dunkle, M. E. (2002). Development and validation of the Epistemic Belief Inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Erlbaum.
- Schwarzer, R., & Taubert, S. (2002). Tenacious goal pursuits and striving toward personal growth: Proactive coping. In E. Frydenberg (Ed.), *Beyond coping: Meeting goals, visions, and challenges* (pp. 19–35). London, UK: Oxford University Press.
- Scott, S. G., & Bruce, R. A. (1995). Decision-making style: The development and assessment of a new measure. *Educational and Psychological Measurement, 55*(5), 818–831.
- Shenhav, A., Botvinick, M. M., & Cohen, J. D. (2013). The expected value of control: an integrative theory of anterior cingulate cortex function. *Neuron, 79*(2), 217–240.
- Silvia, P. J. (2005). What is interesting? Exploring the appraisal structure of interest. *Emotion, 5*(1), 89–102.
- Smith, C. A., & Ellsworth, P. C. (1985). Patterns of cognitive appraisal in emotion. *Journal of Personality and Social Psychology, 48*(4), 813–838.
- Sorrentino, R. M., & Short, J. C. (1986). Uncertainty orientation, motivation, and cognition. In R. M. Sorrentino & E. T. Higgins (Eds.), *Handbook of motivation and cognition: Foundations of social behavior* (Vol. 1, pp. 379 – 403). New York, NY: Guilford Press.

- Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High Self-Control Predicts Good Adjustment, Less Pathology, Better Grades, and Interpersonal Success. *Journal of Personality, 72*(2), 271–324.
- Thistlethwaite, D. L. (1951). A critical review of latent learning and related experiments. *Psychological Review, 48*, 97–129.
- Thompson, S. C., Schlehofer, M. M., & Bovin, M. J. (2006). The measurement of threat orientations. *American Journal of Health Behavior, 30*(2), 147–157.
- Tobin, D. L., Holroyd, K. A., Reynolds, R. V., & Wigal, J. K. (1989). The hierarchical factor structure of the Coping Strategies Inventory. *Cognitive Therapy and Research, 13*(4), 343–361.
- Tolin, D. F., Abramowitz, J. S., Brigidi, B. D., & Foa, E. B. (2003). Intolerance of uncertainty in obsessive-compulsive disorder. *Journal of Anxiety Disorders, 17*(2), 233–242.
- Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of Personality and Social Psychology, 65*(2), 248–260.
- Toplak, M. E., West, R. F., & Stanovich, K. E. (2014). Rational Thinking and Cognitive Sophistication: Development, Cognitive Abilities, and Thinking Dispositions. *Developmental Psychology, 50*(4), 1037–1048.
- Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*(4157), 1124–1131.

Webster, D. M. (1993). Motivated augmentation and reduction of the overattribution bias.

*Journal of Personality and Social Psychology*, 65, 261–271.

Webster, D. M., & Kruglanski, A. W. (1994). Individual differences in need for cognitive

closure. *Journal of Personality and Social Psychology*, 67(6), 1049.

## Appendix A: Questionnaire Items

### Study 1

#### *Naïve epistemic beliefs*

Scale	Trait/Subscale	Item	FL
EBI	Belief in absolute truth	If two people are arguing about something, at least one of them must be wrong.	.61
EBI	Belief in simple knowledge	Instructors should focus on facts instead of theories.	.59
DOG	Dogmatism	My opinions are right and will stand the test of time.	.55
DOG	Dogmatism	The things I believe in are so completely true, I could never doubt them.	.55
DOG	Dogmatism	Anyone who is honestly seeking the truth will end up believing what I believe.	.53
EBI	Belief in simple knowledge	Most things worth knowing are easy to understand.	.51
EBI	Belief in quick learning	If you don't learn something quickly, you won't ever learn it.	.47
EBI	Belief in omniscient authority	People shouldn't question authority.	.47
EBI	Belief in absolute truth	What is true today will be true tomorrow.	.45
EBI	Belief in simple knowledge	Too many theories just complicate things.	.44
EBI	Belief in innate intelligence	How well you do in school depends on how smart you are.	.44
EBI	Belief in quick learning	Working on a problem with no quick solution is a waste of time.	.42
EBI	Belief in innate intelligence	People's intellectual potential is fixed at birth.	.41
EBI	Belief in quick learning	Students who learn things quickly are the most successful.	.36
EBI	Belief in innate intelligence	Smart people are born that way.	.35

*Note.* FL = item loading on one factor; DOG = DOG Scale; EBI = Epistemic Beliefs Inventory.

*Decisional certainty*

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Item	FL
1. Once I have made a decision, I am confident that it was the right one to make.	.73
2. I rarely doubt my decisions.	.64
3. When deciding, I usually see the best option right away.	.61
4. I always know what I want.	.54
5. I don't change my mind after I've made my decision.	.51
6. I usually make important decisions quickly and confidently.	.51

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*Note.* FL = item loading on one factor.

*Four uncertainty factors (items selected from Study 1 for Study 2)*

<u>Uncertainty Distress</u>			
Scale	Trait/Subscale	Item	FL
URS	Emo Uncertainty	I get worried when a situation is uncertain.	.77
IUS	Prospective IU	Unforeseen events upset me greatly.	.73
IUS	Inhibitory IU	When I am uncertain, I can't function very well.	.72
URS	Emo Uncertainty	I feel anxious when things are changing.	.72
URS	Emo Uncertainty	Sudden changes make me feel upset.	.72
URS	Emo Uncertainty	I am hesitant when it comes to making changes.	.70
MAAS	Discomfort Ambig	I get pretty anxious when I'm in a social situation over which I have no control.	.69
URS	Emo Uncertainty	When uncertain about what to do next, I tend to feel lost.	.66
MAAS	Discomfort Ambig	If I am uncertain about the responsibilities of a job, I get anxious.	.66
URS	Emo Uncertainty	When making a decision, I am deterred by the fear of making a mistake.	.65
URS	Emo Uncertainty	When I can't clearly discern situations, I get apprehensive.	.63
IUS	Inhibitory IU	When it's time to act, uncertainty paralyses me.	.63
NFCS	Discomfort Ambig	When I am confused about an important issue, I feel upset.	.62
IUS	Inhibitory IU	The smallest doubt can stop me from acting.	.60
IUS	Inhibitory IU	Uncertainty keeps me from living a full life.	.59
IUS	Inhibitory IU	I must get away from all uncertain situations.	.58
URS	Emo Uncertainty	When the future is uncertain, I generally expect the worst to happen.	.57

IUS	Prospective IU	It frustrates me not having all the information I need.	.56
NFCS	Discomfort Ambig	I feel uncomfortable when I don't understand the reason why an event occurred in my life.	.55
NFCS	Discomfort Ambig	I feel uncomfortable when someone's meaning or intention is unclear to me.	.53
URS	Emo Uncertainty	When I'm not certain about someone's intentions towards me, I often become upset or angry.	.53
URS	Emo Uncertainty	I really get anxious if I don't know what someone thinks about me.	.49
MAAS	Discomfort Ambig	It intensely disturbs me when I am uncertain of how my actions affect others.	.40

Preference for Structure

Scale	Trait/Subscale	Item	FL
NFCS	Order/Structure	I enjoy having a clear and structured mode of life.	.71
NFCS	Order/Structure	I find that establishing a consistent routine enables me to enjoy life more.	.70
NFCS	Order/Structure	I like to have a plan for everything and a place for everything.	.70
URS	Cog Uncertainty	I like to plan ahead in detail rather than leaving things to chance.	.68
NFCS	Order/Structure	I find that a well ordered life with regular hours suits my temperament.	.68
IUS	Prospective IU	I should be able to organize everything in advance.	.65
IUS	Prospective IU	One should always look ahead so as to avoid surprises.	.63
URS	Cog Uncertainty	I like to know exactly what I'm going to do next.	.63
NFCS	Order/Structure	I hate to change my plans at the last minute.	.61
URS	Cog Uncertainty	I prefer to stick to tried and tested ways of doing things.	.59
NFCS	Order/Structure	I think that having clear rules and order at work is essential for success.	.57

URS	Cog Uncertainty	I like to have things under control.	.55
NFCS	Order/Structure	I believe orderliness and organization are among the most important characteristics of a good student.	.54
URS	Cog Uncertainty	I try to have my life and career clearly mapped out.	.52
NFCS	Desire Predictability	I prefer to socialize with familiar friends because I know what to expect from them.	.48
URS	Cog Uncertainty	When facing an uncertain situation, I tend to prepare as much as possible, and then hope for the best.	.48
URS	Cog Uncertainty	When uncertain, I act very cautiously until I have more information about the situation.	.47
URS	Cog Uncertainty	Before making any changes, I need to think things over thoroughly.	.46
IUS	Prospective IU	I always want to know what the future has in store for me.	.43
URS	Cog Uncertainty	When I feel a situation is unclear, I try to do my best to resolve it.	.32

Preference for Novelty/Complexity

Scale	Trait/Subscale	Item	FL
URS	Desire for Change	I find the prospect of change exciting and stimulating.	.74
URS	Desire for Change	I enjoy unexpected events.	.71
NFCS	Desire Predictability	I enjoy the uncertainty of going into a new situation without knowing what might happen.	-.66
URS	Desire for Change	New experiences excite me.	.65
MAAS	Complexity/Novelty	I generally prefer novelty over familiarity.	.63
MAAS	Complexity/Novelty	I'm drawn to situations which can be interpreted in more than one way.	.60
URS	Desire for Change	I feel curious about new experiences.	.60

MAAS	Complexity/Novelty	I enjoy tackling problems that are complex enough to be ambiguous.	.58
MAAS	Complexity/Novelty	I often find myself looking for something new, rather than trying to hold things constant in my life.	.56
NFCS	Desire Predictability	I like to have friends who are unpredictable.	-.56
URS	Desire for Change	I easily adapt to novelty.	.56
URS	Desire for Change	I enjoy finding new ways of working out problems.	.55
MAAS	Complexity/Novelty	Some problems are so complex that just trying to understand them is fun.	.55
URS	Desire for Change	Taking chances is part of life.	.54
URS	Desire for Change	A new experience is an occasion to learn something new.	.52
MAAS	Complexity/Novelty	It is more fun to tackle a complicated problem than to solve a simple one.	.51
URS	Desire for Change	There is something exciting about being kept in suspense.	.51
URS	Desire for Change	I like going on holidays with nothing planned in advance.	.47
MAAS	Complexity/Novelty	I tend to like obscure or hidden symbolism.	.45
NFCS	Closed-mindedness	I prefer interacting with people whose opinions are very different from my own.	-.42
NFCS	Desire Predictability	When dining out, I like to go to places where I have been before so that I know what to expect.	-.41
MAAS	Complexity/Novelty	Generally, the more meanings a poem or story has, the better I like it.	.36
MAAS	Complexity/Novelty	I pursue problem situations which are so complex some people call them “mind boggling.”	.33
NFCS	Closed-mindedness	I always see several possible solutions to problems I face.	-.32
NFCS	Closed-mindedness	Even after I've made up my mind about something, I am always eager to consider a different opinion.	-.29

Categorical Thinking

Scale	Trait/Subscale	Item	FL
MAAS	Moral Absolut/Split	You can classify almost all people as either honest or crooked.	.75
MAAS	Moral Absolut/Split	There are basically two kinds of people, the "good" and the "bad."	.75
MAAS	Moral Absolut/Split	There are two kinds of people in the world, the weak and the strong.	.72
MAAS	Moral Absolut/Split	There's a right way and a wrong way to do almost everything.	.63
MAAS	Moral Absolut/Split	A person either knows the answer to a question or he doesn't.	.58
MAAS	Moral Absolut/Split	A person is either 100% patriotic or he isn't.	.55
MAAS	Moral Absolut/Split	Our thinking would be a lot better off if we would just forget about words like "probably," "approximately," "perhaps."	.49
MAAS	Moral Absolut/Split	I dislike questions which could be answered in many different ways.	.46
MAAS	Moral Absolut/Split	Nothing gets accomplished in this world unless you stick to some basic rules.	.44
MAAS	Moral Absolut/Split	A good job is one where what is to be done is always clear.	.42
NFCS	Closed-mindedness	I feel irritated when one person disagrees with what everyone else in a group believes.	.36
NFCS	Discomfort Ambig	In most social conflicts, I can easily see which side is right and which is wrong.	.33
MAAS	Moral Absolut/Split	I do not usually consult many different opinions before forming my own view on an issue.	.29
NFCS	Discomfort Ambig	It's annoying to listen to someone who cannot seem to make up his or her mind.	.28

*Note.* FL = item loading on one factor; NFCS = Need for Closure Scale; MAAS = Multiple Attitudes Toward Ambiguity Scale; IUS = Intolerance of Uncertainty Scale (12 item version); URS = Uncertainty Response Scale.

## Study 2

*Four uncertainty factors (items selected in Study 2)*

<u>Uncertainty Distress</u>			
Scale	Trait/Subscale	Item	FL
IUS	General Distress	Uncertainty makes me vulnerable, unhappy, or sad.	.79
NFCS	Desire Predictability	I dislike unpredictable situations.	.70
IUS	Prospective IU	Unforeseen events upset me greatly.	.68
IUS	General Distress	Uncertainty makes me uneasy, anxious, or stressed.	.68
MAT*	Discomfort Ambig	I get pretty anxious when I'm in a social situation involving me, over which I have little control.	.63
IUS	Inhibitory IU	When I am uncertain, I can't function very well.	.62
IUS	Inhibitory IU	When I am uncertain, I can't go forward.	.62
NFCS	Discomfort Ambig	I become uncomfortable when the rules in a situation are not clear.	.60
IUS	Inhibitory IU	When it's time to act, uncertainty paralyses me.	.60
IUS	Prospective IU	I can't stand being taken by surprise.	.58
IUS	Inhibitory IU	The smallest doubt can stop me from acting.	.57
MAT*	Discomfort Ambig	If I am uncertain about the responsibilities of a job, I get anxious.	.55
NFCS	Discomfort Ambig	I feel uncomfortable when I don't understand the reason why an event occurred in my life.	.53
IUS	General Distress	Uncertainty keeps me from sleeping soundly.	.52

NFCS	Discomfort Ambig	When I am confused about an important issue, I feel upset.	.48
NFCS	Discomfort Ambig	I feel uncomfortable when someone's meaning or intention is unclear to me.	.47
IUS	Inhibitory IU	Being uncertain means that I lack confidence.	.47
NFCS	Predictability	I prefer to socialize with familiar friends because I know what to expect from them.	.45
IUS	Prospective IU	It frustrates me not having all the information I need.	.39
IUS	Prospective IU	A small unforeseen event can spoil everything, even with the best planning.	.36
MAT*	Discomfort Ambig	It disturbs me when I am uncertain of how my actions affect others.	.31

Preference for Structure

Scale	Trait/Subscale	Item	FL
NFCS	Order/Structure	I find that establishing a consistent routine enables me to enjoy life more.	.71
NFCS	Order/Structure	I like to have a plan for everything and a place for everything.	.71
NFCS	Order/Structure	I find that a well ordered life with regular hours suits my temperament.	.70
URS	Cog Uncertainty	I like to plan ahead in detail rather than leaving things to chance.	.69
URS	Cog Uncertainty	I like to know exactly what I'm going to do next.	.69
NFCS	Order/Structure	I enjoy having a clear and structured mode of life.	.68
URS	Cog Uncertainty	I try to have my life and career clearly mapped out.	.64
URS	Cog Uncertainty	I like things to be ordered and in place, both at work and at home.	.61
IUS	Prospective IU	I should be able to organize everything in advance.	.58
NFCS	Order/Structure	I believe orderliness and organization are among the most important characteristics of a good student.	.54

NFCS	Order/Structure	I hate to change my plans at the last minute.	.53
URS	Cog Uncertainty	I prefer to stick to tried and tested ways of doing things.	.53
IUS	Prospective IU	One should always look ahead so as to avoid surprises.	.53
NFCS	Order/Structure	I think that having clear rules and order at work is essential for success.	.52
IUS	Prospective IU	I always want to know what the future has in store for me.	.51
URS	Cog Uncertainty	Before making any changes, I need to think things over thoroughly.	.48
URS	Cog Uncertainty	I feel better about myself when I know that I have done all I can to accurately plan my future.	.46
URS	Cog Uncertainty	I like to have things under control.	.39
URS	Cog Uncertainty	When facing an uncertain situation, I tend to prepare as much as possible, and then hope for the...	.39
URS	Cog Uncertainty	When I feel a situation is unclear, I try to do my best to resolve it.	.31
URS	Cog Uncertainty	When uncertain, I act very cautiously until I have more information about the situation.	.30

Novelty Seeking

Scale	Trait/Subscale	Item	FL
NFCS	Desire Predictability	I enjoy the uncertainty of going into a new situation without knowing what might happen.	-.62
IPIP	Excitement Seeking	I seek adventure.	.59
IPIP	Adventurousness	I dislike change.	.58
IPIP	Adventurousness	I like to try new things.	.52
IPIP	Excitement Seeking	I am willing to try anything once.	.51
IPIP	Excitement Seeking	I take risks.	.50

NFCS	Predictability	I think it is fun to change my plans at the last moment.	-.48
IPIP	Adventurousness	I dislike the unknown.	.47
NFCS	Desire Predictability	I like to have friends who are unpredictable.	-.44
NFCS	Desire Predictability	When dining out, I like to go to places where I have been before so that I know what to expect.	-.40
IPIP	Openness/Intellect	I enjoy hearing new ideas.	.38
NFCS	Closed-mindedness	I always see several possible solutions to problems I face.	-.35
NFCS	Closed-mindedness	Even after I've made up my mind about something, I am always eager to consider a different opinion.	-.33
NFCS	Closed-mindedness	I prefer interacting with people who share my beliefs and opinions.	-.31

Categorical Thinking

Scale	Subscale	Item	FL
Naemi	General IA	I don't like things that have more than one interpretation.	.66
Naemi	Simplistic Thinking	I tend to classify people as either for me or against me.	.64
Naemi	General IA	I hate it when you can't solve a problem right away.	.58
Naemi*	Simplistic Thinking	There's a right way and a wrong way to do almost everything.	.57
NFCS	Closed-mindedness	I feel irritated when one person disagrees with what everyone else in a group believes.	.54
NFCS	Closed-mindedness	I dislike questions which could be answered in many different ways.	.54
Naemi	General IA	I prefer simple problems over complex problems.	.49
Naemi	Simplistic Thinking	Of all the different philosophies which exist in this world there is probably only one which is correct.	.49

Naemi	Simplistic Thinking	Most questions can be answered with a simple yes or no.	.47
Naemi	Simplistic Thinking	There are only a few types of people in this world.	.45
Naemi	General IA	I like things that are plain and easy to understand.	.44
MAT*	General IA	In the final analysis, the correct interpretation of a poem or story is the author's interpretation.	.44
Naemi	General IA	I like it when issues are black and white rather than “shades of grey.”	.44
Naemi	Simplistic Thinking	An expert who doesn't come up with a definitive answer probably doesn't know too much.	.43
NFCS	Discomfort Ambig	It's annoying to listen to someone who cannot seem to make up his or her mind.	.39
NFCS	Closed-mindedness	I do not usually consult many different opinions before forming my own view on an issue.	.37
NFCS	Discomfort Ambig	In most social conflicts, I can easily see which side is right and which is wrong.	.24
MAT*	Categorical Think	Nothing gets accomplished in this world unless you stick to some basic rules.	.19

*Note.* FL = item loading on one factor; NFCS = Need for Closure Scale; MAAS = Multiple Attitudes Toward Ambiguity Scale; IUS = Intolerance of Uncertainty Scale (27 item version); URS = Uncertainty Response Scale; MAT = Measurement of Ambiguity Tolerance; Naemi = items from Naemi et al. (2009); IPIP = International Personality Item Pool.

\*Item also appears in the MAAS.

### Study 3

*Four uncertainty factors (items selected from Study 3)*

<u>Uncertainty Distress</u>			
Scale	Trait/Subscale	Item	FL
IUS	General IU	Uncertainty makes me uneasy, anxious, or stressed.	.73
NFCS	Discomfort Ambig	I don't like situations that are uncertain.	.66
IUS	Prospective IU	Unforeseen events upset me greatly.	.64
IUS	General IU	The ambiguities in life stress me.	.61
IUS	Inhibitory IU	When it's time to act, uncertainty paralyzes me.	.61
IUS	Inhibitory IU	When I am uncertain, I can't function very well.	.59
	Worry	The thought of making mistakes in my work worries me.	.58
IUS	General IU	Uncertainty makes me vulnerable, unhappy, or sad.	.58
IUS	Inhibitory IU	The smallest doubt can stop me from acting.	.57
MAT*	Discomfort Ambig	If I am uncertain about the responsibilities of a job, I get anxious.	.54
IUS	Inhibitory IU	Uncertainty keeps me from living a full life.	.54
NFCS	Discomfort Ambig	When I am confused about an important issue, I feel upset.	.54
IUS	Inhibitory IU	Uncertainty stops me from having a strong opinion.	.53
MAT*	Discomfort Ambig	I get pretty anxious when I'm in a social situation involving me, over which I have little control.	.51
IUS	General IU	Uncertainty keeps me from sleeping soundly.	.51

MAT*	Discomfort Ambig	It bothers me when I don't know how other people react to me.	.45
NFCS	Discomfort Ambig	I feel uncomfortable when someone's meaning or intention is unclear to me.	.44
IUS	Inhibitory IU	When I am uncertain, I can't go forward.	.43
NFCS	Discomfort Ambig	I feel uncomfortable when I don't understand the reason why an event occurred in my life.	.39
IUS	Prospective IU	It frustrates me not having all the information I need.	.37

Preference for Structure

Scale	Trait/Subscale	Item	FL
NFCS	Order/Structure	I like to have a plan for everything and a place for everything.	.70
URS	Cog Uncertainty	I like to know exactly what I'm going to do next.	.70
URS	Cog Uncertainty	I like to plan ahead in detail rather than leaving things to chance.	.69
IUS	Prospective IU	I should be able to organize everything in advance.	.65
NFCS	Order/Structure	I find that establishing a consistent routine enables me to enjoy life more.	.65
URS	Cog Uncertainty	I try to have my life and career clearly mapped out.	.64
NFCS	Order/Structure	I enjoy having a clear and structured mode of life.	.62
NFCS	Order/Structure	I find that a well ordered life with regular hours suits my temperament.	.61
NFCS	Order/Structure	I hate to change my plans at the last minute.	.58
URS	Cog Uncertainty	Before making any changes, I need to think things over thoroughly.	.56
IUS	Prospective IU	I always want to know what the future has in store for me.	.51
URS	Cog Uncertainty	When uncertain, I act very cautiously until I have more information about the situation.	.50
NFCS	Order/Structure	I think that having clear rules and order at work is essential for success.	.49

URS	Cog Uncertainty	I prefer to stick to tried and tested ways of doing things.	.49
IUS	Prospective IU	One should always look ahead so as to avoid surprises.	.45
URS	Cog Uncertainty	I like to have things under control.	.38
NFCS	Desire Predictability	I prefer to socialize with familiar friends because I know what to expect from them.	.25
URS	Cog Uncertainty	When I feel a situation is unclear, I try to do my best to resolve it.	.17

Novelty Seeking

Scale	Trait/Subscale	Item	FL
CEI	Curiosity/Exploration	I prefer jobs that are excitingly unpredictable.	.67
NFCS	Desire Predictability	I enjoy the uncertainty of going into a new situation without knowing what might happen.	.65
CEI	Curiosity/Exploration	I am the type of person who really enjoys the uncertainty of everyday life.	.64
IPIP	Excitement Seeking	I seek adventure.	.63
CEI	Curiosity/Exploration	I am the kind of person who embraces unfamiliar people, events, and places.	.57
CEI	Curiosity/Exploration	I like to do things that are a little frightening.	.56
IPIP	Adventurousness	I prefer variety to routine.	.53
CEI	Curiosity/Exploration	I am always looking for experiences that challenge how I think about myself and the world.	.52
ECI	Epistemic Curiosity	I enjoy exploring new ideas.	.47
CEI	Curiosity/Exploration	Everywhere I go, I am out looking for new things or experiences.	.44
URS	Desire for Change	There is something exciting about being kept in suspense.	.44
NFCS	Desire Predictability	I like to have friends who are unpredictable.	.43

NFCS	Desire Predictability	When dining out, I like to go to places where I have been before so that I know what to expect.	.41
CEI	Curiosity/Exploration	I view challenging situations as an opportunity to grow and learn.	.41
ECI	Epistemic Curiosity	I enjoy learning about subjects that are unfamiliar to me.	.35
MSTAT	General IA	I generally prefer novelty over familiarity.	.34
MSTAT *	General IA	I enjoy tackling problems that are complex enough to be ambiguous.	.31
NFCS	Closed-mindedness	I always see several possible solutions to problems I face.	.26
NFCS	Closed-mindedness	Even after I've made up my mind about something, I am always eager to consider a different opinion.	.13

#### Categorical Thinking

Scale	Subscale	Item	FL
Naemi	Simplistic Thinking	I tend to see most issues in black and white terms.	.64
Naemi	General IA	I like it when issues are black and white rather than “shades of grey.”	.58
Naemi	General IA	I don't like things that have more than one interpretation.	.52
EBI	Naïve Epistemic Bel	Too many theories just complicate things.	.51
MAAS	Moral Absolut/Split	There are basically two kinds of people, the "good" and the "bad."	.50
Naemi	Simplistic Thinking	A good job is one where what is to be done is always clear.	.49
AOT	Closed-mindedness	Changing your mind is a sign of weakness.	.47
EBI	Naïve Epistemic Bel	If two people are arguing about something, at least one of them must be wrong.	.44
MAAS	Moral Absolut/Split	A person either knows the answer to a question or he doesn't.	.43
DOG	Dogmatism	The things I believe in are so completely true, I could never doubt them.	.42

EBI	Naïve Epistemic Bel	If you don't learn something quickly, you won't ever learn it.	.38
MAAS	Moral Absolut/Split	There's a right way and a wrong way to do almost everything.	.37
Naemi	Simplistic Thinking	Most questions can be answered with a simple yes or no.	.36
NFCS	Closed-mindedness	I dislike questions which could be answered in many different ways.	.36
NFCS	Closed-mindedness	I feel irritated when one person disagrees with what everyone else in a group believes.	.35
NFCS	Discomfort Ambig	In most social conflicts, I can easily see which side is right and which is wrong.	.32
NFCS	Closed-mindedness	I do not usually consult many different opinions before forming my own view on an issue.	.28
MAAS	Moral Absolut/Split	Our thinking would be a lot better off if we would just forget about words like "probably," "appr..."	.25
NFCS	Discomfort Ambig	It's annoying to listen to someone who cannot seem to make up his or her mind.	.24

*Note.* FL = item loading on one factor; NFCS = Need for Closure Scale; MAAS = Multiple Attitudes Toward Ambiguity Scale; IUS = Intolerance of Uncertainty Scale (27 item version); URS = Uncertainty Response Scale; MSAT = Multiple Stimulus Types Ambiguity Tolerance Scale-II; MAT = Measurement of Ambiguity Tolerance; Naemi = items from Naemi et al. (2009); IPIP = International Personality Item Pool; EBI = Epistemic Belief Inventory; AOT = Actively Open-Minded Thinking Beliefs Scale; DOG = DOG Scale; CEI = Curiosity and Exploration Inventory-II; ECI = Epistemic Curiosity Inventory.

\*Item also appears in the MAAS.

*Intolerance of Ambiguity (items selected in Study 3)*

Scale	Trait/Subscale	Item	FL
NFCS	Discomfort Ambig	I dislike it when a person's statement could mean many different things.	.68
Naemi	General IA	I hate it when you can't solve a problem right away.	.65
Naemi	General IA	I don't like things that have more than one interpretation.	.62
NFCS	Discomfort Ambig	I don't like situations that are uncertain.	.59
Naemi	Simplistic Thinking	I tend to see most issues in black and white terms.	.55
Naemi	General IA	I like it when issues are black and white rather than "shades of grey."	.50
NFCS	Discomfort Ambig	I become uncomfortable when the rules in a situation are not clear.	.49
new	Pref for Complexity	I prefer works of art or literature that have multiple layers of meaning.	.45
CTI	Categorical Thinking	I tend to classify people as either for me or against me.	.44
NFCS	Discomfort Ambig	It's annoying to listen to someone who cannot seem to make up his or her mind.	.42
NFCS	Discomfort Ambig	When I am confused about an important issue, I feel upset.	.42
NFCS	Discomfort Ambig	I feel uncomfortable when someone's meaning or intention is unclear to me.	.41
Naemi	General IA	I like movies with clear cut endings.	.41
new	Pref for Complexity	I get more satisfaction from literature, artwork, or films that can be analyzed in several different ways.	.40
Naemi	General IA	I don't like to work on a problem unless there's a possibility of coming out with a clear cut answer.	.39
NFCS	Discomfort Ambig	I feel uncomfortable when I don't understand the reason why an event occurred in my life.	.39
MAT*	Discomfort Ambig	If I am uncertain about the responsibilities of a job, I get anxious.	.39

NFCS	Discomfort Ambig	I like to know what people are thinking all the time.	.37
MAAS	Moral Absol/Split	There are basically two kinds of people, the "good" and the "bad."	.37
MAT*	Discomfort Ambig	I am just a little uncomfortable with people unless I feel that I can understand their behavior.	.35
MAT*	Discomfort Ambig	It bothers me when I don't know how other people react to me.	.35
MAT*	Discomfort Ambig	I get pretty anxious when I'm in a social situation involving me, over which I have little control.	.31
Naemi*	Simplistic Thinking	Most questions can be answered with a simple yes or no.	.31
NFCS	Discomfort Ambig	I would rather know the bad news than stay in a state of uncertainty.	.26

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*Note.* FL = item loading on one factor; NFCS = Need for Closure Scale; MAAS = Multiple Attitudes Toward Ambiguity Scale; MAT = Measurement of Ambiguity Tolerance; Naemi = items from Naemi et al. (2009); CTI = Constructive Thinking Inventory.

\*Item also appears in the MAAS.

*Effort Aversion*

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	FL
1. When performing cognitively demanding tasks, I get tired relatively quickly.	.75
2. I have trouble sustaining mental effort for long periods of time.	.75
3. During difficult tasks, I tend to experience mental fatigue very quickly.	.73
4. I try to avoid activities that demand a lot of mental effort.	.71
5. I find cognitively demanding activities stressful and unpleasant.	.69
6. Whenever I have to think hard, I tend to lose interest in what I'm doing.	.66
7. I would describe myself as "cognitively lazy"; someone who doesn't like to do a lot of thinking.	.66
8. Thinking long and hard stresses me out at times.	.38

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*Note.* FL = item loading on one factor.

## Appendix B: Scoring Methods for the Choice Rate Data

Although the default approach to scoring the choice rate data is to take the mean proportion of low-ambiguity selections, there are at least two potential drawbacks to this method. One is that the resulting variable may consist of individual differences in two possible preferences: one for the easier condition and one for the harder condition. If one is strictly interested in measuring preference for the easier condition, then I would argue that any choice rate below .50 represents noise because .50 is the rate at which one is expected to choose the easier condition due to chance (i.e., without preference). The second drawback is that the mean proportion method ignores the order and sequence of choices, which may provide useful information as to whether or not there was a preference. To illustrate the issue, consider the difference between these two strings of choices, where 1 is coded as choosing the easier condition: (A) 11010101, (B) 01011111; although both have the same mean, string A suggests no preference (i.e., alternating equally between options), whereas string B shows that a consistent preference emerged by the end of the block.

I compared the validity and reliability of the mean-proportion method with those of two other methods addressing the concerns noted. The first alternative was to replace any individual proportion below .50 with .50 before averaging the proportions across the 5 blocks, and the second was to average the proportions of *consecutive* low-ambiguity selections. Consecutive selections were counted as long as they reached a minimum of 3 and were not succeeded by more than 2 high-ambiguity selections, which would imply that there was no clear preference (e.g., '00111011' fits this criterion but '11101100' does not). Convergent validity was indicated by the correlations between the choice rates for each task and between the choice rate and the rate of use of the pass option, and internal consistency reliability was estimated using Cronbach's alpha. Although convergent correlations did not appear to be very different across the three methods, the value-replaced and consecutive scores were considerably more reliable, as shown in Table B1. I ultimately decided to use the value-replaced scores, as they have a more transparent interpretation and do not reflect any arbitrary decision as to what counts or does not count as a preference.

Table B1

*Alpha Reliability Estimates for Three Alternative Choice Rate Scores*

	MP	MPr	CMP
<b>Majority task</b>			
Implicit choice rate	.80	.88	.87
Explicit choice rate	.49	.64	.64
<b>Brightness task</b>			
Implicit choice rate	.64	.78	.80
Explicit choice rate	.53	.66	.68

*Note.* MP = mean proportions; MPr = mean proportions with replaced values; CMP = consecutive mean proportions.

## Appendix C: Additional Questions Under Investigation

### 1. Are the four factors uniquely predictive of political conservatism?

Fortunately, I collected data on political orientation in all three studies that can be used to answer this question. In Studies 1 and 3, US participants were asked to rate their general political outlook on social and economic issues, as well as their overall political orientation, on a scale from 1 to 7 (“very liberal” to “very conservative”), and these 3 ratings were averaged to obtain a single variable reflecting conservatism. In Study 2, only overall political orientation was measured. For each sample, conservatism was first regressed on NFC, IA, and IU, individually, with age and gender as covariates; then, it was regressed on age, gender, and the four factors (note that their measurement varied somewhat from sample to sample).

Results showed, first of all, that across samples, conservatism was inconsistently related to NFC ( $r = .15/.00/.09$ , for samples from studies 1-3, respectively; bolded coefficients are significant at  $p < .05$ ) and unrelated to IA and IU. Second, conservatism was predicted by Categorical Thinking ( $\beta = .43/.20/.23$ ) and Uncertainty Distress ( $\beta = -.16/-.35/-.17$ ), with Preference for Structure showing an inconsistent relationship ( $\beta = .05/.20/.15$ ), and Preference for Novelty/Complexity showing no relationship. However, when two aspects of Novelty/Complexity were added to the model separately (Study 1 sample only), Preference for Complexity was a weak, negative predictor ( $\beta = -.13$ ).

Bearing in mind that these are informal and unaggregated results, based mostly on undergraduate samples, they provide a much more nuanced picture of the conservative personality than one that is informed solely by traits like NFC. The picture that emerges is that conservative individuals tend to be unsophisticated thinkers, lacking in intellectual curiosity, who may prefer routine and structure in their lives, yet who are also more emotionally stable (than their liberal counterparts) in the face of threat and uncertainty. The lower levels of Uncertainty Distress of conservative individuals, in particular, may account for the weak or non-existent relationship found between conservatism and NFC, IA, and IU in the present analysis.

Interestingly, the pattern of associations I found appears to be consistent with some of the effect sizes reported by Jost, Sterling, and Stern (2017) in an updated meta-analysis involving 181 distinct samples. They reported a large average effect size for dogmatism ( $r = .51$ ), which is conceptually cut from the same cloth as Categorical Thinking, a smaller average effect size for “personal need for order and structure” ( $r = .18$ ), which maps onto Preference for Structure, and a small, negative effect size for Need for Cognition ( $r = -.09$ ), which is similar to Preference for Complexity.

## 2. Does aversion to uncertainty differentiate Orderliness from Industriousness?

Study 1 provides suggestive, correlational evidence that this may be the case: correlations between Orderliness and NFC/IA/IU ranged from .20 to .61, compared to -.20 to 0 for Industriousness. A more definitive answer, however, can be reached using the bifactor (CFA) model from Study 1, which assessed the latent correlations among the general factors of the NFCS and other scales. If the variation that is unique to Orderliness represents individual differences in aversion to uncertainty, then it should be no different from the variation common to all these scales.

To test this hypothesis, I conducted another CFA using Study 1 data, in which Orderliness was measured as a latent variable with three facets—planfulness, tidiness, and perfectionistic attention to detail. Items for these facets came from the IPIP resource and they were aggregated into 3 parcels per facet. Like the rest of the instruments, Orderliness was specified as a general bifactor with three specific factors per facet. In turn, Industriousness was specified as a separate factor with items from BFAS (pooled into 3 parcels), and it was specified to explain the residual variance shared by the items of Orderliness; this specification meant that the variance Orderliness shares with Industriousness was partialled out of its measurement. Additionally, correlations were specified between Orderliness and all the other general factors representing NFC (etc.), and Industriousness was allowed to correlate with the facets of the other instruments. This model showed a close fit to the data ( $p$ -close > .05), and results revealed that Orderliness had correlations ranging from .90 to 1 with the other general factors, whereas these correlations were below .90 when it was allowed to correlate with Industriousness (i.e., without any variance partialled out). In short, these results confirmed that what is unique to Orderliness is that it taps aversion to uncertainty.

In future investigations, this analysis may also be extended to the cases of Obsessive-Compulsive Disorder (OCD) and Obsessive Compulsive Personality Disorder (OCPD), which can be characterized to a certain degree as extreme manifestations of Orderliness. Pathological doubt—the lack of subjective certainty about one's perceptions and internal states—is generally considered one of the major features of OCD/OCPD, and more than a handful of articles have either hypothesized or established a relationship between these disorders and IU or similar traits (e.g., Gallagher, South, & Oltmanns, 2003; Samuels et al., 2017; Tolin, Abramowitz, Brigidi, & Foa, 2003). It is therefore of clinical relevance to understand the strength of the relationship between these disorders and dispositional aversion to uncertainty.