Measurement and Characterisation of Individual Differences in
Need for Cognition

by

Mathew Ling
BA/BSc, GDipPsych

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Executive Summary

Need for Cognition (NFC) is a widely utilised construct in the psychological literature, however the construct itself is poorly understood. While the progenitors of the widely utilised self-report scale describe the construct as reflecting individual differences in the tendency to engage in and enjoy effortful cognition, there is no consensus on the specific motivation underpinning these differences. A clear model of this individual difference would allow for accurate prediction of the conditions under which this tendency is most strongly manifest, but also how it might be promoted. This thesis seeks to develop a more complete representation of what it is to vary in NFC though systematic review of the literature regarding the NFC scale’s dimensionality; empirical evaluation of the factorial structure of the NFC scale in two samples; and examination of the proximate behavioural products of NFC in both lab settings and ecological contexts.

Through evaluation of the literature it was found that while the measure is generally treated as unidimensional, there is a trend for studies using true factor analysis methodologies finding multifactorial solutions. However, within studies using these, no consistent factorial solution was found, possibly due to methodological variation between these studies.

To address this, factor analysis was conducted on the full-length scale in two independent samples using consistent methodology. As such, consistency (or lack thereof) in the factorial solutions derived in the two samples should reflect either the presence of replicable factors or demonstrate that previously observed multifactorial solutions are a function of incomplete optimisation of the NFC scale. Results favoured the latter, suggesting that there is one replicable factor in the NFC scale reflecting tendency to engage in effortful cognition; this duly did not provide insight into the drivers of this behaviour.

Further insight into the motivation underpinning NFC was sought, specifically evaluating the model of NFC as differences in enjoyment of the process of effortful
cognition. In a controlled (lab) setting, NFC was shown to not be associated with either the persistence with puzzle tasks or enjoyment of educational videos, suggesting that the impact of NFC on engagement might not be as universal as would be expected if it indexed the degree to which effortful cognition was intrinsically enjoyable.

To obtain a better understanding of NFC outside of lab settings, an Ecological Momentary Assessment (EMA) study was undertaken, examining the frequency and quality of engagement in effortful cognition in real-world contexts. This further permitted the validation of the prior study’s findings. The results of this study show that the NFC scale predicts engagement in effortful cognition in ecological settings, but none of the enjoyment thereof, effort invested, or the attribution to internal causes, despite there being individual differences in tendency for these latter outcomes.

This program of research therefore is able to conclude that the 18-item short form scale is better considered as an optimised measure, where the longer measures are liable to include additional error. Further, while individual differences exist in the tendency to engage in effortful cognition, the enjoyment thereof, as well as the investment of effort and attribution bias for this engagement, the NFC scale only predicts engagement. While these results particularly do not support the enjoyment of process account of intrinsic motivation in NFC, more broadly they suggest that differences in behaviour associated with NFC may be driven by both intrinsic and extrinsic motivations. Potential avenues for promoting effortful cognition remain through the increased exposure to complex cognitive tasks.
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Chapter 1

General Introduction

As individuals vary in generalised cognitive ability, they may also vary in their level of general cognitive engagement; that is to say, while individuals may invest more or less cognitive effort based on the nature of the task, some are inclined to invest more effort in all tasks generally. This variability in thoughtfulness or cognitive elaboration has been characterised in terms of “investment traits” (von Stumm & Ackermann, 2013), and is increasingly recognised as important to the development and characterisation of adult intelligence and intellectual competence (Ackerman, 1996; von Stumm, Chamorro-Premuzic & Ackerman, 2011; von Stumm, Hell & Chamorro-Premuzic, 2011). Among these investment traits, and characterised as reflecting investment broadly (von Stumm & Ackerman, 2013), is the widely utilised Need for Cognition (NFC; Cacioppo & Petty, 1982; Cacioppo, Petty, Feinstein, & Jarvis, 1996).

NFC, typically defined as an individual difference in tendency for an individual to engage in and enjoy effortful cognition (e.g., Cacioppo & Petty, 1982), has specifically been shown to associate with a range of desirable cognitive performance outcomes. These include improved complex skill acquisition (Day, Espejo, Kowollik, Boatman, & McEntire, 2007; Espejo, Day, & Scott, 2005) and problem solving (Nair & Ramnarayan, 2000); more information (Levin, Huneke, & Jasper, 2000) and reduced heuristic use (Carnevale, Inbar & Lerner, 2011) use in decision making; and greater perceived interpersonal persuasiveness (Shestowsky & Horowitz, 2004; Shestowsky, Wegener, & Fabrigar, 1998). These diverse outcomes are made more pertinent by the moderate association between NFC and intelligence (Fleischhauer et al., 2010; Hill et al., 2013; von Stumm & Ackerman, 2013). As such, understanding differences in investment traits and NFC in particular is likely to have implications for intellectual competence broadly, but also may be important in understanding
responses to social issues like crime and punishment (Sargent, 2004), or selecting better candidates for management (Carnevale et al., 2011) or advanced education (Meier, Vogl & Preckel, 2014).

That noted, NFC is itself not wholly characterised, with no singular model of the motivation which causes the associated differences in behaviour, the development of these differences, or its lived experience. This research program will endeavour to characterise the individual differences in NFC so as to provide insights into the types of outcomes it may predict, the conditions under which it may be moderated, but also how it might be promoted. This chapter will briefly review the literature on NFC to establish the current understanding of the nature of the construct through its history, relationship to other variables and theoretical models.

**History and Definitions**

The term NFC was originally used by Cohen, Stotland and Wolfe (1955), where they defined it as a desire to meaningfully structure one’s experiences. This initial conceptualisation waned until, finding that no copy of Cohen et al.’s original measurement instrument existed, Cacioppo and Petty (1982) developed their own measure, attempting to capture the original construct. Cacioppo and Petty (1982) conceptualised NFC initially as a statistical tendency or likelihood for effortful cognition, before adopting the widely accepted and broader definition as the tendency to both engage in and enjoy effortful cognition. This construct had significant impact within their program of research on the Elaboration Likelihood Model of persuasion (Petty, Cacioppo & Morris, 1983), as a factor determining the likelihood of processing a persuasive message centrally (i.e., utilising more cognitive resources to evaluate the argument quality) versus peripherally (i.e., relying on heuristic processing of positive or negative cues; Cacioppo & Petty, 1982; Petty et al., 1983). Since the development of this measure and the subsequent development of a short form scale
(Cacioppo, Petty & Kao, 1984), researchers have applied the construct to a variety of other contexts.

In a 1996 review of over 100 studies, Cacioppo et al. indicated that the new version of the construct was somewhat divergent from the original definition proposed by Cohen et al. (1955). Specifically, they felt the initial construct was more akin to the need for structure (the need to simplify one’s perceived reality; Neuberg & Newsom, 1993) and need for cognitive closure (the need to have an answer, potentially at the expense of accuracy; Webster & Kruglanski, 1994). These variables have been found to be weakly and even negatively correlated with the more recent iteration of NFC (Neuberg & Newsom, 1993; Webster & Kruglanski, 1994). Further, in 2005 Petty, Cacioppo, Strathman and Priester defined their modern NFC as simply “the tendency for people to enjoy thinking or not” (p. 94), demonstrating the importance of enjoyment to the modern construct and the variability over time in its definition.

The impact of NFC on behaviour is best understood within the context of the Elaboration Likelihood Model amidst which it was developed. This model acknowledges the importance of situational factors, such as personal relevance (Petty & Cacioppo, 1979; Petty, Cacioppo & Schumann, 1983), as well as dispositional factors like NFC in determining the likelihood of engaging in elaborative cognition. This is consistent with the conceptualisation of humans as ‘motivated tacticians’, who are selective in their application of cognitive effort (Fiske & Taylor, 1991). However, the value of NFC is made clearer within the conceptualisation of people as ‘cognitive misers’ who, all things being equal, will minimise cognitive effort (Cacioppo, et al., 1996; Cacioppo, et al., 1986). In this light, NFC represents a generalised individual difference (i.e., independent of contextual demands) in ‘cognitive miserliness’; duly, while all individuals may selectively invest effort, those higher in NFC
might more chronically engage in high-effort cognition while whose lower might be more situationally determined.

Subsequent research, however, has suggested that this understanding may be insufficiently complex to account for the variability in the behaviour of those varying in NFC. For example, while NFC may be positively associated with effortful cognition generally, individuals high in NFC can be situationally induced into applying less cognitive effort by extrinsic rewards (Thomson, Chaiken & Hazelwood, 1993), perceiving a task as simple (See, Petty & Evans, 2009; Wheeler, Petty & Bizer, 2005), or other unmeasured factors (Shestowsky & Horowitz, 2004). Overall, this highlights the importance of understanding variability in NFC in a manner which considers what causes dispositional differentiation in engagement in effortful cognition.

In addition, the study of these behaviours is focussed primarily on cross-sectional associations with either distal outcomes such as academic performance (see von Stumm & Ackermann [2013] or Richardson, Abraham & Bond [2013] for review and meta-analysis) or laboratory tasks (e.g. Lassiter, Briggs & Slaw, 1991; Leding, 2011), particularly many relating to persuasion (e.g. Cacioppo et al., 1986; Haugetvedt, Petty & Cacioppo, 1992). As such, the relationship between NFC and naturalistic outcomes and also the broader lived experience of those varying in NFC is not clearly characterised.

In sum, while NFC has been applied to many different areas of investigation and appears to have potential for broad individual and social impacts, in and of itself it is not well understood, particularly its underlying motivation and phenomenology. There is some research that could, in principle, provide insight into the nature of NFC, examining the correlation with other investment traits, fundamental correlates, and motivation models.
Relationship to Other Investment Traits

As noted earlier, NFC is one of an array of investment traits including Typical Intellectual Engagement (TIE; Goff & Ackerman, 1992), epistemic curiosity (Litman, 2008), openness to experience (McCrae & Costa, 1987), and others. These are each characterised by investment (von Stumm & Ackerman, 2013) or intellect (Mussel, 2013), which is the tendency to find opportunity for, engage in, and enjoy effortful cognitive activity. If these similarities in behavioural correlates reflect a common causation, insights into the drivers of any of these constructs represents insights into all; however, the ontogeny and nature of these related variables are also incompletely characterised. Furthermore, common outcomes such as the engagement in effortful cognition are not necessarily indicative of common causation.

What is shown is, while there is substantial overlap, there is also some heterogeneity within the interrelations of these variables. NFC and TIE, identified as indicators of core investment (von Stumm & Ackerman, 2013), have been shown to be substantially redundant (Mussel, 2010; Woo, Harms & Kuncel, 2007) along with epistemic curiosity (Mussel, 2010), but the relationship between NFC and openness is more mixed. NFC is strongly associated with openness to experience largely as a function of strong association with the openness to ideas facet (Fleischhauer et al., 2010; Mussel, 2010). However, these are not wholly redundant, instead reflecting the Openness/Intellect distinction (DeYoung, 2014; Nusbaum & Silvia, 2011), with NFC reflecting more investment of effort and goal focus while openness to ideas reflecting more novelty and sensation seeking behaviours (Fleischhauer et al, 2010).

Relationship to Pre-Contemplative Variables

Examination of more fundamental correlates of NFC provides a different form of insight into the construct. In particular, differences in neurological responses or pre-contemplative behaviours may indicate processes that pre-empt elaborative behaviour and duly may have explanatory value. Studies in this domain demonstrate that the NFC scale is
positively associated with both neurological responses to auditory stimuli characterised as reflecting voluntary and reflective orientation of attention (Enge, Fleischhauer, Brocke & Strobel, 2008; Strobel, Fleischhauer, Enge & Strobel, 2015) and focus on goal-relevant characteristics of stimuli in visual masking paradigms (Fleischhauer, Miller, Enge & Albrecht, 2014). This suggests that not only is NFC indicative of differences in the perception of stimuli, but some component of this processing is bottom-up or automatic; duly, engagement in behaviour might be driven in part by perceptual and attentional processes rather than conscious motivation or a generalised preference for effortful cognition.

Examination of preconscious correlates of NFC has also identified a distinction between implicit NFC, measured by Implicit Association Test (IAT), and the self-reported, explicit NFC (Fleischhauer et al, 2012). This independent implicit NFC which predicts reflexive or automatic application of cognitive effort (e.g. improved peripheral recall) is beyond the scope of this research program. However, the research into this construct has provided additional characterisation of the explicit NFC as predicting controlled, reflective behaviours (e.g. deliberate information searching) only, and not these automatic behaviours associated with implicit NFC (Fleischhauer et al, 2012; Fleischhauer et al., 2015). Overall, this suggests that while there may be automatic processes in attention allocation associated with self-reported NFC\(^1\), differences in effortful cognition will likely be governed also by the reflective processes specified in dual-system models like the Associative-Propositional Evaluation model (Gawronski & Bodenhausen, 2007) or the Reflective-Impulsive Model (Strack & Deutsch, 2004).

\(^1\) For brevity, NFC will henceforth be used primarily to refer to the explicit, self-reported NFC. Where implicit NFC is discussed it will be specifically identified as such.
**Theoretical Models**

Research directly attempting to characterise motivational differences underlying NFC represents only a small fraction of the literature on NFC, describing the motivation as an enjoyment of process, self-schema adherence (Wheeler et al., 2005), avoidance of punishment (Steinhart & Wyer, 2009), or manifestation of an inherent drive for self-development (Thompson et al., 1993). However, no strongly supported, consensus representation of this motivation has been reached.

Most commonly, the NFC scale has been characterised as indexing the “process oriented” (Cacioppo et al., 1996, p.199) tendency to “enjoy thinking or not” (Petty et al., 2005, p. 94) and “the extent to which effortful thinking is intrinsically reinforcing” (Cacioppo et al., 1996, p. 246). This implies that a domain-general enjoyment of effortful thought for its own sake may motivate behaviour. It has been further posited that such enjoyment is derived through extensive prior experience with effortful problem solving initially driven by idiosyncratic, goal-directed motives such as a need to control one’s environment or need to evaluate (Cacioppo et al., 1996). However, while a difference in the generalised enjoyment of effortful cognition would account for the diversity of outcomes, there is limited direct evidence for such a difference. The Cacioppo et al. (1996) review demonstrated that the association between NFC and enjoyment of cognitive tasks is weak on average and highly variable (with correlation estimates ranging from 0 to 0.45). A more recent study has indicated that enjoyment is highest for those moderate in NFC, and lower in those both high and low in NFC (Knobloch-Westerwick & Keplinger, 2008). Additionally, while an interaction with complexity has been proposed, where high NFC individuals enjoy more complex tasks and low NFC more simple tasks (Cacioppo and Petty, 1982), there is not a simple positive relationship between complexity and enjoyment for high NFC individuals or negative relationship for those low in NFC (Knobloch-Westerwick & Keplinger, 2008).
As noted earlier, the fact that where a message is perceived as being low in complexity individuals high in NFC engage in less effortful processing than low NFC individuals (See et al., 2009) suggests a more complex mechanism. It may be that trait-like enjoyment of process is overwhelmed by situational factors, or NFC may be characterised by other sources of motivation including the adherence to self-schemas (Wheeler et al., 2005), avoidance of failure (Steinhart & Wyer, 2009) and inherent drive for positive growth as per Self Determination Theory (SDT; Thompson et al., 1993). Each of these accounts has some empirical support, though as with the enjoyment based model, it is unclear whether these accounts are sufficient as a complete representation of the motivation underpinning NFC.

Self-Schema Matching

The self-schema matching account proposes that NFC reflects a self-representation as a person who bases their decision on consideration and thought and evaluates others with respect to intellect (Wheeler et al, 2005). Markus (1977) proposes self-schemata broadly are derived from one’s past experiences and thereafter are used to inform the attending to, and processing of, self-related information. That is to say, as a function of prior experiences with effortful cognition, individuals internalise a self-representation as being inclined to engage with effortful cognition or not and enact this in future episodes. It is therefore posited by Wheeler et al. (2005) that individuals will attend and invest effort where the complexity of a task matches an individuals’ NFC; that is, High NFC individuals elaborate on complex tasks and low NFC individuals elaborate on simple tasks.

This is supported with regards to the attending to quality of arguments in persuasive messages (Wheeler et al, 2005), even where the message complexity is held constant and individuals are only primed to expect differences (See et al., 2009). However, this does not account for low NFC individuals showing better argument discrimination than high NFC individuals when the message is not differentially primed (e.g. Shestowsky & Horowitz,
2004). Further, to explain typical effects of NFC, this model requires individuals generally assume information or tasks to be complex, suggesting no relationship between NFC and perceptions of complexity. Within See et al.’s second study (2009), NFC was inversely correlated with perceived complexity, though it did not overcome the complexity manipulation. If this relationship between NFC and perception of complexity is representative, then a self-schema matching account may predict lower elaboration by high NFC individuals and higher elaboration by low NFC individuals in settings absent such manipulations. Equally, as suggested by See et al, these matching effects could be explained by differential trust in simplicity or complexity for those varying in NFC.

**Differences in Extrinsic Motivation**

Steinhart and Wyer (2009) observed that individuals higher in NFC report or demonstrate more avoidance motives when specifically anticipating failure, notably this change in motivation did not manifest when told that the relevant challenges would be difficult but solvable. Steinhart and Wyer posit this avoidance of failure as only one component of the motivational differences in NFC, while a more generalised intrinsic motivation is the dominant cause of outcomes as many demonstrated effects of NFC occur in the absence of failure cues (e.g. Lassiter et al., 1991).

**Self Determination Theory**

Thompson et al. (1993) explored SDT (Deci & Ryan, 2000) as a model of NFC, characterising NFC as a manifestation of the innate drive for growth posited within this theory that is contingent on needs for autonomy, relatedness and competence being met. Specifically, this study demonstrated that NFC-associated free engagement in effortful tasks was reduced by the provision of external rewards; this effect was attributed to the undermining of perceived autonomy. However, this same study demonstrated that effects of NFC could be accounted for by Desire for Control (Burger & Cooper, 1979) which was
strongly associated with NFC. This raises further uncertainty as to whether NFC is indicative of a more abstract motivation, or specific goal-directed motivation such as a desire to control one’s life.

In sum, while the literature has provided some broad insights into NFC and some more specific models for the motivation which drives differences in behaviour, there is limited direct support for any particular account. In the absence of a clearer representation of NFC, it is difficult to be confident of which behaviours NFC will predict, the conditions under which this can be undermined, as well as any meaningful attempts to foster the construct. Duly, efforts must be made to better characterise NFC. Given there is only one broadly accepted means of assessing NFC, the self-reported scale, the measurement of the construct is central to any attempt to characterise these differences. As such, it is worthwhile considering the degree to which the measure itself may reveal additional insights into the construct.

While the scale was not created with theoretical underpinnings in mind and was posited as a unidimensional measure, consistent with the initial conceptualisation as a tendency to think (Cacioppo & Petty, 1982), a number of prior studies have observed multifactorial structures for the NFC scale (Davis, Severy, Kraus & Whitaker, 1993; Furnham & Thorne, 2013; Lord & Putrevu, 2006; Tanaka, Panter & Winborne, 1988). This could be a function of incomplete optimisation in the full scale or may indicate meaningful sub-factors, reflecting key features in NFC (e.g., self-efficacy, need for understanding). Where this is a function of residual variance, failure to resolve this represents an impediment to progress in better characterising NFC; alternately, meaningful sub-factors may indicate a particular model for NFC. For example, where self-efficacy and autonomy factors exist within the NFC scale and contribute to the prediction of behaviour by the scale as a whole, this may suggest a SDT account of motivation. In either instance, any uncertainty regarding the measurement of
NFC undermines attempts to comprehend and foster levels of cognitive engagement and duly, this represents the most pressing priority for research into the nature of NFC.

Overall, there remains a need to develop a richer understanding of NFC in terms of how it is measured, manifest and experienced on which to found subsequent investigations into its causes and outcomes. This thesis will further develop that understanding of NFC, focussing on the traditional self-reported, explicit form of the construct with a view to understanding what drives individuals to dispositionally vary in their engagement in effortful cognition. As measurement issues are likely to confound all other avenues, the first objective of this program is to address the previously discussed uncertainty in the factorial structure of the NFC scale, first by examination of the existing literature and secondly by empirical investigation of the structure of the measure.
References


Chapter 2

Systematic Literature Review on the Dimensionality of Need for Cognition

As discussed in Chapter One, given the wide-reaching applications of self-reported NFC, defining the conditions under which it is likely to have the largest influence on outcomes, but also how it might be promoted within individuals, is valuable. However, as previously stated, while characterised as a disposition to engage in and enjoy thinking (Cacioppo & Petty, 1982), no consensus model of what underpins and precipitates these behavioural differences has been established, with prior authors describing the antecedents of NFC as an unanswered question (Cacioppo, Petty, Feinstein & Jarvis, 1996) and the motivation underpinning the construct as ambiguous (Steinhart & Wyer, 2009). Research in this domain has been scarce, and instead researchers’ attention has been focussed on attempts to locate the NFC within broader networks of individual differences in information processing (e.g. Rational-Experiential model; Epstein, 1994) and intellectual engagement (e.g. intellect model; Mussel, 2013). A small amount of literature has addressed these fundamental questions about what drives these dispositional differences in effortful cognition, but this has not coalesced around any single account, with diverse explanations including enjoyment of effortful cognition itself (Cacioppo & Petty, 1982), self-schema matching (Wheeler, Petty & Bizer, 2005), avoidance of failure (Steinhart & Wyer, 2009) and Self Determination Theory (SDT; Thomson, Chaiken & Hazlewood, 1993). Duly, efforts need to be directed at finding avenues to develop a unified understanding of NFC but also to address any barriers to progress in the understanding of NFC. This review aims to address these issues by examining the literature on the factorisation of the NFC scale to address concerns regarding the consistency of the measure’s structure and potentially provide insights into the motivation underpinning NFC.
As there is no broadly accepted behavioural index of the NFC construct or investment traits broadly (von Stumm & Ackerman, 2013), the NFC scale, its short form (Cacioppo, Petty & Kao, 1984) and its translations (e.g. Bless, Wänke, Bohner, Fellhauer & Schwarz, 1991; Ginet & Py, 2000) represent the only measures of NFC. As such, the scale itself, as the lens through which all insights into NFC are derived, is central to any attempt to improve understanding of the underlying phenomenon. For example, issues compromising reliability and validity in the scale would undermine results examining its correlates, and duly any insights into the nature of NFC broadly. Furthermore, where subfactors exist within the scale, these may provide insights into the underlying processes driving the engagement in effortful cognition associated with NFC. It is for these reasons that understanding multifactorial solutions observed in past studies (e.g. Lord & Putrevu, 2006; Tanaka, Panter & Winborne, 1988), contrary to the stated unifactorial structure of the measure, is important to making progress in the development of theory.

While not constructed with the intent to capture factors reflecting underlying processes, it has been argued that the construct as defined is inherently multifactorial (Lord & Putrevu, 2006), reflecting cognitive or behavioural aspects (tendency to engage in effortful cognition) and affective components (enjoyment of effortful cognition). Further, empirical investigations have suggested the presence of subfactors such as “confidence in cognitive ability” (Lord & Putrevu, 2006; Tanaka et al, 1988) or “desire for understanding” (Lord & Putrevu, 2006; Furnham & Thorne, 2013). As discussed in Chapter One, where there is some replicable set of factors, these could implicate a particular account for the NFC such as Self Determination Theory (SDT; Ryan & Deci, 2000; 2002), which specifies competence (conceptualised as perceived ability to influence the world), relatedness (the sense of social affiliation and support), and autonomy (perceiving oneself as the origin of one’s behaviour) as determinants of intrinsic motivation.
The question of the factorisation has been addressed many times in the past, however, these investigations have demonstrated appreciable methodological variability. One notable example is the use of Principal Components Analysis (PCA) in a number of studies (e.g. Cacioppo & Petty, 1982) rather than true factor analysis in assessing the dimensionality of the NFC scale. There is an extensive body of literature on the differences between PCA and Factor Analysis (e.g. Bentler & Kano, 1990; Fabrigar, Wegener, MacCallum, & Strahan, 1999; Gorsuch, 1990; Loehlin, 1990; McArdle, 1990). As this literature discusses, PCA is not intended to determine or preserve the pattern of covariance between observed variables; it is instead a data reduction method used to identify components which account for all variance in observed variables, both shared and unshared variance. By contrast, true Factor Analysis methods attempt to identify unobserved variables which underpin response patterns in the observed variables and duly consider only shared variance. Variability in methodology represents a complication in attempts to identify the factorial structure of the measure, with variation in methods being confounded with variations in results. As such, evaluation within single studies is unlikely to provide the necessary insight into the underlying dimensionality of the NFC scale.

**The current study**
As discussed in Chapter One, understanding the motivation underpinning NFC and its causes is potentially valuable in promoting good outcomes in areas such as intellectual performance (von Stumm, Chamorro-Premuzic & Ackerman, 2011; von Stumm, Hell & Chamorro-Premuzic, 2011), but these causes remain unknown. There has been some uncertainty regarding the dimensionality of the NFC scale which may suggest either incomplete optimisation of the measure or possibly theoretically relevant factors; in either case, resolving the question of the scale factorisation is central to better characterising NFC. This review will therefore systematically evaluate the literature examining the NFC scale’s
structure, seeking to account for the influence of methodological variability between studies in obtaining the best possible insight into the measurement of NFC.

**Methods**

A systematic review methodology was utilised (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009) in order to obtain the most accurate reflection of the state of the literature on this topic.

**Identification of Papers**

Searches focussed upon literature relating to dimensionality of NFC. As all extant measurement scales are derived from the one produced by Cacioppo and Petty (1982), this review was limited to peer-reviewed journal articles published after 1982, in English using English language scales¹. Given the breadth of disciplines that NFC has been applied in, the search included a correspondingly diverse array of databases from EBSCOhost (Academic Search Complete, Business Source Complete, EconLit, ERIC, PsycARTICLES, Psychology & Behavioral Sciences Collection, PsycINFO) and Scopus. Searches were conducted for “Need for cognition” and any of “factor analysis”, “factor structure” or “dimensionality” on 6th October 2015. Checking of citations for additional articles not captured by the searches was conducted before the results were screened for duplicates.

**Inclusion and exclusion Criteria**

No additional criteria were imposed upon results relating to the dimensionality of NFC.

**Results**

Searches examining dimensionality analyses of NFC returned 304 unique articles and 31 duplicates. Of these, 268 were screened due to lack of relevance to NFC (Predominantly

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¹ As the factorisation of the scale is a primary focus of this study, given there is no evidence of robust measurement invariance across translations it was considered inappropriate to include the translations.
addressing Need for Cognitive Closure; Kruglanski, Webster, & Klem, 1993), 23 were excluded due to publication prior to 1982. A total of 13 articles, containing \(^1\) independent studies, were selected by the primary author for the synthesis and the details of these are presented in Tables 2.1 and 2.2. Table 2.1 contains the sample characteristics, the measurement of the NFC construct and (where available) descriptive statistics for NFC in each sample. Predominantly samples comprised tertiary education students (15 studies explicitly stating this), and NFC was measured utilising Cacioppo, Petty and Kao’s (1984) 18-item scale (11 studies). Four studies were conducted using the original 34-item scale, the remaining five studies using various (16-, 19-, 42- or 45-item) subsets from the original 45 item pool (Cacioppo & Petty, 1982).

\(^1\) Lord and Putrevu (2006) study 2a cannot be considered independent of study 2b and so will be considered one result for the purpose of this review.
<table>
<thead>
<tr>
<th>Study</th>
<th>Entry criteria</th>
<th>Sample gender / age</th>
<th>Country</th>
<th>Survey and Scale</th>
<th>Response format</th>
<th>Mean (SD) of NFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bors, Vigneau, &amp; Lalande (2006) - Study 2</td>
<td>Volunteer Undergraduate psychology students</td>
<td>64% Female, M = 19.85 (3.06)</td>
<td>Canada</td>
<td>18-item NFC scale (Cacioppo, Petty &amp; Kao, 1984)</td>
<td>Not reported</td>
<td>Males: M = 60.66 (11.42), Females: M = 58.04 (10.97)</td>
</tr>
<tr>
<td>Bors et al. (2006) - Study 3</td>
<td>Volunteer Undergraduate psychology students</td>
<td>66% Female, M = 19.85 (3.06)</td>
<td>Canada</td>
<td>18-item NFC scale (Cacioppo, Petty &amp; Kao, 1984)</td>
<td>Not reported</td>
<td>Males: M = 61.67 (10.71), Females: M = 60.16 (11.26)</td>
</tr>
<tr>
<td>Cacioppo &amp; Petty (1982) - Study 1</td>
<td>University Faculty members (N=43) and Assembly line workers (N=53)</td>
<td>38% Female, Age not recorded</td>
<td>USA</td>
<td>42 items administered to participants, 34 items retained based on their capacity to discriminate between Line workers and Faculty members.</td>
<td>9 pt Likert</td>
<td>Faculty Members: M = 2.18, Assembly line workers: M = 0.7</td>
</tr>
<tr>
<td>Cacioppo &amp; Petty (1982) - Study 2</td>
<td>Undergraduate psychology students</td>
<td>Not Reported</td>
<td>USA</td>
<td>Pen-and-paper survey, 34-item NFC scale</td>
<td>5 pt likert</td>
<td>Not reported</td>
</tr>
<tr>
<td>Cacioppo et al. (1984)</td>
<td>University students</td>
<td>Not Reported</td>
<td>USA</td>
<td>18-items extracted from 34-item NFC scale</td>
<td>Not reported</td>
<td>Not reported</td>
</tr>
<tr>
<td>Culhane, Morera, &amp; Hosch (2004) - Study 1</td>
<td>Hispanic Undergraduate Psychology students</td>
<td>58.4% female, M = 20.17 (4.90)</td>
<td>USA</td>
<td>Pen-and-paper survey, group administration, 18-item NFC scale (Cacioppo, Petty &amp; Kao, 1984)</td>
<td>5 pt likert</td>
<td>M= 3.35</td>
</tr>
<tr>
<td>Study</td>
<td>Sample Description</td>
<td>Sample Characteristics</td>
<td>Methodology</td>
<td>Scale Characteristics</td>
<td></td>
<td></td>
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<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------</td>
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<tr>
<td>Culhane et al. (2004) - Study 2</td>
<td>Hispanic Undergraduate Psychology students</td>
<td>59.8% female, M = 19.62 (3.64) USA</td>
<td>Pen-and-paper survey, group administration, 18-item NFC scale (Cacioppo, Petty &amp; Kao, 1984)</td>
<td>Not reported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culhane, Morera, &amp; Watson (2006)</td>
<td>Undergraduate psychology students</td>
<td>White (289): 59.8% Female, M = 19.33 (3.45). Hispanic (175): 64.8% female, M = 19.61 (3.60) USA</td>
<td>Pen-and-paper survey, group administration, 18-item NFC scale (Cacioppo, Petty &amp; Kao, 1984)</td>
<td>5 pt likert M (White) = 40.30 (9.35); M (Hispanic) = 41.85 (9.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Davis, Severy, Kraus, &amp; Whitaker (1993)</td>
<td>Undergraduate students</td>
<td>Not reported USA</td>
<td>18-item NFC scale (Cacioppo et al., 1984)</td>
<td></td>
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<td></td>
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<tr>
<td>Epstein, Pacini, Denes-Raj, &amp; Heier (1996)</td>
<td>Undergraduate psychology students</td>
<td>70.11% Female, Age not reported USA</td>
<td>19 items selected from 45-item NFC scale (Cacioppo &amp; Petty, 1982) based on unspecified &quot;variations in content and item-total correlations&quot;.</td>
<td>5 pt likert M = 64.29 (10.54)</td>
<td></td>
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</tr>
<tr>
<td>Forsterlee &amp; Ho (Forsterlee &amp; Ho, 1999) - Study 1</td>
<td>No specified criteria</td>
<td>50% Female, M = 32.04, SD not reported. Range from 18 to 58 years Australia</td>
<td>18-item NFC scale (Cacioppo et al., 1984)</td>
<td>5 pt likert Not reported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forsterlee &amp; Ho (1999) - Study 2</td>
<td>No specified criteria</td>
<td>49.1% female, M = 31.16, SD not reported. Range from 18 to 60 years Australia</td>
<td>18-item NFC scale (Cacioppo et al., 1984)</td>
<td>5 pt likert Not reported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study Authors and Year</td>
<td>Sample Description</td>
<td>Sample Characteristics</td>
<td>Measure</td>
<td>Likert Scale</td>
<td>Additional Information</td>
<td></td>
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<td>------------------------</td>
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<tr>
<td>Furnham &amp; Thorne (2013)</td>
<td>Undergraduate psychology students</td>
<td>61% Female, M=18.9, SD = 2.4; 12.3% male, M=21.8, SD = 6.0</td>
<td>Not Reported</td>
<td>7 pt likert</td>
<td>34-item NFC scale, reworded to have all pro-trait items</td>
<td></td>
</tr>
<tr>
<td>Lord and Putrevu (2006) - Study 1</td>
<td>Undergraduate marketing students</td>
<td>Not reported</td>
<td>USA</td>
<td>Not reported</td>
<td>34-item NFC scale (Cacioppo &amp; Petty, 1982)</td>
<td></td>
</tr>
<tr>
<td>Lord and Putrevu (2006) - Study 2</td>
<td>Business students</td>
<td>54% Female, Age data not reported</td>
<td>USA</td>
<td>Not reported</td>
<td>34-item NFC scale (Cacioppo &amp; Petty, 1982), plus 21 items reworded from negative to positive orientation</td>
<td></td>
</tr>
<tr>
<td>Lord and Putrevu (2006) - Study 3</td>
<td>Undergraduate students</td>
<td>46% Female, Age data not reported</td>
<td>Australia</td>
<td>Not reported</td>
<td>18-item NFC scale (Cacioppo et al., 1984)</td>
<td></td>
</tr>
<tr>
<td>Perri &amp; Wolfgang (1988)</td>
<td>Attendees at four medical clinics</td>
<td>58% Female, Age data not reported continuously, 71% with Chronic medical conditions, 40% with High school or lower education, 45% with some to complete undergraduate college degree, 15% with Graduate degrees.</td>
<td>USA</td>
<td>Not reported</td>
<td>16-items drawn from full 34-item NFC scale (Cacioppo &amp; Petty, 1982) based on high factor loadings and question direction</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Population</td>
<td>Gender Composition</td>
<td>USA</td>
<td>NFC Scale</td>
<td>Likert Scale</td>
<td>Mean (SD)</td>
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<td>-------</td>
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</tr>
<tr>
<td>Sadowski (1993)</td>
<td>Undergraduate students</td>
<td>58.13% Female, Females M = 20.70 (5.39), Males M = 20.36 (3.89)</td>
<td>USA</td>
<td>18-item NFC scale (Cacioppo et al., 1984)</td>
<td>9 pt likert</td>
<td>M = 15.28 (21.46)</td>
</tr>
<tr>
<td>Tanaka, Panter, &amp; Winborne (1988) - Study 1</td>
<td>Undergraduate psychology students</td>
<td>52% Female, M = 19, 66% White</td>
<td>USA</td>
<td>45-item NFC scale (Cacioppo &amp; Petty, 1982), 25 retained after Factor analysis</td>
<td>Dichotomous response format (T-F)</td>
<td>Not reported</td>
</tr>
<tr>
<td>Tanaka et al. (1988) - Study 2</td>
<td>Undergraduate psychology students</td>
<td>Not available for full sample</td>
<td>USA</td>
<td>45-item NFC scale (Cacioppo &amp; Petty, 1982), 25 retained after Factor analysis</td>
<td>Dichotomous response format (T-F)</td>
<td>Not reported</td>
</tr>
</tbody>
</table>
Table 2.2 contains results pertaining to examinations of NFC scales’ dimensionality. Of the 20 studies included, seven of the studies found utilised PCA (many of them forming the basis of later confirmatory analyses), eight used Exploratory Factor Analysis (EFA), one using an Oblique Procrustes Procedure (OPP), and the remaining studies used Confirmatory Factor Analysis (CFA). The latter typically evaluated the fit of single factor models or contrasted against method factor models.
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Size</th>
<th>Analysis</th>
<th>Model Fit</th>
<th>Model Fit Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bors et al. (2006) - Study 2</td>
<td>453</td>
<td>CFA - One trait-factor, positive and negative method factors</td>
<td>$\chi^2(117) = 225$, GFI = 0.95, CFI = 0.94, AIC = -9.32 RMSEA (90% CI) = 0.05 (0.04–0.05)</td>
<td></td>
</tr>
<tr>
<td>Bors et al. (2006) - Study 3</td>
<td>650</td>
<td>CFA - One trait-factor, positive and negative method factors</td>
<td>$\chi^2 (117) = 233$, GFI = 0.96, CFI = 0.95, AIC = -0.94, RMSEA (90%CI) =0.04 (0.03–0.05)</td>
<td></td>
</tr>
<tr>
<td>Cacioppo &amp; Petty (1982) - Study 1</td>
<td>96</td>
<td>PCA</td>
<td>Ten components exceeding Kaiser’s criterion (The first three components having eigenvalues of 10.22, 2.31 and 1.82, explaining 30.1%, 6.8% and 5.4% of the variance respectively), single factor selected based on scree plot.</td>
<td></td>
</tr>
<tr>
<td>Cacioppo &amp; Petty (1982) - Study 2</td>
<td>419</td>
<td>PCA</td>
<td>Ten components exceeding Kaiser’s criterion (The first three components explaining 20.0%, 5.7% and 4.6% of the variance respectively), single factor selected based on scree plot.</td>
<td></td>
</tr>
<tr>
<td>Culhane et al. (2004) - Study 1</td>
<td>237</td>
<td>EFA (Maximum Likelihood) rotation methods unspecified</td>
<td>Four factors exceeding Kaiser’s criterion, explaining 31.58%, 7.95%, 6.11% and 5.63% of variance respectively. Three and Four factor solutions rejected due to single item loadings, two factor solution gave two strongly correlated factors (0.68) and three items did not load sufficiently (≥0.3) on either factor.</td>
<td></td>
</tr>
<tr>
<td>Culhane et al. (2004) - Study 2</td>
<td>185</td>
<td>CFA - One factor model</td>
<td>$\chi^2 (135)= 221.85$, p &lt; .001, GFI = .97, RMSEA = 0.06</td>
<td></td>
</tr>
<tr>
<td>Culhane et al. (2006)</td>
<td>464</td>
<td>Multigroup (cultural invariance) CFA - One factor model</td>
<td>Configural invariance: $\chi^2(270) = 521.03$, GFI = 0.88, SRMR = 0.06, RMSEA (90% CI) = 0.07 (.06-.07)</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Methodology</td>
<td>Rotation</td>
<td>Findings</td>
</tr>
<tr>
<td>-------</td>
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</tr>
</tbody>
</table>
| Davis et al. (1993) | 1993 | EFA (Varimax) | | Two factor solution – No fit statistics provided. Factors reflecting “amount of effort an individual enjoyed putting forth when thinking” and “preference for solving problems”.
| Epstein et al. (1996) | 1996 | PCA (Varimax rotation) on 19 item NFC scale and 12 item "Faith in Intuition" (FI) scale | | Two factor solution accounting for 32.2% of variance chosen based on scree plot. First component accounted for 19.8% of variance and captured the items from the NFC scale; the second component, measuring FI, accounted for 12.4% of variance.
| Forsterlee & Ho (1999) - Study 1 | 1999 | PCA, Oblique rotation (Oblimin) | | Two components with eigenvectors greater than 1 (5.88, explaining 32.7% of variance, and 1.31, explaining 7.3% of variance respectively). Rotation resulted in correlation of -0.524 between factors, with positive items loading on one factor, and negative on the other.
| Forsterlee & Ho (1999) - Study 2 | 1999 | CFA | | Best fitting model, one factor with correlated residuals for negatively worded items. $\chi^2(83) = 384.82$, $p < .001$, NFI = 0.93, CFI = 0.94, IFI = 0.94, NNFI = 0.90, GFI = 0.94, AGFI = 0.89.
| Furnham & Thorne (2013) | 2013 | EFA (Promax rotation) | | Three factors extracted (Number determined by scree test), accounting for 42% of the variance. Factors defined as “Need for Cognitive Challenge”, “Need for knowledge and understanding”, and “Enjoyment of Cognitive Effort”. Factors intercorrelated at $r = 0.53 - 0.58$.
<p>| Lord and Putrevu (2006) - Study 1 | 2006 | EFA (Maximum Likelihood), Harris-Kaiser oblique rotation | | Eight factor solution selected, based on TLI = .95. Final 3 factors measured by &lt;3 items each. First factor was suggested to correspond to &quot;enjoyment of cognitive tasks&quot;, second to &quot;confidence in cognitive ability&quot;, the third to a &quot;preference for complexity&quot;, the fourth to &quot;commitment of cognitive effort&quot; and the fifth &quot;a desire for understanding&quot;. |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>Methodology</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lord and Putrevu (2006) - Study 2a</td>
<td>EFA (Maximum Likelihood), Harris-Kaiser oblique rotation</td>
<td>Eight factor solution selected, based on TLI = .95. All factors were measured by items with appreciable crossloading. The first factor was not readily interpretable, but contained items relating to avoidance of cognitive effort and low confidence in ability, the second to &quot;commitment of cognitive effort&quot;, third factor was suggested to correspond to &quot;enjoyment of cognitive tasks&quot;, the fourth to a &quot;preference for complexity&quot;, and the fifth &quot;a desire for understanding&quot;.</td>
</tr>
<tr>
<td>Lord and Putrevu (2006) - Study 2b</td>
<td>EFA (Maximum Likelihood), Harris-Kaiser oblique rotation, all positively worded items</td>
<td>Eight factor solution selected, based on TLI = .95 and non sig. Chi-square. Substantial cross-loading was observed. The authors interpreted only three factors, concluding that the first reflected &quot;enjoyment of cognitive stimulation&quot;, the second a &quot;desire for understanding&quot; and the seventh &quot;preference for complexity&quot;. The items loading on the third factor tend to reflect volitional investment of cognitive effort, as do the fifth factor. Critically, as this was assessed in the same sample and using some of the same items, this results should not be considered independent of the prior result.</td>
</tr>
<tr>
<td>Lord and Putrevu (2006) - Study 3</td>
<td>EFA (Maximum Likelihood), Harris-Kaiser oblique rotation</td>
<td>Four eigenvalues greater than 1.0, TLI and Chi-square indicated a five factor solution. There was substantial cross-loading of items, and the authors only interpreted two factors, reporting that the second factor reflects &quot;Enjoyment of cognitive stimulation&quot; and the fourth factor a &quot;preference for complexity&quot;. These factors were also present in an analysis of the items which constitute the short form from the study 2a data (as the first and third factors); in that analysis, the second factor was associated with items reflecting &quot;volitional investment of cognitive effort&quot;.</td>
</tr>
<tr>
<td>Perri &amp; Wolfgang (1988)</td>
<td>PCA</td>
<td>Four Components met Kaiser’s criterion, Authors selected a one component solution based on examination of a scree plot, reporting that this component captured 38.8% of total measured variance. No further results were reported.</td>
</tr>
<tr>
<td>Sadowski (1993)</td>
<td>PCA</td>
<td>Two components met Kaiser’s criterion (5.57, explaining 30.92% of variance, and 1.61, explaining 8.95% of variance respectively). Author indicates gender invariance based on between gender correlation of factor loadings r(16) = .89, p &lt; 0.0001</td>
</tr>
</tbody>
</table>
Interpretation was made starting from the 34-items in the final NFC scale (Cacioppo & Petty, 1982). Three factor solution was selected accounting for 25% of the total observed variance. Factors were suggested to reflect "Cognitive Persistence" or volitional cognitive engagement, "Cognitive complexity" and "cognitive confidence". Solution selection criteria not specified beyond fit, scree and proportion of variance explained, 9 items were omitted to reduce cross-loading.

Factor loadings of the previous sample were generally preserved, two items reflecting a desire for understanding from the "Cognitive persistence" factor loaded at substantially lower levels in sample 2 though. Correlations unspecified.

*Note.* The use of OPP in Tanaka et al. (1988) study 2 will result in an orthogonal rotation by merit of their constraint of the latent covariance (ψ) matrix to equality with that of study one which used a varimax rotation.
While the factor structures drawn from item sets of different size are inherently incomparable, the number of items used in each analysis is likely to have an independent effect on the number of factors extracted. This is particularly true where smaller item pools are selected for their loading on a particular factor in prior analyses, as was the case for all of the short scales, duly consideration should be given to the possibility of interactions between item pool length and analyses. Table 2.3 shows cross tabulations of the analysis method and item pool length, most notably all the CFA analyses were on the 18-item pool.

<table>
<thead>
<tr>
<th>Item pool length</th>
<th>Analysis Method</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>PCA</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
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<tr>
<td>18</td>
<td>3</td>
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<tr>
<td>19</td>
<td>1</td>
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<tr>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>42</td>
<td>1</td>
</tr>
<tr>
<td>45</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
</tr>
</tbody>
</table>

Seven studies of the 20 were found to demonstrate a multifactorial solution (Davis et al., 1993; Furnham & Thorne, 2013; Lord & Putrevu, 2006; Tanaka, Panter, & Winborne, 1988); the balance returned unidimensional structures. It is noteworthy that of the seven studies using true EFA methods, only one study using the 18-item scale (Culhane et al, 2004) returned a unifactorial solution, while all studies using PCA and CFA found unifactorial solutions.

Discussion

This review has sought to address the dimensionality of NFC for insights into underlying motivational factors. The systematic approach taken here allows for a critical evaluation of the literature to date and identify patterns within the literature as a whole that may explain some of the inconsistency in results. In particular, methodological factors such
as the choice of analytic methods, the choice of rotation methods and the selection of item pools may represent weaknesses in portions of the literature, and provide a path toward resolution of the NFC’s dimensionality.

As previously stated, the use of PCA for investigating the dimensionality of a measure is potentially problematic; however the results show that this analytical choice has been adopted in 35% of papers addressing dimensionality of NFC, with seven studies (35%) using true exploratory factor analysis, the remaining 30% utilising CFA or OPP. Given that PCA is not intended to identify latent factors, cautions should be employed in placing confidence in structures for NFC proposed by the seven studies utilising PCA.

The use of orthogonal rotation, which assumes any factors extracted are uncorrelated, in three of the EFA studies is also problematic given it is likely, based on their shared associations with behaviours, that any factors within the NFC scale would correlate to some degree. The imposition of an assumption of no correlation in these analyses would undermine the capacity of the estimation methods to derive factors which replicate the covariance between items. Oblique rotation methods relax this assumption, allowing for the fitting of a factor solution that contains correlated factors without precluding the possibility of orthogonal factors (Fabrigar, et al., 1999; Ford, MacCallum & Tait, 1986). As such, the use of orthogonal rotation is an assumption imposed upon the data which may have compromised the validity of the obtained results in these studies.

The method utilised in determining the number of factors extracted is also likely to have influenced the factorial structures obtained in EFA and PCA studies. A majority of the studies (Cacioppo & Petty, 1982; Cacioppo et al. 1984; Epstein et al., 1996; Furnham & Thorne, 2013; Perri & Wolfgang, 1988) utilised the Scree test as the primary criteria for determining the number of factors to extract. While exposed to the risk of subjectivity, this method is performs well where there are strong factors (Fabrigar et al, 1999)and duly these
solutions are more likely to reflect somewhat accurate estimates of the true number of factors. By contrast, the TLI>0.95 and non-significant chi-square criteria utilised by Lord & Putrevu (2006) are likely to expose these solutions to substantial risk of overfitting. This may go some way to explain the substantially larger number of factors extracted in this solution relative to the remainder of the studies reviewed.

It is also worth considering the potential for an additional confound in the assessment of underlying dimensionality arising from the use of the short form scale (Cacioppo, Petty & Kao, 1984). Items were selected for inclusion in this measure based explicitly upon their high loading on the principal component in a prior study and then their intercorrelation with other items included; this strategy was duly employed in the development of the other short scales used in other studies (Epstein et al., 1996; Perri & Wolfgang, 1988). This inherently assumes unidimensionality in the 34-item scale but also is likely to maximise the chances of observing a unidimensional structure in the abbreviated form even if the original scale was multi-factorial. As such, the studies utilising the short form scale may be less likely to support a multidimensional conceptualisation of NFC.

Considering these issues, we feel that strongest consideration must be given to the results obtained from use of the full scale with true factor analysis and oblique rotation. Although by no means definitive given concerns regarding risk of overfitting in Lord & Putrevu’s (2006) study, all of the studies meeting these criteria suggest a multi-dimensional structure, while two (Davis et al, 1993; Lord & Putrevu, 2006 [study 3]) of three studies using EFA and the 18-item scale found multiple factors. By contrast, all of studies using PCA found single component/factor solutions irrespective of the item pool, as did the remaining 11 studies using short (16-19 item) scales including all of the CFA studies.
Multifactorial Solutions.

While there are some differences in the numbers and order of factors extracted and also their identifying items, there is some consistency in the interpretation of factors found across solutions (see Table 2.4). Tanaka et al.’s (1988) solution, replicated in two samples, identifies three factors assessing enjoyment of cognitive tasks (persistence), self-appraised ability for these tasks (confidence) and preference for complexity over simplicity (complexity). These factors are observed as the first three factors in Lord and Putrevu’s (2006) solution; the replication in Lord and Putrevu’s second study however, found the factors measured by different items and the factors extracted in a different order (with Tanaka’s confidence, persistence and complexity items loading onto the first third and fourth factors respectively) and with an increased amount of cross-loading. This instability in Lord and Putrevu’s findings may be a function of overfitting of the covariance, duly some caution is warranted in the interpretation of these structures. Furnham and Thorne (2013) also observe a factor relating to enjoyment of cognitive challenges similar to the persistence factor, as well as factors relating to a need for understanding and enjoyment of cognitive efforts (specifically items relating to engagement in effortful cognition autonomously), these also being factors identified by Lord and Putrevu (2006). The recurrence of some factors in multiple samples contrasts with the lack of one common structure across these studies. This suggests that while there may be underlying factors assessed by the existing scale, there can be limited confidence in their robustness or that of the scale.
Table 2.4

Representation of NFC scale factors in studies employing EFA

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Enjoyment of cognitive challenges</th>
<th>Preference for complexity</th>
<th>Need for understanding</th>
<th>Enjoyment of effort</th>
<th>Cognitive Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanaka et al. (1988)</td>
<td>289</td>
<td>/</td>
<td>X</td>
<td></td>
<td>X</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Davis et al. (1993)</td>
<td>230</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Lord &amp; Putrevu (2006)</td>
<td>195</td>
<td>X</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Furnham &amp; Thorne (2013)</td>
<td>195</td>
<td>X</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Note. Davis et al. (1993) utilised the 18-item scale and is duly their solution is not wholly comparable.

Variability in the results obtained between studies is not entirely surprising however, given that variability in measurement and analysis persists even within this subset of studies. Examples of this include the conversion of all items to pro-trait orientation to correct for possible method factors (Furnham & Thorne, 2013), the use of True-False instead of Likert-type response formats (Tanaka, Panter & Winborne, 1988) or aforementioned variability in criteria for determining the number of factors. It is therefore unclear the degree to which the inconsistency across prior studies is induced by methodological differences or is indicative of instability of the underlying factor structure, perhaps due to incomplete optimisation for measurement of sub-factors. Duly, despite the existing literature, there remains a need to further investigate the factor structure of the NFC measure empirically while minimising method variance to resolve this more finally.

The results from these studies, despite the concerns detailed, do suggest the presence of subfactors that may in turn favour a particular theoretical account of NFC. While these should be interpreted with caution due to the lack of a consistent structure, it is important that the development of theory be simultaneous to, not replaced by the conduct of factor analysis (Armstrong, 1967). As such, efforts must be made to identify theoretical accounts in the broader literature which may be relevant to the manifestation of effortful cognition.
As discussed in Chapter One, one of the proposed accounts for differences in engagement which is somewhat consistent with results reviewed here is a Self-Determination Theory (SDT) conceptualisation (Deci, 1971; Ryan & Deci, 2000). In particular, the manifestation in factor analysis in some samples of a confidence or self-efficacy dimension (Lord & Putrevu, 2006; Tanaka, et al., 1988) and a preference for complexity which may be interpreted as an autonomy factor is consistent with this model, duly the use of this theory as a basis for understanding NFC will be considered.

Self Determination Theory is an account of intrinsic motivation that states that individuals will engage in exploratory, self-developing behaviours insofar as needs for autonomy (perception of control over one’s behaviour), relatedness (feelings of support and social connectedness) and competence (capacity to effect change on one’s environment) are met (Deci & Ryan, 2000). Within this theoretical context, the engagement in effortful cognition is a manifestation of these fundamental tendencies toward active self-growth. This tendency will be moderated as a function of individuals’ felt competence, autonomy and relatedness in a multiplicative fashion, where the effects of these variables on elaborative tendency are not maximised individually, but in concert. This framework would account for stability previously observed in measures of NFC (Sadowski & Gulgoz, 1992; Verplanken, 1991), in that degrees or relatedness, autonomy and competence may be relatively stable in individuals.

An extension of SDT, Cognitive Evaluation Theory (CET; Deci, Cascio & Krusell, 1975) posits the means by which external consequences might influence the future manifestation of intrinsic motivation, and duly this may provide an account of how dispositional NFC might be promoted. In particular, it states that where engagement in a particular behaviour affects the sense of autonomy and competence, this behaviour will become more or less intrinsically motivated. With respect to NFC, CET would propose where
episodes of effortful cognition provide information with respect to the autonomy of engagement and competency, future engagement should be more intrinsically motivated.

This model is consistent with the view that NFC develops through experience of problem solving (Cacioppo, Petty, Kao & Rodriguez, 1986) resulting in competence feedback (Cacioppo et al., 1996), but specifically accounts for the moderating role of autonomy. That is, where individuals receive boosts in self-efficacy from engaging in elaborative behaviour, but feel that their autonomy is being undermined by their engagement with the behaviour this would undermine the effects of increased competence. For example, where a student performs well at a challenging task they have been set by an authoritarian teacher, the satiation of their competence need may not result in the otherwise expected increase in intrinsic motivation for elaborative behaviour due to the decrement in autonomy associated with engagement. In general, an individual’s relatedness, autonomy, and perceived competence in cognitive elaboration will interactively promote the engagement in elaborative behaviours.

Effects consistent with this model have been previously demonstrated, where a $3 cash incentive, at least situationally, suppressed free-choice re-engagement with puzzles, ostensibly by undermining participants’ felt autonomy (Thompson et al., 1993). However, these effects were equally accounted for by the covariance of NFC with generalised desire for control, which was taken to reflect an individual’s control orientation (Deci & Ryan, 1985), the tendency to act autonomously or on external control. In addition, the degree to which this generalises to a trait-like effect of NFC is unclear, although it may be possible for an individual to be habituated into reliance on direction, suppressing their tendency to freely explore and manifest NFC-like behaviours. Nonetheless, this does suggest a possible role of autonomy feedback in intrinsic motivation for effortful cognition, and consequently in the development of NFC.
The importance of perceived competence in predicting NFC behaviours could provide insight into the correlation between need for cognition and academic performance (Richardson, Abraham & Bond, 2012). While the literature is rightly interested in the value of investment traits like NFC as a predictor of these outcomes independent of factors such as intelligence (von Stumm, Hell & Chamorro-Premizic, 2011), the possibility of reciprocal effects should not be ignored. That is, NFC may represent an avenue to improving outcomes, but these outcomes may in turn, through the development of felt competence, promote NFC. In sum, the SDT represents a possible account for differences in NFC consistent with the evidence available to date. By resolving any uncertainty regarding the dimensionality of the scale that exists due to the methodological variability the viability of this account can be more rigorously considered.

A secondary consideration in understanding the dimensionality of NFC is obtaining a better understanding of what it is to vary on this construct. As noted earlier, since the NFC scale represents the only measure of the construct, some caution must be exercised in inferring characteristics of those varying in NFC. While the prior research has reliably shown that scores on the NFC scale predict behaviours consistent with individual differences in elaborative tendency (Kardash & Scholes, 1996; Lassiter, Briggs, & Bowman, 1991; Lassiter, Briggs, & Slaw, 1991; Leding, 2011; Levin, Huneke, & Jasper, 2000; Reinhard, 2010), it is unclear whether these correlates are direct outcomes of NFC, or of some covariate. It is worth recalling the initial scaling of the NFC measure on discrimination between academics and line workers (Cacioppo & Petty, 1982), while these groups are likely to vary in tendency to engage in and enjoy effortful cognition, such differences are unlikely to be the sole discriminator between these groups. More proximate examination of the behaviours associated with differences in NFC is likely to improve our understanding the phenomenon at its base, but also potentially understand both its foundations and its applications more fully.
As discussed in Chapter One, there is distinct value in understanding the nature and causes of NFC, this review sought to address this through the examination of literature on the dimensionality of the NFC scale. What has been shown is that methodological factors do seem to have influenced past results. While a majority of the literature does support a unifactorial structure, the studies supporting this do so on the basis of PCA instead of EFA, or utilised the short form which was optimised to assess a single factor. Of the studies that utilise the full scale and more ideal methods, while these do support multifactorial solutions they do not agree on a singular structure, potentially as a function of subtle methodological variability between these studies. There is a pressing need to resolve this question before exploring any other avenue of research, to identify relevant factors where they exist, or guide optimisation of measurement. In particular, efforts must be directed to addressing the degree to which variability in the factor structure of the NFC scale is a function of methodology or the scale itself. Following this, other lines of research into the nature of motivation in NFC can be pursued.
References


Chapter 3

Empirical Evaluation of the Factor Structure of the NFC scale

As covered in Chapter One, theoretical accounts of Need for Cognition (NFC) remain relatively limited, particularly with respect to the motivations underpinning the individual difference and their antecedents. Persistent uncertainty regarding the dimensionality of the NFC scale, with a number of studies finding multifactorial structures (e.g. Furnham & Thorne, 2013; Lord & Putrevu, 2006), is a barrier to the development of a theory of NFC. Given the widespread usage of NFC in the literature the measurement of this individual difference is vital in ensuring that its relationship to causal factors or outcomes is accurately characterised.

While the conventional interpretation of NFC is as a unifactorial construct, as shown in the systematic review of the literature (Chapter Two), studies using true factor analyses tend to demonstrate multifactorial structures in the measure. There is no consistent solution found across these studies however, possibly due to methodological variability between these studies. If NFC is truly unifactorial, the presence of additional factors in previous studies would indicate that the scale is incompletely optimised, with items within the 34-item full scale that are sensitive to error variance or poor indicators of the core NFC construct. The use of this measure in research may therefore misrepresent the relationship between NFC and other variables. Equally, the identification of replicable factors could suggest a specific account of the motivation to engage; for example, factors reflecting autonomy of engagement and self-efficacy for effortful cognition may suggest at a self-determination account. Given this, there is a need to resolve the issue of dimensionality in the NFC scale empirically, ideally in a manner which accounts for the impact of sample specific variance.

As argued in the Chapter 2, a likely source of variability in factorial representations in prior studies is variability in the choice of analytic methods, with a large proportion of studies
(Cacioppo & Petty, 1982; Epstein et al., 1996; Forsterlee & Ho, 1999; Perri & Wolfgang, 1988; Sadowski, 1993; Verplaken, Hazenberg & Palenéwen, 1992) into the factor structure utilising Principal Components Analysis (PCA). The methodology literature clearly differentiates the applications of PCA versus Exploratory Factor Analysis (EFA) as the former subsumes all variance instead of only common variance making it unsuitable to the purpose of determining the underlying factor structures (Bentler & Kano, 1990; Fabrigar, et al., 1999; Gorsuch, 1990; Loehlin, 1990; McArdle, 1990). While PCA is less computationally intensive (Fabrigar, et al., 1999; Velicer & Jackson, 1990) and preferred in the past, these analyses are simply not interchangeable. As such, studies utilising PCA approaches, including the original scale derivation (Cacioppo & Petty, 1982), may have mischaracterised the factor structure of the measure. Further, given the items in the short form scale (Cacioppo, Petty & Kao, 1984) were selected by their strong loading on the primary component of the full scale, any potential misspecification may have been perpetuated in the 18-item scale. This is demonstrated by 82% of studies using the 18-item scale finding unidimensional structures irrespective of analysis method while only 29% of studies using 34-item or longer iterations of the scale found unidimensional structures (Chapter Two).

Although a number of studies have subsequently reinvestigated the underlying factor structure of the English language NFC scale4, the majority have perpetuated the use of PCA as per the original derivation and have derived comparable unifactorial solutions. By contrast, with only one exception (Culhane, Morera, & Hosch, 2004), all of those that have employed true exploratory factor analysis (Davis, Severy, Kraus & Whitaker, 1993; Furnham & Thorne, 2013; Lord & Putrevu, 2006; Tanaka, Panter & Winborne, 1988) have derived multifactorial

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4 Measures exist in a number of other languages, some of which demonstrate multifactorial structures also (Bless et al., 1994; Preckel, 2014), however the invariance of measures is not assured, particularly considering potential issues in the English language scale, duly these are beyond the scope of this research.
solutions, and show similarity to each other at least insofar as the factor contents are conceptualised by the original authors as previous summarised in Table 2.4.

While these studies contradict the widely utilised unifactorial structure; their results do not converge on a consistent solution and thus they provide no clear multifactorial alternative. A number of the observed factors are found somewhat consistently across multiple samples, with factors relating to enjoyment of cognitive challenges, preference for complex problems, and enjoyment appearing in three of four solutions and confidence in cognitive capacity and need for understanding factors were found in two studies. However, these comparable factors are not reliably measured by the same items often with items associating in different ways between studies. Furthermore, on replication, the Lord and Putrevu’s (2006) solution was marred by substantial cross-loading, further suggesting instability in the proposed structure.

There are a number of potential explanations for the differences in factor solutions across studies. In addition to the absence of intent to capture multiple factors in scale construction, and likely issues with sample-specific, random covariances, there were a number of methodological differences between the studies. Alternate versions of the response formats were utilised such as the true-false response format utilised in the Tanaka et al. study (1988) and the all pro-trait worded items in the Furnham and Thorne (2013) paper. Furthermore, there are as many rotation methods applied as there are individual studies with both orthogonal (Tanaka et al., 1988) and various oblique (Furnham & Thorne, 2013; Lord & Putrevu, 2006) rotations applied. Divergences like these, particularly problematic variance reducing options like the dichotomous response format (see Altman & Royston, 2006; MacCallum, Zhang, Preacher & Rucker, 2002; Royston, Altman & Sauerbrei, 2006), or choice of rotation (Fabrigar et al, 1999) put serious caveats on the direct comparability across
studies, and the ability to determine the most appropriate representation of the factorial structure of the measure.

As established, the determination of the most accurate representation of covariance in the measures of NFC is tied to the understanding the full extent of its application and its causes. However, tests of the predictive utility of these multifactorial solutions have not emerged, with studies referencing these multifactorial solutions failing to evaluate of potential independent effects of these factors (e.g. Blais, Thompson & Baranski, 2005; Carlson, Bearden & Hardesty, 2007; Zhang & Brunning, 2011). This may be a function of irreplicability of the structures, with the lack of continuity between these studies making the nature of any instability harder to discern; each new study investigating the factor structure of the measure without reference to prior solutions. Continuation of this trend, producing novel solutions with each study, will not conclusively resolve the question of whether additional factors are captured within the NFC scale.

The subtle deviations that emerge through each successive study indicate that the determination of the most valid solution is unlikely to be derived by EFA in a single sample alone; instead, selection of an optimal solution is likely better informed by direct comparison of alternative models in terms of fit, replicability, predictive validity, and where possible, coherence with theory. This research aimed to investigate the apparent instability in the measurement of NFC by comparing EFA derived structures and the fit of existing models for the NFC scale within two independent samples, using consistent and best-practice methodology. By direct comparison of EFA solutions derived in multiple samples using identical methodology and direct attempts to replicate prior solutions within each sample, insight can be gained regarding the factorisation of the NFC scale so as to guide future revision of measurement and application.
Methods

Participants

Sample 1. Participants were 315 individuals (119 male and 196 female) with a mean age of 26.54 years (SD=11.84) recruited through undergraduate psychology classes, as well as through online social networks.

Sample 2. Participants were 290 individuals (161 male and 129 female) with a mean age of 33.35 years (SD=10.39) recruited through Amazon Mturk. This service has been shown to provide access to diverse samples (Buhrmester, Kwang & Gosling, 2011) without compromising validity (Casler, Bickel & Hackett, 2013).

Materials and Procedure

Participants were invited to complete an online questionnaire, taking approximately 15 minutes. All scales were assessed using 7-point Likert scales ranging from 1 (Completely inaccurate) to 7 (Completely accurate). Although there is no “gold standard” for response options, 7-point scales have been show to demonstrate high reliability, validity, and ease of use when contrasted against scales of either shorter or longer length (Diefenbach, Weinstein & O’Reilly, 1993; Preston & Colman, 2000). Participants were administered the 34 item version of the NFC scale (Cacioppo & Petty, 1982), and asked to assess how accurate each statement was in describing them.

Statistical analysis

Prior to the main analyses, missing data were replaced using single imputation (Schafer, 1999). Data were screened for univariate outliers, normality and multicollinearity and no violations were present. All inferential analyses were conducted using R 3.2.2 (R Core Team, 2015) and the psych package (Revelle, 2015). In order to overcome the limitations previously discussed, parallel exploratory and confirmatory approaches were taken to
determine the factor structure of the NFC scale. EFA was utilised to identify factor structures based wholly on the covariance within each sample. Confirmatory Factor Analyses (CFAs) were used to assess the relative replicability of prior models within each sample.

**Exploratory Factor Analysis.** EFA (Minimum Residual with Geomin oblique rotation; Yates, 1987) was conducted upon the 34 item scale to investigate the underlying factor structure. The Minimum Residual method frequently produces solutions comparable to more widely utilised Maximum Likelihood estimation methods, without the distributional assumptions (Harman & Jones, 1965), and the Geomin rotation method performs well by reference to other oblique rotation methods (Browne, 2001). As EFA may capitalise on random covariances within a sample, evaluation of the factorial structure of the measure was undertaken by comparison across samples, this allows for determination of the replicability of any factors under maximally equivalent situations (i.e., same response format, consistent analyses).

Parallel Analysis (Horn, 1965) was utilised in conjunction with the scree test to determine the number of factors to extract. Parallel Analysis produces a series of correlation matrices of random data with the same number of items and cases as the data under investigation, then obtains an average of the eigenvalues from the reduced correlation matrices of these random data against which to compare the eigenvalues of the real data in parallel (that is, first eigenvalue of the random data against first of the real data and so on). Where the eigenvalues of the real data correlation matrix exceed those of the random data, they are retained, while those below are attributed to sampling error and discarded. This provides more conservative and coherent estimates of the appropriate number of factors than traditional criteria such as Kaiser’s criteria (Hayton, Allen & Scarpello, 2004). Given Parallel Analysis can be taken to present a lenient criterion for the retention of factors, the most conservative estimate of the number of factors from the Parallel Analysis and the scree test
was utilised for each solution. As the objective is to contrast the stability of emergent structures within the scale across two samples, optimisation of the solutions by removal of items was not conducted⁵.

**Confirmatory Factor Analyses.** In order to evaluate the fit and duly the generalisability of the previously published factor structures, CFA was conducted. Where previously these have been fitted within separate samples and may be peculiar to their sample characteristics, evaluation of these alternate structures within a single sample allows for a direct competitive evaluation of these structures against recommended criteria (Hu & Bentler, 1999). The models tested were the full length (Cacioppo & Petty, 1982) and 18 item (Cacioppo, Petty & Kao, 1984) structures, the multifactorial solutions from Furnham and Thorne (2013), Tanaka et al. (1988), and Lord and Putrevu (2006). The Tanaka et al. study used orthogonal rotation, however, oblique rotations would allow for an oblique or orthogonal solution to emerge (Fabrigar et al., 1999), therefore factors were freely permitted to correlate. In an attempt to moderate the effects of unequal number of items utilised in each solution, the items utilised in the multifactorial solutions were also tested for fit in unifactorial configurations to assess their individual improvement over forced unifactorial structures.

**Results**

**Exploratory Factor Analyses**

The items and loadings for the factor analyses are presented in Table 3.1, loadings larger than 0.32 are highlighted in bold.

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⁵ Thanks to an anonymous reviewer for this proposal
<table>
<thead>
<tr>
<th></th>
<th>Sample 1</th>
<th></th>
<th></th>
<th>Sample 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The notion of thinking abstractly is not appealing to me.</td>
<td>0.70</td>
<td>-0.18</td>
<td>0.06</td>
<td>0.72</td>
<td>0.10</td>
<td>0.02</td>
</tr>
<tr>
<td>Thinking is not my idea of fun</td>
<td>0.61</td>
<td>-0.02</td>
<td>0.00</td>
<td>0.73</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>I appreciate opportunities to discover the strengths and</td>
<td>0.54</td>
<td>0.06</td>
<td>0.01</td>
<td>0.28</td>
<td>0.50</td>
<td>0.02</td>
</tr>
<tr>
<td>weaknesses of my own reasoning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The idea of relying on thought to make my way to the top</td>
<td>0.51</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.68</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>does not appeal to me</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>I more often talk with other people about the reasons for</td>
<td>0.50</td>
<td>0.11</td>
<td>0.02</td>
<td>0.09</td>
<td>0.44</td>
<td>-0.23</td>
</tr>
<tr>
<td>and possible solutions to international problems than about</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>gossip or tidbits of what famous people are doing.</td>
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<td></td>
</tr>
<tr>
<td>Learning new ways to think doesn’t excite me very much</td>
<td>0.49</td>
<td>0.22</td>
<td>0.05</td>
<td>0.73</td>
<td>0.09</td>
<td>0.04</td>
</tr>
<tr>
<td>I enjoy thinking about an issue even when the results of my</td>
<td>0.48</td>
<td>0.26</td>
<td>-0.17</td>
<td>0.19</td>
<td>0.41</td>
<td>-0.31</td>
</tr>
<tr>
<td>thought will have no effect on the outcome of the issue.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am an intellectual.</td>
<td>0.46</td>
<td>-0.02</td>
<td>0.17</td>
<td>0.10</td>
<td>0.58</td>
<td>0.15</td>
</tr>
<tr>
<td>I tend to set goals that can be accomplished only by expending</td>
<td>0.45</td>
<td>0.07</td>
<td>-0.12</td>
<td>-0.09</td>
<td>0.70</td>
<td>0.03</td>
</tr>
<tr>
<td>considerable mental effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think best when those around me are very intelligent</td>
<td>0.43</td>
<td>-0.04</td>
<td>0.09</td>
<td>-0.02</td>
<td>0.47</td>
<td>0.04</td>
</tr>
<tr>
<td>I really enjoy a task that involves coming up with new solutions</td>
<td>0.43</td>
<td>0.28</td>
<td>0.15</td>
<td>0.19</td>
<td>0.59</td>
<td>0.04</td>
</tr>
<tr>
<td>to problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I prefer watching educational to entertainment programs.</td>
<td>0.38</td>
<td>0.14</td>
<td>-0.09</td>
<td>-0.01</td>
<td>0.44</td>
<td>-0.10</td>
</tr>
<tr>
<td>I prefer my life to be filled with puzzles that I must solve.</td>
<td>0.35</td>
<td>0.15</td>
<td>0.15</td>
<td>-0.11</td>
<td>0.82</td>
<td>0.06</td>
</tr>
<tr>
<td>I find little satisfaction in deliberating hard and for long</td>
<td>0.33</td>
<td>0.28</td>
<td>0.17</td>
<td>0.64</td>
<td>0.10</td>
<td>-0.06</td>
</tr>
<tr>
<td>hours.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It’s enough for me that something gets the job done, I don’t</td>
<td>-0.07</td>
<td>0.77</td>
<td>0.10</td>
<td>0.75</td>
<td>-0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>care how or why it works.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simply knowing the answer rather than understanding the</td>
<td>0.00</td>
<td>0.75</td>
<td>-0.04</td>
<td>0.70</td>
<td>0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td>reasons for the answer to a problem is fine with me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I usually end up deliberating about issues even when they do</td>
<td>0.25</td>
<td>0.49</td>
<td>-0.22</td>
<td>0.26</td>
<td>0.23</td>
<td>-0.47</td>
</tr>
<tr>
<td>not affect me personally.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I only think as hard as I have to.</td>
<td>0.25</td>
<td>0.46</td>
<td>0.17</td>
<td>0.78</td>
<td>-0.04</td>
<td>-0.02</td>
</tr>
<tr>
<td>I would rather do something that requires little thought than</td>
<td>0.25</td>
<td>0.40</td>
<td>0.31</td>
<td>0.72</td>
<td>0.14</td>
<td>0.05</td>
</tr>
<tr>
<td>something that is sure to challenge my thinking abilities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statement</td>
<td>Factor 1</td>
<td>Factor 2</td>
<td>Factor 3</td>
<td>Factor 4</td>
<td>Factor 5</td>
<td>Factor 6</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Ignorance is bliss.</td>
<td>-0.17</td>
<td>0.39</td>
<td>0.24</td>
<td>0.53</td>
<td>0.07</td>
<td>0.06</td>
</tr>
<tr>
<td>I am usually tempted to put more thought into a task than the job minimally requires</td>
<td>0.13</td>
<td>0.37</td>
<td>0.09</td>
<td>0.14</td>
<td>0.51</td>
<td>-0.27</td>
</tr>
<tr>
<td>I prefer to let things happen rather than to understand why they turned out that way.</td>
<td>0.20</td>
<td>0.34</td>
<td>0.12</td>
<td>0.85</td>
<td>-0.17</td>
<td>-0.20</td>
</tr>
<tr>
<td>I would prefer complex to simple problems.</td>
<td>0.27</td>
<td>0.30</td>
<td>0.18</td>
<td>0.05</td>
<td>0.74</td>
<td>-0.07</td>
</tr>
<tr>
<td>I don’t reason well under pressure.</td>
<td>-0.03</td>
<td>-0.08</td>
<td>0.59</td>
<td>0.34</td>
<td>0.20</td>
<td>0.49</td>
</tr>
<tr>
<td>I have difficulty thinking in new and unfamiliar situations</td>
<td>0.08</td>
<td>0.13</td>
<td>0.56</td>
<td>0.58</td>
<td>0.00</td>
<td>0.39</td>
</tr>
<tr>
<td>I am hesitant about making important decisions after thinking about them.</td>
<td>-0.12</td>
<td>-0.16</td>
<td>0.55</td>
<td>0.47</td>
<td>-0.06</td>
<td>0.37</td>
</tr>
<tr>
<td>I don’t like to have the responsibility of handling a situation that requires a lot of thinking</td>
<td>0.18</td>
<td>0.18</td>
<td>0.50</td>
<td>0.66</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>I like tasks that require little thought once I’ve learned them</td>
<td>0.11</td>
<td>0.10</td>
<td>0.50</td>
<td>0.60</td>
<td>0.12</td>
<td>-0.10</td>
</tr>
<tr>
<td>These days, I see little chance for performing well, even in “intellectual” jobs, unless one knows the right people.</td>
<td>-0.06</td>
<td>-0.04</td>
<td>0.41</td>
<td>0.47</td>
<td>-0.10</td>
<td>0.23</td>
</tr>
<tr>
<td>I feel relief rather than satisfaction after completing a task that required a lot of mental effort.</td>
<td>0.20</td>
<td>0.04</td>
<td>0.40</td>
<td>0.63</td>
<td>0.14</td>
<td>-0.06</td>
</tr>
<tr>
<td>I would prefer a task that is intellectual, difficult and somewhat important to one that is somewhat important but does not require much thought</td>
<td>0.25</td>
<td>0.18</td>
<td>0.38</td>
<td>0.18</td>
<td>0.59</td>
<td>0.00</td>
</tr>
<tr>
<td>More often than not, more thinking just leads to more errors.</td>
<td>0.04</td>
<td>0.20</td>
<td>0.37</td>
<td>0.73</td>
<td>-0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.</td>
<td>0.19</td>
<td>0.20</td>
<td>0.36</td>
<td>0.81</td>
<td>-0.07</td>
<td>-0.10</td>
</tr>
<tr>
<td>I prefer to think about small, daily projects to long-term ones.</td>
<td>0.10</td>
<td>0.06</td>
<td>0.21</td>
<td>0.50</td>
<td>0.16</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Note. In Sample 1 (N=315), the factors are interpreted as reflecting: (1) Enjoyment of cognitive effort (2) Preference for understanding, and (3) Self-efficacy for intellectual tasks. In Sample two (N=290), the factors are interpreted as reflecting (1) Contrait method factor, (2) Protrait method factor, and (3) Self-efficacy for intellectual tasks.
Sample 1.
Parallel analysis indicated a maximum of three factors should be extracted while the scree test indicated four factors; the more conservative three factor solution demonstrated clear delineation of factors and only two items not loading >.32 on any factor. The factors were interpreted as representing “Enjoyment of cognitive effort”, “Preference for understanding” and “Self-efficacy” respectively. Inter-factor correlations were $r_{1,2}=.58$, $r_{1,3}=.49$ and $r_{2,3}=.41$.

Sample 2.
As per Sample one, Parallel analysis indicated a three factor solution, while the scree proposed four or five factors. While the first and second factors (constituted of negatively and positively worded items respectively) differentiated cleanly, the third factor was identified by items that also loaded on the principal factor; these items reflecting self-efficacy for intellectual tasks. Inter-factor correlations were $r_{1,2}=.54$, $r_{1,3}=.15$ and $r_{2,3}=.02$.

Confirmatory Factor Analyses
As per analysis protocol, the factor structures from previous studies were subjected to confirmatory factor analysis, the fit of the models represented below (Table 3.2).
Table 3.2

Fit statistics for tested Need for Cognition solutions

<table>
<thead>
<tr>
<th>Model</th>
<th>-2LL</th>
<th>df</th>
<th>p</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>34 item unifactorial</td>
<td>1190.889 /</td>
<td>527</td>
<td>0.000</td>
<td>0.813 / 0.763</td>
<td>0.801 / 0.0748</td>
<td>0.063 / 0.091</td>
<td>0.059 / 0.081</td>
</tr>
<tr>
<td>18 item unifactorial</td>
<td>315.129 /</td>
<td>135</td>
<td>0.000</td>
<td>0.909 / 0.890</td>
<td>0.897 / 0.876</td>
<td>0.065 / 0.091</td>
<td>0.048 / 0.059</td>
</tr>
<tr>
<td>Lord &amp; Putrevu (2006)</td>
<td>235.506 /</td>
<td>94</td>
<td>0.000</td>
<td>0.892 / 0.921</td>
<td>0.862 / 0.899</td>
<td>0.069 / 0.074</td>
<td>0.061 / 0.061</td>
</tr>
<tr>
<td>Lord &amp; Putrevu (2006) items - unifactorial</td>
<td>281.025 /</td>
<td>104</td>
<td>0.000</td>
<td>0.865 / 0.768</td>
<td>0.844 / 0.732</td>
<td>0.074 / 0.121</td>
<td>0.056 / 0.088</td>
</tr>
<tr>
<td>Tanaka et al. (1988) oblique</td>
<td>636.592 /</td>
<td>272</td>
<td>0.000</td>
<td>0.860 / 0.824</td>
<td>0.846 / 0.806</td>
<td>0.065 / 0.094</td>
<td>0.057 / 0.075</td>
</tr>
<tr>
<td>Tanaka et al. (1988) items - unifactorial</td>
<td>706.344 /</td>
<td>275</td>
<td>0.000</td>
<td>0.835 / 0.814</td>
<td>0.820 / 0.797</td>
<td>0.071 / 0.096</td>
<td>0.058 / 0.076</td>
</tr>
<tr>
<td>Furnham &amp; Thorne (2013)</td>
<td>485.334 /</td>
<td>206</td>
<td>0.000</td>
<td>0.884 / 0.771</td>
<td>0.870 / 0.743</td>
<td>0.066 / 0.108</td>
<td>0.054 / 0.087</td>
</tr>
<tr>
<td>Furnham &amp; Thorne (2013) items - unifactorial</td>
<td>546.727 /</td>
<td>209</td>
<td>0.000</td>
<td>0.860 / 0.761</td>
<td>0.845 / 0.735</td>
<td>0.072 / 0.109</td>
<td>0.056 / 0.084</td>
</tr>
</tbody>
</table>

Note. Statistics for Sample 1 are presented before the slash and those for Sample 2 after.
Sample 1.
The original multifactorial solution posited in Study one of Lord and Putrevu (2006) produced a non-positive definite latent variable covariance matrix due to interfactor correlations greater than 1. Similarly, whilst the fit of the obliquely rotated Tanaka et al. (1988) and Furnham and Thorne (2013) solutions were quite good, the latent factors were substantially intercorrelated (Tanaka et al: $r_s = .745-.891$; Furnham & Thorne: $r_s = .856-.921$). The full 34 item Unifactorial solution performed the weakest but had RMSEA and SRMR below conventional criteria (Hu & Bentler, 1999). Finally, of the previously established models, the 18 item scale (Cacioppo, Petty, & Kao, 1984) showed the best fit across Comparative fit indices and was below cutoffs for the RMSEA and SRMR.

Sample 2.
In Sample two, only the Lord and Putrevu (2006) and 18-item short form scales recorded fit indices near standard cut-offs, however, consistent with sample 1, the Lord and Putrevu solution reported a non-positive definite Psi matrix. This is attributable to the extremely strong correlation ($r = .963$) between “Preference for complexity” and “Commitment of cognitive effort” factors, the remaining correlations between the “Enjoyment of cognitive stimulation”, “Confidence in cognitive ability”, and “Desire for understanding” factors were also high ($r_s > .85$). Performance of the remaining solutions was substantially worse with the Tanaka et al. (1988) solution falling short of criteria with extreme intercorrelations ($r_s > .9$) between the factors and the Furnham and Thorne (2013) and 34 item unifactorial solutions falling well short of fit criteria.

Discussion
This study aimed to address ambiguity surrounding the factorial structure of the Need for Cognition Scale, with a view to improve measurement in future research but possibly also
provide insight into the nature of the construct itself. The strength of these results comes from the methodological consistency, which minimises method variance, thereby increasing sensitivity to sample specific variability and the underlying structure. These results thus can strongly suggest that any previously observed factors within the broader measure are functions entirely of sample specific variance and cannot be reliably replicated.

As noted in Chapter Two, there has been a bias for PCA use in studies advocating unifactorial solutions and EFA based studies to support multifactorial solutions for the NFC scale. As PCA is intended to identify components that represent all the variance rather than the shared variance of interest in Factor analysis (Fabrigar et al., 1999), this has, to date, undermined the assertion that the scales covariance is best represented with a single factor. Further the failure to adhere to a consistent methodology for evaluating factor structures has left unresolved whether varied solutions are a function of varied methods into the third decade of this scale’s life, despite its widespread application. This question is now answered through these results; historical variations in methodology are not the only source of inconsistency in factorisation.

The results of the CFAs (Table 3.2) in Sample one appeared somewhat consistent with multifactorial models posited by earlier studies (Furnham & Thorne, 2014; Tanaka et al., 1988), with model fit appearing incrementally better for these than for the same set of items in unifactorial configuration. Equally, EFA did provide a multifactorial solution with some face validity (Table 3.1), with factors relating to enjoyment of cognitive effort, preference for understanding and self-efficacy emerging. However, results from one sample, even by reference to the common factors across solutions, simply produces another possible solution and adds to uncertainty about the factorial structure of the scale as a whole. Notably in Sample two, method factors emerged in the EFA in place of the substantive factors with the first two factors being defined by negatively worded and positively worded respectively.
Further, the confirmatory analyses show poorer fit for the prior multifactorial solutions despite consistency in measurement in analyses. As such, it becomes apparent that in any given sample the emergence of additional factors in the NFC scale is very likely a function of idiosyncratic sample characteristics rather than representing evidence of a meaningful common factors.

The design intent of the measure was to capture individual differences in a generalised tendency to engage in and enjoy effortful cognition, with the full set of items being intended to reflect this common factor. Duly, the presence of additional substantive factors would have only been serendipitous. Contrary to suggestions that NFC is essentially multifactorial with affective (enjoyment) and behavioural (engagement) aspects (Lord & Putrevu, 2006), these or any other aspects do not differentiate in self-report. While a number of items within the scale do contain content that has been taken to reflect sub-factors, like a desire for understanding or self-efficacy, these have been shown within this research to not demonstrate stable relationships to one another consistent with them representing independent factors.

The lacklustre fit of the 34 item unifactorial solution across both samples suggests, however, that the items differentiating the 34- and 18-item measures has given rise to these supplementary, irreplicable factors in Sample one and in prior research (Furnham & Thorne, 2013; Lord & Putrevu, 2006; Tanaka et al., 1988). This suggests that the 34-item scale is incompletely optimised to capture this single factor; as such, the 18-item scale, which has demonstrated the best fit within the current research might be better conceptualised as an optimised NFC scale rather than a short-form scale. It is recommended, therefore, that the 18-item scale be exclusively used as the measure of NFC, although some further potential for optimisation remains with the fit being closer to the minimum cut-offs. Optimisation of the measure should consider not only the replicability of factors but the predictive validity of the measure and is beyond the scope of this study.
This research has investigated the factor structure of the NFC with a view to resolving measurement issues in the scale and guide development of theory. These results indicate that the replicable covariance in the NFC measure appears to be adequately captured with a single factor which is best assessed by the 18 item scale. The application of this version of the scale is recommended in the present lines of research regarding discriminant validity with other investment traits (Fleischhauer et al., 2010; Mussel, 2013; Woo, Harms & Kuncel, 2007), investigations into behavioural outcomes, and future investigations of the causes of NFC. Notably, in the absence of supplementary factors, the NFC scale does not provide insight into the drivers of the behaviour itself and thus alternate avenues should be explored for understanding the motivations underpinning NFC. One such avenue is the examination of the behaviours proximately associated with the NFC, to better understand how individuals varying in the NFC scale differ in the activities they enjoy and engage in. By identifying the specific types of effortful cognition associated with NFC, insight may be obtained into the motivating processes and this is the focus of the next study.
References


Horn, J. L. (1965). A Rationale and Test for the Number of Factors in Factor Analysis, Psychometrika, 30, 179-85.


Chapter 4

Empirical Test of the Process Enjoyment model of NFC

As discussed in Chapter One, the theoretical underpinnings of NFC remain incompletely accounted for. Based on a systematic review of the literature (Chapter Two), it was proposed that the NFC scale might be better represented by multiple factors, the identification of which might guide investigation into any underlying motivational processes. However empirical investigation of the scale’s dimensionality did not support this (Chapter Three) and instead suggested that the 34-item NFC scale is incompletely optimised and contains only one replicable factor. Given the self-report measure is silent on the underlying motivation, this chapter will investigate the motivation captured by the NFC scale through its prediction of behaviour, in particular whether the NFC scale predicts behaviour by way of a domain-general enjoyment of effortful cognition.

As discussed in earlier chapters and by prior authors (e.g., Steinhart & Wyer, 2009), the motivational force that is described by this measure is still ambiguous. This is somewhat reflected by its various definitions as an abstract statistical tendency for effortful cognition (Cacioppo & Petty, 1982), “the tendency for people to enjoy thinking or not” (Petty, Cacioppo, Strathman & Priester, 2005, p94) and more frequently, a tendency to engage in and enjoy effortful cognition (Petty, Briñol, Loersch & McCaslin, 2009). While this particular aspect of the construct is not discussed extensively in the literature, a dominant account of this motivation appears to be that individuals varying in NFC differ in an inherent desire for and enjoyment of effortful cognition generally (Petty et al., 2009). These differences in enjoyment are suggested to be derived from prior experiences of problem solving which are driven by idiosyncratic and goal-directed motives which may be situational (e.g. compliance with educational tasks) or dispositional (e.g. need to evaluate [Jarvis & Petty, 1996] or desire for control [Burger & Cooper, 1979]. Specifically, environmental factors such as performance
feedback or external pressure on these goal driven elaboration events that, over time, leads to the development of a stable individual differences in enjoyment of the process of effortful cognition (Cacioppo, Petty, Feinstein & Jarvis, 1996). It is then the degree to which individuals perceive effortful cognition enjoyable for its own sake, absent any specific objective like desire for control, which leads to dispositional differences in engagement in pursuit of this enjoyment (Figure 4.1).

![Figure 4.1. Simplified Enjoyment of Process model of NFC with direct effects of goal directed motives in engagement excluded.](image)

That there are meaningful individual differences in the tendency to engage in effortful cognition is not in question. As has been previously discussed (Chapter One), NFC is negatively associated with social loafing on cognitive tasks (Smith, Kerr, Markus & Stasson, 2001); high NFC individuals discriminate between persuasive messages on argument quality more by default (Cacioppo, Petty, Kao & Rodriguez, 1986; Cacioppo, Petty & Morris, 1983), while low NFC individuals need to be motivated by personal relevance (Axsom, Yates & Chaiken, 1987) or mistrust of the source (Priester & Petty, 1995) and so on. However, the essential differences characterised in early specifications of the NFC were in the likelihood of engagement in elaborative cognition, not specifically in the motives thereof. As discussed in Chapter One, this domain-general enjoyment is not the only means by which individuals might be predisposed to this behaviour.
The representation of NFC as reflecting a general enjoyment of effortful cognition initially appears a parsimonious account of the diversity of outcomes associated with NFC. For example, as a simple index of cognitive output NFC is associated with differences in both the quantity ($d_{\text{Meta-analysis}}=.205$, Cacioppo et al, 1996) and quality of thought production, being positively associated with production of explanatory thoughts for others behaviour (Lassiter, Briggs & Slaw, 1991). It also is associated with more expansive seeking of information when making decisions (Levin, Huneke & Jasper, 2000; Verplanken, Hazenberg & Palenéwen, 1992) and the correction (and overcorrection) from biasing information, both when directed to in mock trial situations (Sommers & Kassin, 2001), and when independently becoming aware of priming (Petty, DeMarree, Brinol, Horcajo & Strathman, 2008). Such outcomes are unlikely to be derived from one common goal motive besides seeking intrinsic enjoyment from the process; duly, such a factor initially seems the most parsimonious account of these diverse effects. However, there is limited direct evidence for differences in enjoyment of process being the specific motivator of behaviour or its development in this fashion. Further, these motives that are posed as drivers of early engagement from which this enjoyment is internalised likely continue to independently promote engagement in effortful cognition, possibly in a trait-like fashion consistent with NFC.

Evidence suggests that the relationship between NFC and enjoyment of effortful cognition is not simple, with task enjoyment in one study being highest for those moderate and low for those both higher and lower in NFC (Knobloch-Westenwick & Keplinger, 2008). Additionally, while NFC is associated with approach motives for engaging in argument (Nussbaum & Bendixen, 2003), and high NFC individuals under forced choice situations will select complex puzzles over simple puzzles (Fleischhauer, Strobel & Strobel, 2015), they additionally endorse more avoidance motives when primed to anticipate failure on a cognitive task (Steinhart & Wyer, 2009). Other studies demonstrate that the relationship between NFC
and enjoyment can be situationally moderated, for example, being eliminated by provision of extrinsic rewards concomitantly with the free-choice engagement with a cognitive task (Thompson, Chaiken & Hazlewood, 1993). Further, while there is some evidence that enjoyment is predicted on the complexity of the task, with high NFC individuals preferring more complex tasks and low NFC preferring less complex tasks (Cacioppo & Petty, 1982) there is evidence of that this relationship is non-linear. In one study (Knobloch-Westerwick & Keplinger, 2008), there was an interaction between NFC and plot complexity on enjoyment of a story, with high NFC individuals preferring moderate complexity plots more, though strongly disliking simple narratives. Results such as these suggest that, where motivation in NFC is a function of domain-general enjoyment of effortful cognition, it can be dominated by situational factors, or some other model of motivation is needed.

This claim is further supported by evidence that the behavioural effects of NFC can be wholly inverted by situational factors. That is, while NFC generally has a positive association with the investment of cognitive effort (Cacioppo et al, 1996) individuals high in NFC can be situationally induced to invest less cognitive effort than individuals low in NFC. For example, priming individuals to anticipate a message matching their NFC (i.e., framing message as low in complexity for low NFC individuals or high message complexity for high NFC individuals) induced evaluation of the quality of arguments in both print advertisement (Wheeler, Petty & Bizer, 2005) and the use of prior knowledge when forming an attitude (See, Petty & Evans, 2009). More notable in both of these cases is that priming individuals at either end of the NFC distribution to anticipate a non-matching message resulted in low elaboration (Wheeler, Petty & Bizer, 2005), even where the message is unchanged (See, Petty & Evans, 2009). The reduction in effort in high NFC individuals, who would be expected to apply more effort unless specifically inhibited (e.g., under cognitive load), and particularly the increased effort in low NFC individuals due to expected simplicity, is difficult to
accommodate within a model of NFC reflecting enjoyment of effortful cognition. It is proposed by Wheeler et al. that this is a result of self-schema matching (where NFC represents a self-schema as thoughtful or intellectual), though inversion of the typical effects on discrimination of argument quality were also observed in mock jury deliberations where participants were not cued to the information complexity (Shestowky & Horowitz, 2004). Overall, this further suggests that where the motive factor of NFC is an individual difference in enjoyment of effortful cognition, this is liable to domination by situational factors under some circumstances.

As previously noted, this intermediary trait enjoyment of effortful cognition is not necessary to explain individual differences in effortful cognition associated with NFC scores. The various goal-directed motives which are indicated as precursors to NFC in the conventional model could instead be direct causal influences on behaviour and also of responses on the NFC scale, or these responses could be self-perceptions of an individual’s behaviour (Figure 4.2). This would not necessitate that these differences in engagement be driven by one motive, nor that all individuals with any specific score on the NFC scale must endorse a common set of motives; instead, each individual’s propensity to effortful cognition would be driven by idiosyncratic motives for such behaviour. Accordingly, NFC would not represent a motive in and of itself, but instead an aggregate of all the pro- and con- motives for effortful cognition, such as a desire for understanding, boredom aversion and so forth. For example, an individual may be motivated by a desire for control and boredom aversion, or by sensation seeking and habitual engagement and report similarly on the NFC scale and engage in a diversity of cognitive tasks. Equally, an individual might lack these approach motives and have a fear of failure and a strong belief in simple knowledge, duly responding low on the NFC scale as a function of these factors. Insofar as these are subsumed into a gross index of elaborative tendency, this is still a cogent explanation for the diverse outcomes associated
with the NFC scale; and where these are dispositional (like need to evaluate or sensation seeking) or chronic situational (e.g. extrinsic workplace motivation), this would account for longitudinal stability.

Figure 4.2. Alternate models of NFC, with NFC scores and behaviour commonly caused by goal directed motives (Panel 1) or scale scores being derived by self-perception (Panel 2).

Where the motives are more specific, for example, where behaviour is motivated by a dispositional desire to understand the world, then this would represent a more explicit target by which to promote dispositional effort. In addition, a multi-motive representation would also account for modest effect sizes where stronger direct effects might be expected, as individuals might respond equivalently on the NFC scale, but be expressing this as a function of fundamentally different motive profiles and duly being more or less motivated to engage in a given task.

The Present Study

In sum, while the dimensionality of the NFC scale and its association with behaviour is established, uncertainty remains regarding the motivation for these behaviours - whether they are motivated wholly by a generalised enjoyment of effortful cognition or other processes. While the broad spectrum of behaviours associated with NFC seems most parsimoniously explained by the enjoyment of cognitive effort itself, it is not the only possible explanation for these effects and evidence of situational moderation undermines it as
a comprehensive account. A clearer understanding of this motivation would allow for better understanding of the impact of NFC in ecological contexts but also potentially provide avenues to promoting the tendency to engage in effortful cognition. This study will specifically attempt to test the enjoyment model through evaluating the association between the NFC scale and abstracted cognitive tasks, where the enjoyment model should predict engagement differentially from more goal directed accounts. Insofar as there are no universally accepted examples of domain general effortful cognition, a small cohort of participants will be measured on a pool of tasks which may represent criteria for subsequent evaluations. Where NFC indexes dispositional enjoyment of the process of effortful cognition, it is hypothesised to predict engagement in and self-reported enjoyment of suitably complex cognitive tasks, even where this is not purposeful.

Methods

Participants

Participants who had previously completed an online survey as part of the investigation into the factor structure (Chapter 3, Sample one), were invited to participate in the current, lab-based investigation. Twenty individuals participated in this investigation (13 female, 7 male) aged between 18 and 60 ($M = 27.05$, $SD = 9.52$). The primary sample was recruited via online social media, and promotion in undergraduate university classes.

Materials and Procedure

Online Pre-Survey. Participants completed self-report measures via an online survey that contained demographic measures and the 18-item NFC scale (Petty, Cacioppo & Kao, 1984). This measure contains a series of statements about participants’ engagement in effortful cognition, to which participants respond via a 7 point Likert scale from Strongly Disagree (1) to Strongly Agree (7). Items include “I would prefer complex to simple
problems” and have been shown to be the best available measure of the NFC’s single factor (see Chapter 3); scale scores were derived by summing. Participants were then invited to participate in follow up tasks in person; where participants indicated intent to do so, they were contacted by the researchers to schedule a laboratory session.

Puzzle persistence tasks. Puzzles have been previously used to evaluate the predictive capacity of NFC (e.g. Fleischhauer et al. 2015), however, these typically demonstrate specificity to a domain such as physics (Fleischhauer et al, 2015) or language skills (e.g. Anagrams, Gülgöz, 2001). These types of tasks may be sensitive to contaminating effects of competence but also potentially direct effects of goal-directed motives. Duly, puzzles were specifically chosen to be abstract and purposeless so as to provide the strongest test of NFC reflecting generalised enjoyment of the effortful cognition itself. Participants were administered a series of four puzzles, two wooden “burr” puzzles, where the object is to assemble a collection of pieces into a singular structure, and two wire disentanglement puzzles, with the object of separating a component of the puzzle from the remainder. Participants were shown the solved state for each puzzle on a tablet computer to mitigate concerns that the puzzle was unsolvable, however tasks were selected to be unlikely to be solved within the allotted time so as to minimise the censoring of data due to factors other than motivation. Participants were given a maximum of 10 minutes to complete each puzzle but were instructed that they could desist at any time before then. While this censoring might restrict the sensitivity of the measure, this was offset against the potential loss of comparability between participants where the length of the lab session more substantially varied, or extended beyond one hour. Time (in seconds) spent on the puzzle was covertly recorded for each participant, and the average time invested in the puzzles was taken. Where individuals successfully solved a given puzzle (4 cases), the times for that puzzle were not

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6 See Appendix C.1
included in the average. Self-reported enjoyment of the puzzle tasks was additionally recorded on seven point scales from *Extremely unenjoyable* (1) to *Extremely enjoyable* (7); the sum of this was taken to represent overall enjoyment.

**Video engagement.** Participants were shown a series of 10 educational videos\(^7\) with durations ranging from 1 to 12 minutes and whose content covered an array of topics. Videos were used as an adjunct to the puzzles to account for the possibility that NFC may differentially predict enjoyment of active (e.g., puzzles) or passive (e.g., video) tasks. The content of the videos (drawn from educational channels on YouTube) covered topics from humanities, economics, and the sciences and were selected for their non-technical explanations of technical content; these were selected by two raters attempting to match the videos for complexity and production quality across domains where possible. Example topics include the role of Collateralised Debt Obligations and credit default swaps in precipitating the US sub-prime mortgage crisis and the influence of the Norman Conquest on the English language. After watching each video, participants were asked to rate the video on enjoyability on seven point scales from *Extremely unenjoyable* (1) to *Extremely enjoyable* (7). As the enjoyment of individual videos or clusters based on intercorrelations is likely to reflect differences in domain specific interests and potentially goal-directed motives, the mean enjoyment was taken of all videos, to capture only enjoyment of educational videos broadly.

**Cognitive Reflection Task.** While on-site, participants were administered the original Cognitive Reflection Task (CRT; Frederick, 2005). This is a 3-item measure designed to elicit wrong answers which can be detected by further cognitive reflection; these wrong answers tend to involve verbatim responding with item content (Liberali, Reyna, Furlan, Stein & Pardo, 2012). For example the first item asks “A bat and ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?” typically attracting an answer of 10

\(^{7}\) Videos listed in Appendix C.1; playlist available here: [http://tinyurl.com/z9kmaaa](http://tinyurl.com/z9kmaaa)
cents instead of the correct answer, 5 cents. A point is awarded per correct answer and the results from this task are summed to provide an index of cognitive reflection ranging from 0-3.

Results

Data were screened for missing data and assumption checks were made. Descriptive statistics and Pearson’s correlations were derived for the variables of interest (Table 4.1). Inconsistent with the enjoyment model of NFC, no significant correlations were found between NFC and any of the outcomes even after correcting for reliability. While caution is warranted in interpreting trends given the low power (80% for |r|=0.5) of this investigation, it is noteworthy that the coefficients describing the relationship between NFC and the outcomes were all weak and, in the case of the enjoyment of the videos, negative. A significant correlation was, however, observed between persistence with and enjoyment of the puzzles.

Table 4.1
Descriptive statistics and Pearson’s correlations for NFC and behavioural outcomes

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NFC</td>
<td>90.3</td>
<td>13.45</td>
<td>0.904</td>
<td>-0.287</td>
<td>-</td>
<td>0.144</td>
<td>0.178</td>
</tr>
<tr>
<td>2. Video Enjoyment</td>
<td>4.72</td>
<td>1.00</td>
<td>-0.255</td>
<td>0.873</td>
<td>-</td>
<td>0.316</td>
<td>0.340</td>
</tr>
<tr>
<td>3. CRT</td>
<td>1.00</td>
<td>0.92</td>
<td>0.026</td>
<td>-0.114</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. Puzzle persistence</td>
<td>419.41</td>
<td>145.36</td>
<td>0.122</td>
<td>0.263</td>
<td>0.122</td>
<td>0.793</td>
<td>0.590*</td>
</tr>
<tr>
<td>5. Puzzle enjoyment</td>
<td>16.00</td>
<td>4.77</td>
<td>0.144</td>
<td>0.270</td>
<td>-0.114</td>
<td>0.446*</td>
<td>0.723</td>
</tr>
</tbody>
</table>

Note. * = p<.05, Raw correlations presented below the diagonal, Cronbach’s alpha on diagonal, disattenuated correlations presented above. Puzzle persistence results based on 16 cases, N=20 for all other effects.

Discussion

The present study aimed to provide insight into the possible motivation underlying NFC, specifically testing the hypothesis that a generalised enjoyment of effortful cognition drives the associated differences in behaviour. Given no significant relationships were observed between NFC and the indices of effortful cognition nor enjoyment of educational
videos, this suggests that any motivation captured by the NFC lacks the generality proposed by the model of NFC as enjoyment of process.

As previously detailed, the applications of the NFC scale are many and varied (Cacioppo et al, 1996), suggesting higher levels of NFC are associated with better skill learning (Day et al., 2007), better academic outcomes (Elias & Loomis, 2002; Richardson, Abraham & Bond, 2012; Wang & Newlin, 2000) and responses to psychological intervention (Capone & Wood, 2009), and other distal outcomes. The current research does not contradict these earlier results, but may give cause to reconsider the causative factors in these relationships. That is to say, that while NFC certainly assesses some motivation for effortful cognitive activity, the present results suggest that this motivation itself may not be a function of enjoyment of effortful cognition in its own right. As the motivation underlying NFC will determine the specific applications and limitations of its predictive validity, identifying this remains a key objective.

While the results of this small study in isolation should not be given undue weight, the failure of NFC scores to associate with the persistence in an effortful cognitive task, reflection in processing, and enjoyment of complex videos sits at odds with the conventional interpretation of the scale. These tasks were chosen to offer a diversity of manifestations of effortful cognition, that none of these correlated with the NFC scale in a manner consistent with it representing a generalised enjoyment of effortful cognition represents stronger evidence than any one in isolation. Furthermore, the largest non-significant effect size was NFC’s negative correlation with the most explicit enjoyment outcome, enjoyment of the videos. While not overstating the ecological validity of the videos as ideal stimuli for effortful cognition, nor the sample’s representativeness of the population at large, a substantive positive correlation, comparable to that between puzzle persistence and enjoyment, would be
anticipated were enjoyment the motive factor in NFC; the observed correlation (bootstrapped 95% CI for that effect ranges from -0.5456 to 0.0275) is substantially inconsistent with this.

This, in many ways, is consistent with the aforementioned complexity in the association between NFC and enjoyment of effortful cognition (Knoblock-Westerick & Keplinger, 2008) and constitutes further evidence that such a representation of motivation in NFC may presently be oversimplified. Consideration should be given to the explanations for intrinsically motivated engagement in effortful cognition other than finding this inherently enjoyable, such as the avoidance of error, or desire for control (Thompson, Chaiken & Hazlewood, 1993). Alternately, NFC scores may be a function of self-perception or cognitive dissonance processes (Fazio, Zanna & Cooper, 1977) based on prior performance at learning tasks or like outcomes – that is, individuals who find themselves involved in effortful cognition due to chronic situational demands may attribute this internally.

As an initial examination of the correlation of enjoyment of and engagement with complex cognition with the NFC scale, this study is not without limitations. While no norms are known for the NFC scale, the sample had a high mean NFC (71.67% of maximum score), and a limited range which may limit generalisability to lower levels of NFC; this may have affected the estimation of the relationships due to limited range or censoring. Comparable means have been reported in prior studies where NFC has had an impact on behaviour, such as Tsfatsi and Capella (2005) with a mean for NFC 70.2% of maximum score. Also limiting confidence in the generalisability of these results is the divergence between the correlation between NFC and the Cognitive Reflection Test in this sample and prior samples (Frederick, 2005). However, recent research has suggested participants may no longer be naive to the CRT due to its proliferation in popular media and extensive use in research (Thompson & Oppenheimer, 2016). Insofar as this contributes additional random influences on performance
on this task, non-naiveté may reduce effect sizes (Chandler, Paolacci, Peer, Mueller & Ratliff, in press) though it is unclear if this has had an influence in this sample.

In addition, the tasks utilised in this study are only a limited representation of stimuli for elaboration. Pointedly, while the diversification and aggregation of the puzzles and videos limits the impact of individual differences in domain specific interests and goals, the degree to which these reflect true domain-general indices for engagement and enjoyment is unknown. For example, engagement might be suppressed by a particular distaste for these types of tasks undermining the assessment of any true effect of a generalised enjoyment of effortful cognition. Moreover, given the inversion of typical NFC effects observed in some prior research (See et al., 2009; Shestowky & Horowitz, 2004; Wheeler et al, 2005), there is some risk that effects have been overwhelmed by situational factors including the burden of participation, which was not insubstantial. While efforts were made to standardise delivery and control for complexity as much as possible within this design, individual differences in the perception of task complexity could confound measurement. That is to say, where participants do not agree on the perceived complexity of the puzzles or videos, mismatching of NFC would effectively induce random error. Each of these limitations are exacerbated by the limited sample size.

Specificity mismatch, the poor prediction of single behaviours with a broad attitudinal measures (Fishbein & Ajzen, 1974), may also be a challenge to the validity of this test of NFC. Insofar as personality or attitude variables may only be expected to predict behaviours over the long term-average, strong associations with these particular tasks might be unlikely; that noted, the prediction of single behaviours by NFC has been part of the evidence for the measure’s criterion validity as reviewed in Chapter one. Moreover, the aggregation across tasks may attenuate some of this concern.
While ideally these tasks might have been more extensively applied to the investigation of the motivation underlying NFC, given the trend of the results being contrary to the typical outcomes of NFC, coupled with the caveats to the tasks’ validity, alternate lines of investigation are warranted. In light of the limitations of the laboratory setting and the importance of the manifestation of NFC in real-world contexts to key distal outcomes, efforts should be undertaken to maximise the ecological validity of the outcome behaviours. By doing so, not only can greater confidence be taken in the relevance of results to motivation of substantive outcomes, but further insights can be obtained into NFC more broadly. With the increasing importance of situational factors such as personal relevance and schema consistency to what has otherwise been treated as a trait variable, direction might be taken from other domains of research with similar state-trait considerations.

Research into phenomena such as coping (Schwartz, Neale, Marco, Shiffman & Stone, 1999), body image (Mills, Fuller-Tyszkiewicz & Holmes, 2014), and alcohol consumption (Swendson et al., 2000) have made use of Ecological Momentary Assessment (EMA) designs, which utilise repeated measurements of behaviour in context. This allows for the detailed evaluation of within-individual stability and variance in addition to between-subjects effects, and as such, is ideally suited to the investigation of whether there is a consistent motivation for effortful cognition. The EMA design may also provide the opportunity to assess the degree to which the stability in NFC scale scores (Sadowski & Gulgoz, 1992) reflects stability in realised cognitive elaboration.

In sum, the current study provides a test of the generalised enjoyment of effortful cognition suggested to underpin the engagement in effortful cognition associated with the NFC scale. While limited by power and precision, the results of this study contribute to a small body of literature suggesting that this enjoyment based model may be an incomplete representation of the motivational processes that characterise individual differences in NFC.
References


Chapter 5

Ecological Momentary Assessment Investigation of NFC

As previously discussed, uncertainty remains regarding the underlying motivation, development and lived experience of NFC. Most pointedly, this places limits on the ability to predict substantive outcomes under ecological conditions and the promotion of elaborative cognition broadly. One widely accepted feature of NFC, besides its prediction of effortful cognition, is its characterisation by enjoyment of the process of effortful cognition, with implications that differences in enjoyment motivate engagement. However, the relationship between NFC and enjoyment of cognitive tasks has demonstrated some inconsistency (Cacioppo, Petty, Feinstein & Jarvis, 1996) and one study has suggested it may be non-linear (Knobloch-Westerwick & Keplinger, 2008). Additionally, the demonstration of moderation of NFC effects by perceived complexity of a task (See, Petty & Evans, 2009; Wheeler, Petty & Bizer, 2005) suggests that the model of NFC as differences in the enjoyment of effortful cognition may be insufficiently complex to account for the manifestation of effortful cognition.

In Chapter 4, an attempt was made within the lab setting, to evaluate the model of NFC as individual differences in enjoyment of effortful cognition. Were such a model valid, it was presumed that NFC would correlate with enjoyment of and persistence in abstract tasks that were unlikely to be motivated by alternate goal-focussed motives for effortful cognition like need to evaluate. However, no such correlations were observed; even considering the power issues arising from the small sample, the effects themselves were very small and, regarding the mean enjoyment of a series of complex educational videos, even negative. It is pertinent to ask to what degree these results are a fair test of the model particularly whether intrinsic motivation is truly evaluated when participants are required to engage with a task in the first instance.
Such considerations are not unique to the previous chapter, with much of the prior research utilising manipulations and designs which require some trade off of ecological validity to achieve standardised and rigorous implementation. For example, these studies involve a lack of choice and autonomy for participants (e.g., reading of allocated persuasive messages; Priester & Petty, 1995), they lack realistic tasks (e.g., circling numbers according to a rule [Cacioppo & Petty, 1982], counting dots on a screen [Smith et al., 2001], or unitization of behaviour [Lassiter, Briggs & Bowman, 1991]) and exist within very controlled circumstances. The limited resemblance of these to real behaviours such as problem solving in the workplace or engagement with schoolwork may consequently result in some effects observed being dissimilar to the true effects of NFC in relation to these real-world outcomes. For example, dispositional enjoyment of effortful tasks might be underreported due to a dislike of control, or the engagement in choice-free, artificial tasks may not reflect differences in enjoyment or intrinsic motivation broadly, but rather differential acquiescence to the demands of the situation. Duly, exclusive reliance on laboratory studies where engagement in a task may be forced or more subtly motivated by the situation may not give full insight into the motivational processes as they exist in daily experience or the ecological manifestations of NFC more broadly.

It is therefore valuable to obtain a better understanding of NFC in naturalistic settings, not only to gain insight into the motivations that may drive differences in effortful cognition, but more broadly to characterise the lived experience of those varying in NFC. This could also potentially allow new insights into the effects of NFC on distal outcomes, and the unique contribution of NFC with respect to other investment traits.

First, ecological manifestations of effortful cognition are likely to provide novel insights into the nature of what it is to have a particular score on the Need for Cognition scale, beyond what has been obtained by trait self-report or response to laboratory tasks.
Research to date has had limited capacity to understand the substantive differences in actualised effortful cognition in ecological settings. Further, the extent to which the NFC scale predicts enjoyment of particular episodes of real world effortful cognition can specifically address the degree to which it is a motivating factor in this engagement, not only in the single instance, but also dispositionally. Equally, the degree to which individuals varying in NFC attribute their engagement to internal versus external factors may provide additional insight into the drivers of the associated behavioural outcomes.

Second, demonstration of the relationship between the NFC scale and effortful cognition outside of lab settings provides novel insight into the relationships between the NFC scale and real, substantive outcomes like academic achievement (Elias & Loomis, 2002; Richardson, Abraham & Bond, 2012; Wang & Newlin, 2000), which are posited as indirect consequents of differences in elaborative tendency. Evaluation in real settings of the relationship between NFC and engagement in effortful cognition, can explicitly characterise the scale of its impact on every day engagement, but also the situational moderators of this tendency that are relevant in lived experience. For example, matching effects—where elaboration occurs only where complexity matches NFC (See et al., 2009; Wheeler et al., 2005)—can be evaluated for its impact on freely chosen activity where there may be no explicit cues to complexity. Demonstration of these effects may allow for more strategic workplace and educational task allocation. This would additionally provide support for the contention that self-reported NFC is influential in promoting distal outcomes like educational attainment rather than reflecting retrospective justifications of behaviour (e.g., “I have this profession, therefore I must prefer complex to simple problems”) or some other byzantine connection to these outcomes.

Third, ecological behaviours represent a novel criterion on which to determine the relative importance of the NFC over measures of Openness (Costa & McCrae, 1985; De
Young, Shamosh, Green, Braver & Gray, 2009) and Curiosity as Interest and Deficit (Litman, 2008); the discriminant validity of these constructs has been the subject of prior research as discussed in Chapter One (Fleischhauer et al., 2010; Mussel, 2010; Woo, Harms & Kuncel, 2007). Given their substantial redundancy, evaluation within the context of ecological behaviours allows for assessment for differential utility in predicting engagement or effort, or even the enjoyment of effortful cognition. Integrative frameworks such as the Intellect model (Mussel, 2013) and models of intellectual capacity (Ackerman, 1996; Chamorro-Premuzic, & Furnham, 2006; von Stumm, Hell & Chamorro-Premuzic, 2011; Zeigler, Danay, Heene, Asendorpf & Bühner, 2012), which attempt to posit explanations for ecological performance phenomena based on personality factors, would be strengthened by a focus on the measures that correspond most strongly to ecological behaviour.

Ecological Momentary Assessment (EMA) designs allow for sophisticated examinations of ecological behaviour, involving the taking of multiple measurements per day over a number of days as individuals go about their regular affairs (see review, Shiffman, Stone & Hufford, 2008). This design has grown in implementation in concert with the rapid development of smartphone and application (app) technology, which allow for reduced participant burden relative to those using paper diaries (e.g., Litt, Cooney & Morse, 1998) or PDAs (e.g., Colautti et al., 2011). The high-frequency, in-situ, repeated measurements make these designs ideally suited for the characterisation of real-world phenomena that exhibit between between-subjects variability (such as individual differences in NFC) and also within-subjects variability (such as situational moderation of elaborative tendency), while minimising the effects of retrospective recall biases. These recall biases, particularly the estimation of one’s experiences based on recency, extremity (Thomas & Diener, 1990), or coherence with an implicit theory of their behaviour (Ross, 1989) could otherwise
misrepresent the correspondence between the NFC and behaviour in ecological contexts and duly the representation of the construct.

This method also allows for the explicit assessment of the between subjects variability in observed, momentary outcomes like enjoyment of effortful cognition, against which to assess NFC. Additionally, situational moderation by measured factors such as preoccupation, and perceived complexity can be explicitly evaluated (Bolger & Laurenceau, 2013), rather than being artificially manipulated or constrained. As such, this method is ideal for the characterisation of the natural emergence of elaborative behaviours by which to evaluate the motivational characteristics of the NFC scale.

**Current Study**

In sum, uncertainty remains in the motivations underpinning NFC in particular, and its lived experience more broadly. The previous study (Chapter 4) tested the enjoyment of process account of motivation in NFC, and found results contrary to this model. However, the scale and nature of this study, where the choice of initial engagement with cognitive tasks was deprived to participants, may not be a fair test of the motivation underpinning NFC.

To address this limitation and to obtain a more generalised understanding of differences in NFC in naturalistic contexts, this study utilises an EMA design to generate a rich characterisation of the real-world manifestations of effortful cognition. Particularly, it characterises the frequency of engagement in effortful cognition as well the qualities of such engagement in terms of enjoyment, effort, and attribution of cause for engagement in the moment, while controlling for situational factors like complexity, tiredness and busyness.

This record of engagement in effortful cognition in-context is then utilised to contextualise the impact of NFC in real settings by way of its relationship to directly observed individual differences in behaviour. Duly, it can address specific theoretical
questions; testing its relationship with the NFC scale to evaluate the model of NFC as individual differences in the generalised enjoyment of effortful cognition; and evaluating the incremental validity of the NFC and other investment traits. This investigation will be focussed by a series of research questions:

1. To what extent is the engagement in effortful cognition and the qualities of this engagement dispositional rather than situational?
2. What is the relationship between self-reported NFC and effortful cognition in ecological settings when controlling for the situational factors of tiredness and busyness?
3. What is the relationship between the NFC scale specific qualities of the engagement in effortful cognition, particularly enjoyment, but also perceived effort invested and perceived attribution to intrinsic and extrinsic factors while controlling for situational factors? And,
4. What is the incremental validity of the NFC over Openness and Curiosity in predicting these outcomes?

Methods

Design

In order to account for both individual differences variables and the episodic nature of effortful cognitive activity, an EMA design was employed (Bolger & Laurenceau, 2013). This involved two phases of measurement. The first phase used an online baseline survey, measuring between-subjects variables like demographics and NFC. Phase two was implemented through a smartphone app, “Instant Survey” (Richardson, 2015), installed on participants’ iPhone or Android Smartphone. This phase included five days of momentary assessment, where engagement in effortful cognitive activity and momentary covariates were assessed five times per day at pseudo-random intervals.
Participants

Participants were 45\textsuperscript{8} volunteers recruited via advertisements posted on Social Media and on noticeboards, as well as within undergraduate classes at an Australian university. All 45 cases that completed the baseline survey and some EMA data were used in the single level analyses. For the multilevel analyses, 2 were excluded due to responding to the EMA substantially outside the set five day period after baseline. A further two were excluded for providing fewer than 5 responses in the EMA portion of the study (<20% of the possible maximum). The remaining 41 cases constituted 31 females and 10 males aged between 18 and 44 ($M=27.68$, $SD=5.55$).

Materials

**Baseline Survey.** The Baseline survey assessed demographics and self-reports of traits of interest via an online web form. All self-report scales were assessed using 7-point Likert scales ranging from 1 (*Completely inaccurate*) to 7 (*Completely accurate*) which have been show to demonstrate high reliability, validity, and ease of use when contrasted against scales of either shorter or longer length (Diefenbach, Weinstein & O’Reilly, 1993; Preston & Colman, 2000).

**Need for cognition.** NFC was measured using the 18-item form (Cacioppo, Petty & Kao, 1984) of the scale, participants were asked to indicate the degree to which a series of statements such as “I prefer my life to be filled with puzzles that I must solve” described them. This measure is faster to administer and demonstrates better optimisation than the full length scale (Chapter 3).

\textsuperscript{8} 10 Additional participants completed the baseline survey but did not complete any momentary surveys.
Openness. Openness was measured using the IPIP Openness/Intellect Markers (Goldberg et al, 2006), a series of ten items such as “I enjoy hearing new ideas” (α=.83). The IPIP Big-Five from which these are drawn provide a brief, non-proprietary assessment method that shows concurrent validity in the assessment of the Big Five Personality Factors (Gow, Whiteman, Pattie & Deary, 2005).

Epistemic curiosity. Curiosity was measured using the I/D scale (Litman, 2008), this characterises Curiosity as having two dimensions; Interest (CI), which is concerned with discovery and stimulation of positive affect (5 items, α=.68); and Deficit (CD), which involves focus on reduction of uncertainty due to incomplete knowledge (5 items, α=.88).

Momentary Survey.

Momentary covariates. Given an individual’s likelihood of engagement in effortful cognition may be determined in part by situational barriers, like pre-occupation and exhaustion, measures were included to control for these factors. Participants were asked to respond to the following two questions: “How tired do you feel right now?” and “How busy have you been since the last assessment?” on 10-point scale from “Not at all” to “Extremely”.

Elaboration measures. Participants were asked to report on their engagement in effortful cognition. First, they were asked to indicate whether they had engaged in any of four behaviours that reflected the type of effortful cognitive activity identified by the NFC scale which will be hereafter referred to as elaboration. These were (1) putting more thought into something than was required, (2) thinking about something that did not directly affect them, (3) thinking about an issue that they had no control over, or (4) attempting to understand something complex. Where participants responded in the affirmative, they were asked to characterise their engagement using a series of seven point scales. Responses were characterised with respect to how complex they found the subject of engagement to be, along
with how enjoyable they found it, how much effort they invested and the degree to which they felt it was internally (1) versus externally (7) motivated. Where participants responded in the negative, they were not cued to respond to these items.

**Elaboration cues.** As individuals’ environments likely vary in the quantity of prompts for effortful cognition, participants may not differentiate in manifest effortful cognition wholly as a function of no environmental stimuli meeting a sufficient threshold for engagement. To mitigate this risk, each day the participants were asked their agreement or disagreement with a position on a complex social issue. Issues included marijuana decriminalisation, mandated maximum wage ratios, GMO labelling, reducing the legal Blood Alcohol Concentration for drivers, and government subsidies for struggling industries. These were specifically selected for their inherent conflicts and complexity (e.g., the trade-off between the economic fallout of increased unemployment versus the tax burden caused by supporting industries under comparative disadvantage); it was presumed that individuals would differentially engage with this complexity as a function of their NFC and respond accordingly to the elaboration item. To support this, participants were provided links to resources on these topics (both pro and con) via the app but were not specifically instructed to investigate these so as to minimise imposition of artificial constraints on behaviour.

**Procedure**

Participants were first required to install the smartphone app later used for Momentary Assessments on their personal phones. This app issued them a randomly generated ID code via the information section which was needed to access the baseline measures which they then completed, taking approximately 10 minutes. For the subsequent five days after the baseline measure, the app signalled participants five times per day at quasi-random intervals
between 10 am and 6pm (based on device time), at which time participants had 30 minutes within which to complete a survey. This ensured participants did not complete large numbers of surveys within a confined period of time later in the day. Completion of the app based surveys took about a minute per measurement episode.

**Statistical Analysis**

As participants each provide multiple responses to the momentary measures, the data obtained are hierarchical or clustered, with momentary observations (level 1) nested within participants (level 2). Clustered data do not meet the assumption of the independence of errors and duly cannot be analysed using conventional multiple regression (Cohen, Cohen, West & Aiken, 2003), nor are they suited to ANOVA due to its requirement of sphericity and no missing data (Quené & van den Bergh, 2004) duly research questions regarding the associations between the NFC and engagement, enjoyment, effort and attribution, were evaluated via Multi-Level Modelling (MLM). All analyses were conducted using R 3.2.2 (R Core Team, 2015).

The level of clustering—or similarity between observations from a single participant—can be evaluated through the use of Intraclass Correlation Coefficients (ICCs). The ICC represents the proportion of the total variability in the measure that exists between-versus within-subjects, where an ICC of 0 would indicate no between-subjects variability (i.e., on average, all participant elaborate to the same extent and all variability is within participants), and an ICC of 1 indicates no within-subjects variability (i.e., within each participant, responses are invariant across time points). ICCs were used to address research question 1 regarding dispositional versus situational variability in the outcome variables of cognitive elaboration, enjoyment of this elaboration, effort and motivation. ICCs were derived using the psychometric package (Fletcher, 2010).
The prediction of momentary behaviours with the NFC scale was evaluated using multilevel modelling implemented via the lme4 package (Bates, Maechler, Bolker & Walker, 2015) using a logistic function where the engagement in elaboration since the previous time point (yes or no) was the predicted outcome. Models were fit using the BOBYQA optimiser, a derivative free optimisation algorithm (Powell, 2009). Consistent with recommendations of Bolger and Laurenceau (2013), to allow for separate estimation of the contribution of within and between subjects variance in variables recorded at level 1, variance was separated into a between-subjects components (mean per participant) and within-subjects components (the participant-mean centred score). Variables measured only at level 2 (e.g. NFC) were Z-transformed for ease of interpretation.

Engagement in effortful cognition (RQ 2), along with enjoyment, effort and attribution of cause (RQ 3) were each individually modelled as outcomes in separate models. All models were built additively retaining variables that significantly contributed to the explanation of the DV as evaluated by significant coefficients and Parametric Bootstrap tests of model fit using 1000 simulations. NFC was used as a level 2 IV, and all variables measured at the momentary level were utilised as separate level 2 (Participant mean) and level 1 (Participant mean-centred) components. Where level 1 variables have significant fixed effects, between-subjects differences in these effects (Random effects) were evaluated for. Where between-subjects variability in these effects are identified, cross-level interactions (e.g, complexity x NFC) are tested as explanations for these variable effects on the effort, enjoyment and attribution outcomes. Finally, to assess the discriminant validity of the NFC

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9 The authors have found this method less susceptible to convergence issues than the Nelder-Mead optimisation method
10 This test does not assume the null distribution conforms to a χ² distribution as per the conventional likelihood ratio test (Halekoh & Højsgaard, 2014)
11 As complexity was only evaluated for episodes of elaboration, the interaction of NFC and complexity on the initiation of effortful cognition could not be evaluated.
from Openness, CI and CD (RQ 4), these variables were included as the final step in each model test.

**Results**

The relationships between the measured investment traits (NFC, openness and curiosity as interest and deficit) and the aggregate indices of the level 1 measures are presented along with descriptive statistics in Table 5.1. Large, significant correlations were found between NFC, openness and Curiosity as Interest, with a moderate correlation between NFC and Curiosity as Deficit. Large significant correlations were found for both NFC and Openness with the proportion of observations where elaboration was recorded, CI had a moderate correlation with the same outcome. No other significant correlations were observed.
Table 5.1. Descriptives and Correlations between Self report Traits and Aggregate Indices of Elaboration (N=45)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>NFC</th>
<th>Openness</th>
<th>Curiosity as Deficit</th>
<th>Curiosity as Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFC</td>
<td>92.18</td>
<td>12.58</td>
<td>1.00</td>
<td>0.67</td>
<td>0.47 **</td>
<td>0.69 ***</td>
</tr>
<tr>
<td>Openness</td>
<td>53.27</td>
<td>10.43</td>
<td>0.67</td>
<td>1</td>
<td>0.18</td>
<td>0.72 ***</td>
</tr>
<tr>
<td>Curiosity as Deficit</td>
<td>24.07</td>
<td>7.37</td>
<td>0.47</td>
<td>0.18</td>
<td>1</td>
<td>0.30 *</td>
</tr>
<tr>
<td>Curiosity as Interest</td>
<td>28.93</td>
<td>4.08</td>
<td>0.69</td>
<td>0.72</td>
<td>0.30 *</td>
<td>1</td>
</tr>
<tr>
<td>Proportion of Measurements reporting Elaboration</td>
<td>0.42</td>
<td>0.23</td>
<td>0.51</td>
<td>0.51 **</td>
<td>0.23</td>
<td>0.32 *</td>
</tr>
<tr>
<td>Average enjoyment</td>
<td>4.14</td>
<td>1.16</td>
<td>0.18</td>
<td>-0.08</td>
<td>0.28</td>
<td>0.06</td>
</tr>
<tr>
<td>Average Effort</td>
<td>4.79</td>
<td>1.09</td>
<td>-0.06</td>
<td>-0.12</td>
<td>-0.04</td>
<td>-0.05</td>
</tr>
<tr>
<td>Average Attribution of Motivation</td>
<td>3.38</td>
<td>1.29</td>
<td>0.01</td>
<td>-0.06</td>
<td>-0.12</td>
<td>-0.09</td>
</tr>
<tr>
<td>Average complexity of Elaborations</td>
<td>4.51</td>
<td>1.05</td>
<td>0.21</td>
<td>0.02</td>
<td>0.11</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note. * = p < .05, ** = p < .01, *** = p < .001
Characterising Variability in Ecological Behaviour

Intra-class correlations were evaluated to evaluate the distribution of variability in the outcomes to within and between-subjects components (RQ 1). These results show a majority of variability in engagement in elaboration is within-subjects (ICC = .158), and likewise for the enjoyment of elaboration events (ICC = .257), effort invested (ICC=.311) and attribution of motivation (ICC=.260).

Multilevel Analyses

41 participants returned a total of 561 EMA observations across the five days, mean of 13.68 observations per participant (SD = 5.06). Of these observations, 233 recorded an elaboration event (41.53%) and 328 did not. To evaluate for differential rates of responding among participants varying on the NFC scale, the correlation between the number of EMA measurements completed and NFC scores was tested and found to be small and non-significant (r = -0.044, n = 41, p=.785). The following analyses relate to the second research question, testing the degree to which the NFC predicts the momentary episodes of elaboration and the qualities of these episodes.

NFC predicting elaboration. No significant effects were found for the average tiredness or busyness variables at level 2, and so they were excluded in model refinement. Elaboration was significantly and positively predicted by NFC scores and the busyness in the moment. No meaningful random effects were observed for busyness, so no interactions were evaluated; Parameters from final model are shown in Table 5.2.
Table 5.2.
Generalised Linear Mixed Effects Model of Elaboration

<table>
<thead>
<tr>
<th></th>
<th>Odds ratio</th>
<th>Coefficient</th>
<th>S.D.</th>
<th>S.E.</th>
<th>Z-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.49</td>
<td>0.73</td>
<td>0.15</td>
<td>-3.14</td>
<td></td>
<td>.002</td>
</tr>
<tr>
<td>Level 2: Between-subjects effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>1.93</td>
<td>0.66</td>
<td>-</td>
<td>0.16</td>
<td>4.13</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Level 1: Within-Subjects effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Felt Busyness</td>
<td>1.24</td>
<td>0.21</td>
<td>-</td>
<td>0.04</td>
<td>5.29</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note. All Variables at Level 2 are Z-transformed

The inclusion of openness at level two, to test its incremental validity over NFC (RQ 4), significantly improved the model fit (Parametric Bootstrap test, estimate=5.02, p=0.038) and resulted in the positive relationship between NFC and elaboration becoming non-significant, with the coefficient reducing by .326. Openness had a positive and significant effect (Table 5.3).

Table 5.3.
Generalised Linear Mixed Effects Model of Elaboration

<table>
<thead>
<tr>
<th></th>
<th>Odds ratio</th>
<th>Coefficient</th>
<th>S.D.</th>
<th>S.E.</th>
<th>Z-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.48</td>
<td>0.65</td>
<td>0.15</td>
<td>-3.30</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Level 2: Between-subjects effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>1.40</td>
<td>0.33</td>
<td>-</td>
<td>0.20</td>
<td>1.67</td>
<td>.096</td>
</tr>
<tr>
<td>Openness</td>
<td>1.60</td>
<td>0.47</td>
<td></td>
<td>0.20</td>
<td>2.32</td>
<td>.021</td>
</tr>
<tr>
<td>Level 1: Within-Subjects effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Felt Busyness</td>
<td>1.24</td>
<td>0.21</td>
<td>-</td>
<td>0.04</td>
<td>5.30</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note. All Variables at Level 2 are Z-transformed

Neither curiosity as interest nor curiosity as deficit had any significant effect on the likelihood of elaboration.

**NFC predicting Enjoyment.** Enjoyment of reported elaboration was modelled (Table 5.4), however no significant effect of NFC was observed, with no significant slope and no significant improvement of model by inclusion. Neither of the two curiosity factors, nor
openness significantly improved prediction of enjoyment, with only average busyness predicting enjoyment. No significant random effects were found.

Table 5.4.  
Linear Mixed Effects Model of Enjoyment of Elaboration  
<table>
<thead>
<tr>
<th>Coefficient</th>
<th>S.D.</th>
<th>S.E.</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.61</td>
<td>1.31</td>
<td>0.57</td>
<td>4.56</td>
</tr>
<tr>
<td><strong>Level 2: Between-subjects effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Felt Busyness</td>
<td>0.29</td>
<td>-</td>
<td>0.10</td>
<td>2.90</td>
</tr>
<tr>
<td><strong>Variance components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_{00}$</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>1.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. All Variables at Level 2 are Z-transformed*

**NFC predicting Effort.** NFC was not found to significantly predict effort invested in elaboration events. Both the average and momentary complexity of elaboration, average attribution to external causes, and momentary enjoyment of elaboration were significant positive predictors, no significant random effects were found (Table 5.5). Momentary external attribution did not have a significant effect on effort invested. This model was not improved by the inclusion of openness, curiosity as interest or curiosity as deficit.

Table 5.5.  
Linear Mixed Effects Model of Effort in Elaboration  
<table>
<thead>
<tr>
<th>Coefficient</th>
<th>S.D.</th>
<th>S.E.</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.37</td>
<td>0.54</td>
<td>0.65</td>
<td>2.09</td>
</tr>
<tr>
<td><strong>Level 2: Between-subjects effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Complexity</td>
<td>0.55</td>
<td>-</td>
<td>0.12</td>
<td>4.60</td>
</tr>
<tr>
<td>Mean External Attr.</td>
<td>0.27</td>
<td>-</td>
<td>0.10</td>
<td>2.77</td>
</tr>
<tr>
<td><strong>Level 1: Within-subjects effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enjoyment</td>
<td>0.15</td>
<td>-</td>
<td>0.06</td>
<td>2.49</td>
</tr>
<tr>
<td>Complexity</td>
<td>0.36</td>
<td>-</td>
<td>0.07</td>
<td>5.25</td>
</tr>
<tr>
<td><strong>Variance components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_{00}$</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>1.21</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. All Variables at Level 2 are Z-transformed*
**NFC predicting Attribution.** NFC had no association with the attribution of elaboration. Only momentary Busyness and Enjoyment were found to associate with Attribution, the effects being small, no significant random effects were found (Table 5.6). There were no effects of Openness, Curiosity as Interest or Curiosity as Deficit.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>S.D.</th>
<th>S.E.</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.31</td>
<td>0.96</td>
<td>0.20</td>
<td>16.45</td>
</tr>
<tr>
<td>Busyness</td>
<td>0.10</td>
<td>-</td>
<td>0.05</td>
<td>1.99</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>-0.21</td>
<td>-</td>
<td>0.09</td>
<td>-2.29</td>
</tr>
</tbody>
</table>

**Note.** All Variables at Level 2 are Z-transformed

**Discussion**

This study aimed to provide insight into the motivation and manifestations of NFC through Ecological Momentary Assessment. Specifically, this study sought to characterise the dispositional nature of variability in engagement in effortful cognition (Research Question 1), and the prediction by NFC of this engagement (Research question 2) and its qualities such as enjoyment (Research question 3) above and beyond situational factors and other investment traits (Research question 4). Insight was sought into the motivation underlying NFC through this characterisation of NFC variability in the prediction of ecological behaviour. Results demonstrate that while individuals vary in their tendency toward effortful cognition in ecological settings, these individual differences accounted for only a small fraction of the total variability in this behaviour. As expected this difference in behaviour was captured by the NFC scale. However, while enjoyment of effortful correlation was determined to a greater degree by dispositional rather than situational factors, this enjoyment was not associated with the NFC scale.
This study provides novel insights into the degree to which the engagement in effortful cognition is individually variant (independently of NFC) through the examination of the similarity of responses within subjects, across repeated measurements (ICCs). These results suggest that on average individuals do differ in their tendency to exhibit effortful cognition, and these differences account for 15.8% of the total variability in the engagement in complex thinking. The enjoyment of any such engagement is also predominantly within-subjects, though 25.7% of the variability in enjoyment was dispositional. That noted, these individual differences do not necessarily correspond with differences in NFC.

The results of the multi-level modelling indicates that NFC does predict engagement, with engagement in elaboration being positively associated with NFC independently of any situational moderators. While this is non-controversial given the extensive demonstration of NFC predicting differential behaviour in the lab, as far as it is possible to discern, this is the most proximate measurement to date of NFC predicting effortful cognition in real-world settings. Of more theoretical interest is the failure of NFC to associate with enjoyment of complex thinking in the real-world. Given enjoyment of effortful cognition is characteristic by which NFC is defined, and its purported importance to motivation for effortful cognition the absence of an association between the NFC scale and enjoyment in real-world settings is noteworthy. Again, this is not in absence of underlying individual differences in enjoyment, as results show that a quarter of all variance in enjoyment is attributable to individual dispositional factors.

This contributes to the evidence suggesting enjoyment is not the motivating force underpinning NFC. As was previously discussed the relationship between NFC and enjoyment has been suggested to be non-linear (Knobloch-Westerwick & Keplinger, 2008), suggesting enjoyment is unlikely to motivate engagement in high NFC individuals. In our previous study,
the absence of correlation between NFC and enjoyment of and persistence with abstract puzzles or mean enjoyment of a set of complex videos further suggested that motivation in effortful cognition may not be driven by mere enjoyment of complex cognition itself. Duly, the present findings, where NFC did not predict enjoyment even where attempts were made to control for complexity, represents further evidence that some alternate mechanism likely motivates engagement. As such, NFC may better be represented as a statistical tendency for behaviour as initially posited (Cacioppo & Petty, 1982).

An alternate explanation for NFC’s prediction of engagement was considered in the form of matching, which has been posited as a determinant of situational elaboration—that is, individuals are likely to elaborate only where the complexity of the situation matches their NFC (Wheeler et al., 2005; See et al., 2009). As individuals have been shown to self-report their cognitive effort consistently with their NFC (dmeta-analytic = .272; Cacioppo, Petty, Feinstein & Jarvis, 1996), it was anticipated that an interaction might be observed between NFC and complexity in the prediction of effort in an episode of effortful cognition12. However, while both the participants’ average complexity score and their momentary deviation from average had positive effects on the effort invested in an episode of elaboration, NFC had no significant effect. Again, this absence of an effect of NFC is not a function of an absence of individual differences in effort applied, with 31.1% of the variability in effort being between-subjects, simply the measure does not associate with these differences in practice. It is noteworthy, however that cognitive effort was predicted by average perceived complexity of elaboration events and external attribution. That individuals would invest more effort where the task at hand is more

12 While it would have been preferable to test this interaction on the initiation of effortful cognition, it was impossible to have participants report on the complexity of issues/tasks/situations on which they did not elaborate. Nonetheless, the test on effort is comparable to previous tests of the NFC complexity interaction where behaviour was initiated based on the tasks administered to participants.
complex than normal is not unsurprising, but that between-subjects variability in perceived complexity has an impact on momentary effort suggests exposure to more complex stimuli may dispositionally increase cognitive effort, even where NFC does not. Combined with the effect of the average attribution on effort invested, this suggests that there is potential for externally imposing complex cognitive tasks as a means of promoting effortful cognition.

Finally, the attribution of cause for elaboration did not associate with NFC either, again despite there being real individual differences in the tendency to attribute an episode of effortful cognition to external causes. Insofar as NFC is taken to reflect intrinsic motivation for engagement in effortful cognition, and duly increases in effortful cognition associated with NFC should be a function of this, it was anticipated that NFC should be negatively associated with the (external) attribution variable. That it was not would suggest that either individuals have no insight into their motivations or are not differentiated in their causes for elaboration; that is, individuals higher in NFC are not systematically more internally motivated.

The implication of this is that where participants have insight into the causality of their behaviour, any differences in the manifestation of effortful cognition between those varying in NFC arise proportionally from situational imposition and internal causes. It is credible that individuals varying in NFC may have different thresholds for perceiving external causation and duly this might obscure the true differences in their propensity to engage intrinsically, however it is also possible that extrinsic motivation for effortful cognition begets intrinsic motivation—similarly to the effects of complexity on effort—or vice versa. Specifically, individuals with an environment that chronically precipitates effortful cognition may become more likely to self-initiate, or self-starters may become targets for imposition of effortful cognitive tasks. Whatever the specific cause of this effect, the absence of self-perceived differences in attribution imply
that, as suggested by Steinhart and Wyer (2009), differences in effortful cognition associated with NFC in ecological settings are not uniquely a function of some approach oriented process.

On balance, while they demonstrate the prediction of effortful cognition by NFC, the results of this study support the findings of the previous study (Chapter Four) with no demonstration that individuals varying in NFC concomitantly vary in their enjoyment of effortful cognition. Further, no evidence was found of matching effects (See et al, 2009; Wheeler et al., 2005), and more broadly, there is no evidence of differences in effort or attribution of the causes of elaboration in ecological settings among individuals varying in NFC. It is important to reiterate that the lack of association between the NFC and enjoyment, effort and attribution of effortful cognition is not in absence of underlying individual differences in these criteria. Results show that relative to the engagement in elaboration, a larger proportion of the variance is attributable to between-subjects effects in all of these qualities of engagement, and these between-subjects differences may have broader implications; instead, the results simply suggest that NFC is not a measure of these differences.

The NFC’s prediction of elaboration is tempered by the comparable effects of the Openness scale; the openness measure, which itself was substantially redundant with NFC, in fact being the better predictor of this outcome. These results are consistent with earlier cross-sectional results finding limited discriminant validity between NFC and the Openness to Ideas facet (Mussel, 2010) which could be suggestive of the Jangle fallacy (assuming constructs with different names are truly different; Kelley, 1927). These results, along with those of prior studies demonstrating similar patterns of intercorrelations, suggests that measures like the scales of Typical intellectual engagement (Goff & Ackerman, 1992), Openness to Ideas (Costa & McCrae, 1992), and Epistemic curiosity (Litman, 2008)—over which the NFC demonstrated incremental
validity on all criteria in this study—are likely redundant in their prediction of behaviour in many cases (Mussel, 2010; Woo, Harms & Kuncel, 2007). However, results showing NFC and openness to ideas have differential correlations with multiple outcomes including neurological responses to novelty (Enge, Fleischhauer, Brocke & Strobel, 2010) suggests that a singular factor is unlikely to capture all that is substantive in these constructs. Therefore, as proposed by Mussel (2013), some unification of these constructs is likely merited, at least with regards to the prediction of effortful cognition, however, consideration should be given to uncovering how they might have divergent situational effects.

It remains inconclusively answered what factors might be promoting differences in the manifestation of effortful cognition in those higher in NFC. While the authors of the NFC scale posited that there are likely to be many and varied influences on the development of NFC (Cacioppo et al., 1996), the implication that these lead to a common enjoyment of effortful cognition that precipitated engagement for all individuals is not supported by the results of this study. Further, while the self-schema matching account of NFC was not directly tested within this study, the absence of NFC by perceived complexity interactions on effort suggest that this may not represent a general account for differences in effortful cognition. Instead, in order to account for the diversity of outcomes associated with NFC, a more diverse account of the motivation should be considered. As proposed in Chapter 4, individuals may manifest a propensity toward effortful cognitive activity due to a variety of idiosyncratic intrinsic factors that promote effortful cognition, such as a desire for understanding or an avoidance of punishment, and report these in common on the NFC scale. As such, two individuals may enjoy their engagement to varying degrees as a function of their differentiated motives and not be differentiated in measurement on the NFC scale. This model may not have differential
implications to outcomes such as estimation of intellectual performance, where differences in engagement overall is the important aspect. However, this would predict substantially less reliability in the prediction of specific behaviour, as a function of a singular score of NFC not reflecting a common motive, and would preclude the development of a singular approach to promoting NFC.

The inability to capture and control for the frequency and quality of stimuli for effortful cognition constitutes a limitation of the present study. Particularly where some environments may promote the engagement in effortful cognition more than others, the engagement in complex thinking as an absolute quantity or ratio of responses may be less informative than the possibly impossible to capture ratio of elaboration events to pressures to elaborate. These types of observations regarding the opportunities not taken, both in terms of number and qualities like complexity, would provide richer insights into the processes of NFC such as if complexity moderated NFC related engagement. A better understanding of the context in which these agents act could provide additional insight into whether higher NFC is associated with higher susceptibility to external influence or simply more external influence; or if their causal attributions for behaviour are valid. This absence of environmental insight is an unfortunate trade-off of internal validity in pursuit of the improved ecological validity of the EMA design.

In addition, while the EMA design allows for more proximate measurement to minimise recall biases and so on, it is still subject to the limitations of self-report. Particularly, this limits confidence regarding the attribution of engagement where, as previously discussed, individuals may vary in their threshold for attribution to external causes. This equally applies to differences in the perception of complexity; although NFC was not significantly correlated with the perceived complexity of elaboration events this is not to say there were no substantive
differences between individuals that are not captured by self-report. Pointedly, NFC may be associated with the perception of task complexity, such that increasing NFC may result in tasks being seen as less complex or vice versa. The literature is broadly silent on this possibility, with most studies either manipulating the objective complexity of a task (e.g. Cacioppo & Petty, 1982), or framing tasks as more or less complex (e.g. See et al, 2009) without assessing for differences in perception. That noted, were there an appreciable effect of NFC on complexity perception, this would either exacerbate predicted NFC effects on engagement (assuming a positive relationship), or would result in minimised matching effects where higher NFC promoted lower perceived complexity. Nevertheless, participants’ perceptions of these events still provides some novel insights into the phenomenology of differences in NFC.

Recent research has investigated an implicit type of NFC, measured using an Implicit Association Task, which predicts more automatic types of effortful cognition, independently of the traditional explicit NFC investigated here (Fleischhauer et al, 2012; Fleischhauer et al., 2015). The prediction of reflexive engagement in NFC-like behaviours in laboratory settings by implicit measures may also account for variance in tendency to elaborate in ecological settings, where purposeful, reflective engagement may be less relevant than automatic responses to distracting complexity (Strobel, Fleischhauer, Enge & Strobel, 2015). That is to say that while the present findings do support the association between NFC and elaborative cognition in real-world settings, by focussing only on the degree to individuals are aware of their behavioural tendency we may be underestimating the intrinsic component of the engagement in effortful cognition. Further, while the motivations underpinning explicit NFC may be infeasible to identify and modify, evidence from the domain of prejudice reduction suggests that implicit attitudes—such that implicit NFC may be considered—can be, at least temporarily, modified
(Dasgupta & Greenwald, 2001). As such, if implicit NFC has influence on ecological
manifestation of effortful cognition, it may represent a means by which effortful cognition can be
promoted. Duly integration of these implicit NFC measures into future EMA studies is
recommended to evaluate the relative importance of implicit and explicit NFC in ecological
settings.

This study sought to characterise the real-world manifestation of effortful cognition and
duly gain insight into the individual differences in NFC. While these results demonstrate that
individual differences exist in the tendency to engage in, enjoy, apply effort to and attribute the
causation of effortful cognition outside of the laboratory, the NFC scale only predicts
engagement and does so to a comparable extent as Openness. Importantly, these results suggest
that neither enjoyment of effortful cognition, effort invested nor self-attribution of engagement is
associated with NFC. In the absence of associations with enjoyment this suggests that NFC may
be best represented as a tendency to engage in effortful cognition alone. Further given that NFC
was not associated with the attribution of cause to external versus internal factors, the
motivations underpinning the differences in behaviour are likely to be more idiosyncratic;
undermining any attempt to define a singular model for promoting NFC. However, while it is
impossible to determine within this study if this effect generalises to the initiation of behaviour,
these results indicate that the average perceived complexity of elaboration events is positively
associated with effort invested at a single episode. As such, promotion of cognitive effort may be
possible through increased exposure to complex cognitive tasks.
References


Chapter 6: General Discussion

This thesis sought to provide insights into the nature of NFC as measured by self-report, developing an understanding of the motivations underpinning these individual differences in tendency to engage in and enjoy effortful cognition and their lived experience. Four studies were conducted, each providing convergent lines of evidence regarding what it is to vary in the NFC; specifically they aimed to achieve the following:

Study One (Chapter Two) aimed to systematically review the literature on the factorial structure of the self-report measure and the motivational correlates of the NFC scale to resolve measurement uncertainty and provide insights into the drivers of effortful cognition.

Study Two (Chapter Three) sought to empirically resolve issues in the factorial structure of the measure, identifying whether previously observed additional factors were substantive and potentially coherent with theory or a function of methodological variability and incomplete optimisation.

Study Three (Chapter Four) addressed the motivation that drives NFC associated differences in effortful cognition, particularly evaluating the model of NFC as enjoyment of process by assessing the prediction of abstract effortful cognition by the NFC scale.

Study Four (Chapter Five) examined effortful cognition in ecological settings in order to more broadly characterise the experience of effortful cognition for individuals varying in NFC but also evaluate the role of enjoyment in the motivation of this behaviour.

Summary of Findings

The Systematic review showed that while the predominant view of the literature was that the NFC scale was constituted of only one factor, there was a strong trend showing papers using true factor analyses rather than Principal Components Analyses finding multiple factors (Davis et
al., 1993; Furnham & Thorne, 2013; Lord & Putrevu, 2006; Tanaka, Panter, & Winborne, 1988). Furthermore, studies that utilised the short form scale, constituted of the subset of items which loaded most strongly on the principal component of the full measure (Cacioppo, Petty & Kao, 1984), were more likely to return unifactorial structures than the full measure. That noted, there was appreciable inconsistency between these Exploratory Factor Analysis (EFA) based studies both in terms of their methodologies employed and the factors they found. As such it was unclear as to whether the observed factors were substantive or not, despite some of the factors observed being suggestive of explanations of motivation in NFC. Examples include cognitive self-efficacy (Lord & Putrevu, 2006; Tanaka et al, 1988)—consistent with a self-determination account of motivation (Deci & Ryan, 2000)—or need for understanding (Furnham & Thorne, 2013; Lord & Putrevu, 2006) or enjoyment of cognitive challenge (Furnham & Thorne, 2013; Lord & Putrevu, 2006; Tanaka et al., 1988)—comparable to the characterisations of curiosity as deficit or interest (Litman & Silvia, 2006). Given this remaining uncertainty in measurement, which would compromise any attempt to understand the construct, and the possibility of insight into the construct through underlying factors, further investigation of this was pursued.

Examination of the factorial structure in two samples using consistent methodology demonstrated that the source of the previously observed multifactorial solutions was likely to be an interaction between the incompletely optimised 34-item scale and the methodological factors. The approach taken here of evaluating the factorial structure within two samples without alteration of methodology was critical to understanding the degree to which additional factors in the NFC scale were truly replicable and duly if there were systematic motivational factors identified there. Notably, with this consistent approach two completely different structures were derived in the two samples; one with meaningful factors comparable to prior studies; and one
with pro- and con-trait factors and a residual self-efficacy factor with items cross-loading on the pro-trait factor. Furthermore, multifactorial structures from prior studies and the 34-item scale in a unifactorial configuration did not reliably fit across the two samples. Given the relatively stable characteristics of the 18-item scale (Cacioppo et al., 1984) and its broad utilisation within the literature as a whole, this was taken to reflect the intent of the scale as a whole, with item content reflecting an enjoyment of or preference for the engagement in effortful cognition. With the structure of the measure not providing insights into the drivers of the NFC, these findings necessitated a different line of enquiry for investigating the character of the NFC.

Attempts were made to test the enjoyment of process account of motivation in NFC; that differences in effortful cognition arise from the differing levels of enjoyment thereof. It was posited that engagement with abstract cognitive tasks should be associated with NFC, insofar as NFC is characterised as process oriented, driven by the enjoyment of the effortful cognition itself (Cacioppo, Petty, Feinstein & Jarvis, 1996). By contrast, if NFC reflects more object-focussed motives such as a need for understanding or need to evaluate, it would not necessarily motivate such engagement in tasks that were sufficiently abstracted. Results were not consistent with the enjoyment-model, with weak and negative relationships between the NFC scale and persistence with puzzles or enjoyment of these or of educational videos, suggesting any motivation for effortful cognition in NFC may be more task contingent. Given these findings were substantially at odds with a key characteristic of the definition of NFC and were based on a small sample using particular tasks, further support was sought for these findings in the final study.

The EMA study examined engagement in effortful cognition in lived experience with a view to characterise the manifestation of NFC in the contexts which it has the most substantive impact. This design permitted evaluation of the dispositional nature of effortful cognition, the
relationship between NFC scores and enjoyment of effortful cognition in real-world contexts
duly testing the enjoyment model, but broadly allowed for a more detailed characterisation of the
phenomenology of differences in NFC. This demonstrated empirically the presence of individual
differences in engagement in and enjoyment of effortful cognition outside of laboratory settings,
as well as differences in effort invested and causal attribution thereof. However only the
engagement in effortful cognition was associated with NFC scale scores, and the NFC scale did
not account for additional variance above openness to experience here. The absence of
associations between the NFC scale and any of enjoyment of, effort invested in, and perceptions
of extrinsic motivation toward effortful cognition provide a broader insight into the experience of
effortful cognition for those varying in NFC. Particularly, they indicate that in ecological settings
increased engagement in effortful cognition associated with higher NFC is not attributable to
disproportionate increases in intrinsic motivation as far as the actor is concerned. Additionally,
while NFC may not predict the perceived effort invested in any episode of effortful cognition,
the average perceived complexity of elaboration events along with the attribution of these events
generally to external factors did.

This thesis sought to better characterise individual differences in NFC; to this end it has
pursued investigations in the measurement, motivation, and ecological manifestations of these
individual differences. Specifically, this has resolved the dimensionality of the self-report scale,
addressed the role of enjoyment in NFC, and obtained novel insights into the experiences of
effortful cognition in naturalistic settings for those varying in NFC. Collectively, these results
indicate that the NFC scale is a unidimensional index of an individual’s tendency to engage in
effortful cognition, not only in the extensively tested laboratory setting, but also in naturalistic
contexts. That noted, contrary to the widely utilised definition, this scale does not reliably
capture individual differences to *enjoy* effortful cognition, or invest effort, nor is it associated with a bias in attribution of such engagement to internal causes. While individuals are not necessarily impervious to error in attributing their behaviour to internal or external causes (Jellison & Green, 1981), the absence of any association between the NFC and attribution of effortful cognition to internal or external causes importantly indicates that NFC may capture more than just intrinsically motivated behaviour.

The results of this program specifically suggest that NFC is not accurately characterised as “the tendency for people to enjoy thinking or not” (Petty, Cacioppo, Strathman & Priester, 2005, p. 94), with no meaningful association between NFC and enjoyment of effortful cognition in either Lab or ecological settings. It has also been proposed that the NFC associated enjoyment of cognitive tasks is contingent on matching of NFC to task complexity (Cacioppo & Petty, 1982), consistent with similar effects for engagement (See, Petty & Evans, 2009; Wheeler, Petty & Bizer, 2009). This however, sits at odds with the absence of any interaction between complexity and enjoyment within the EMA study (Chapter Five), also paralleled with regards to the investment of effort. Overall, the results described here suggests a re-evaluation of the representation of NFC is needed.

**The Characterisation of Need for Cognition**

While ultimately it may have been more satisfying to have found results congruent with a model such as Self-Determination Theory, or a common cause of individual differences in effortful cognition that could be tested, these results still provide novel insights into the nature of NFC. As noted, NFC has been characterised as a tendency to enjoy effortful cognition derived by environmental influences interacting with idiosyncratic, goal-focussed motives for effortful cognition (Cacioppo et al., 1996); it is proposed that while such differences in enjoyment exist, it
is not what is primarily measured by the scale. Further, given that NFC did not predict attribution of effortful cognition, as suggested by Steinhart and Wyer (2009), the differences in NFC may not be limited to intrinsic motivation. It is proposed that engagement in effortful cognition may be driven by stable factors that are internal, such as a satisfaction derived from problem solving or need to understand, or external, like persistent workplace demands, and these behaviours may both be reflected in the NFC scale. This is to say that the NFC, consistent with the past literature, is a statistical tendency to engage in effortful cognition (Cacioppo, Petty, Kao & Rodriguez, 1986), but inconsistent with past literature, it is not defined by enjoyment (Petty, Cacioppo, Strathman & Priester, 2005). Rather than being a measure of the intrinsic motivation to engage in effortful cognition, the NFC appears to measure the likelihood of engaging in effortful cognition overall.

A critique to this account of the NFC may come from the stability in the measure over time, insofar as a representation of NFC as a trait-like intrinsic motivation is inherently stable while a model including environmental pressures should result in more variability. While the responses on the NFC in addressing the character of the respondent are likely to reflect more than just the momentary level of effortful cognition, it is quite likely that recent history would be more available in making inferences as to the frequency of engagement and duly be more reflected in NFC scores. This needs specific evaluation, externally manipulating the engagement in effortful cognition and testing for changes in the self-report measure. The issue of stability in constructs is not unique to this treatment of NFC. The model presented here owes much to construal models which posit the reification of crystallised attitudes is not needful to the explanation of stability in evaluations; instead, these can be explained by stability in the inputs to judgement (Schwarz, 2006). In much the same fashion, where predictors of engagement in
effortful cognition are stable, such as a dispositional need to evaluate, employment or historical factors, then this should elicit a stability in behaviour that could be consistent with the test-retest reliability of prior research (Sadowski & Gulgoz, 1992; Verplanken, 1991).

**Drivers of Differential Outcomes in NFC**

This conceptualisation of NFC as a self-estimate of behaviour rather than motivation for behaviour is not inconsistent with past findings, many of these are agnostic of the source of motivation. For example, Meier, Vogl and Preckel’s (2014) study demonstrating children in advancement classes demonstrate higher levels of NFC than their peers for example, may be a function of the demands of the advancement classes themselves inducing higher levels of effortful cognition and duly NFC scores. Equally, intrinsic factors other than an enjoyment of effortful cognition may be the determining factor in both belonging to the class and responses to the NFC scale. Further, the NFC’s moderate correlation with performance in online courses (Wang & Newlin, 2000) and weak correlation with GPA based on meta-analytic results (Richardson, Abraham & Bond, 2012) is coherent with any explanation of the behaviour, insofar as the implication is that that more engagement, the better the outcomes. There is no prima facie reason to privilege intrinsically motivated cognition over extrinsically motivated in terms of their outcomes.

This model is also consistent with the finding that endorsement of learning goals and Self efficacy mediate the NFC – academic learning outcome relationship (Day, Espejo, Kowollik, Boatman & McEntire, 2007; Elias & Loomis, 2002). Where NFC scale scores reflect simply the average tendency to engage in effortful cognition, but do not measure a domain-general enjoyment or equally global intrinsic motive, there is no reason to suggest it should strongly
predict learning outcomes where specific motivations to learn may be absent. Further, the specific motives may exist independently of a broader tendency to elaborate and being a more direct motive, wholly account for differences in engagement, particularly if such differences in engagement are more binary (i.e. reflective vs. reflective) rather than continuous.

Additionally, the increased engagement in effortful cognition is likely to contribute to the development of task specific self-efficacy as per self-directed learning activities (Bandura & Schunk, 1981) and duly outcomes thereof such as academic performance (e.g. Elias & Loomis, 2002). These same principles apply to the positive associations between NFC and adaptive strategy use (Evans, Kirby & Fabrigar, 2003; Levin, Hunke & Jasper, 2000), critical thinking (West, Toplak & Stanovich, 2008) or the seeking of explanations (Coutinho, Weimer-Hastings, Skowronski & Britt, 2005). Just as there is no reason to assume outcomes should be better for intrinsically rather than extrinsically motivated cognition, there is no reason to suggest that development of confidence or strategy should be predicated on the motive for practice. As such, some of the agentive properties attributed to the NFC, particularly in learning outcomes, may be a function of self-efficacy, strategy, or critical thinking skills acquired as a function of frequent engagement in effortful cognition.

While this model proposes that enjoyment of effortful cognition is not the defining feature of differences in NFC, previously observed differences in enjoyment (e.g. Cacioppo & Petty, 1982; Knobloch-Westerwick & Keplerger, 2008) and preference for complex tasks (Fleischhauer, Strobel, Enge & Strobel, 2013; Fleischhauer, Strobel & Strobel, 2015) remain to be accounted for. As noted earlier, this enjoyment is not uniform in its manifestation with some interactions between task complexity and NFC in enjoyment (Cacioppo & Petty, 1982; Knobloch-Westerwick & Keplerger, 2008) which were not replicated within this research. The
inability to replicate this effect in ecological settings suggests the laboratory context may be an influential factor. Insofar as the participants’ engagements in these contexts are already characterised by a lack of autonomy for behaviour, minor differences in the complexity of the task may have more substantial impacts than would be the case for freely chosen behaviour. For example, a task that is menial or excessively complex may be made less palatable by the compulsion (however subtle) to engage. In particular, it is notable that in the initial study using letter-circling tasks of varying complexity, participants liked none of the tasks and varied in the level of their distaste (Cacioppo & Petty, 1982). Further, in Knobloch-Westerwick and Keplinger’s (2008) study, high NFC individuals did not simply enjoy the story they were reading more based on its increasing complexity, seeming to hit a threshold and then begin to dislike the incremental complexity. Notably, however, the high complexity story was universally disliked, likely indicating again that the influential factor for high NFC individuals is a dislike of simplicity not present in those lower in NFC. The possibility of self-efficacy—developed as a function of effortful cognitive activity—being an influential factor in the relationship between NFC and enjoyment also should be considered. Individuals engaging more regularly in effortful cognition and developing confidence in their ability may find simpler stimuli boring and therefore aversive, and those less efficacious find more complex tasks comparably so (Abuhamdeh & Csikszentmihalyi, 2011). Testing of such an indirect relationship between NFC and these outcomes, however, is beyond the scope of this thesis.

One result that is inherently more amenable to a model of NFC as enjoyment of effortful cognition is the apparent differences in NFC in tendency to engage in social loafing (Smith, Kerr, Markus & Stasson, 2001). In this study, individuals participated in a vigilance task (counting visual signals via a button click) in groups of three and were told they would either be compared
to one another (coactive condition) or their scores summed (collective condition). A two-way interaction was found demonstrating that high NFC (as determined by a tertiary split) participants scored equally well irrespective of the condition while the low NFC participants performed equivalently to high NFC participants in coactive conditions, but significantly worse in collective conditions. These outcomes are more difficult to explain where NFC does not measure a singular motivation for engagement, where idiosyncratic motivations should dilute the effect. However, high NFC individuals ascribed greater importance to their individual performance in obtaining group outcomes, indicating that rather than personal gratification processes governing this behaviour, an explanation based on collective responsibility is appropriate. It is uncertain why NFC should be associated with this prosocial orientation, though it is feasible that NFC may either derive from or lead to greater role responsibilities, such as positions of leadership where failure of effort would have greater cascading impacts on collective outcomes than those lower in responsibility. This is compatible with the NFC scale’s initial composition of items that discriminated between academics and assembly line workers (Cacioppo & Petty, 1982) and its positive correlation with education (Spotts, 1994). But additionally, this would align with EMA results demonstrating no association between NFC and attribution of effortful cognition, assuming this is indicative of real concomitant increases in both intrinsic and extrinsic drivers of behaviour, rather than differences in perception.

It is important to note that the findings of this research program do not dispute the existence of individual differences in the tendency to attribute effortful cognition to internal or external causes, or the enjoyment of effortful cognition. By contrast, the EMA study shows that there is significant between subject differences in these outcomes, but these simply do not correlate with the NFC scale. Where the NFC scale is not measuring directly these individual
differences, the utility of the measure is somewhat reduced as the frequency of engagement in
general effortful cognition is unlikely to have direct behavioural outcomes. More proximate
predictors such as self-efficacy and complexity of tasks as per the EMA results are likely to both
be more influential for prospective influences on behaviour, but also more amenable to
intervention given the myriad influences likely to underpin NFC.

**Future Directions**

It is noteworthy that individual differences were observed in enjoyment, effort and
attribution of effortful cognition that were not captured by the NFC scale. Attempts to capture
and influence these differences, particularly in effort and enjoyment, may have independent
benefits comparable to those proposed from increasing NFC. Results from Chapter Five
suggesting that cognitive effort in particular might by influenced by the average level of
complexity in episodes of effortful cognition may suggest avenues to its promotion, which might
be explored.

Additionally, this research has further demonstrated redundancy between NFC and
openness and curiosity as interest and deficit, as discussed in the prior literature (Fleischhauer et
al., 2010; Mussel, 2010). This research has shown that NFC is a stronger predictor than curiosity
of elaborative cognition in naturalistic settings but is a slightly weaker predictor than openness.
While this still does not require that these constructs have a common causation, insofar as there
is minimal insight into their respective causes, this may guide the integration of their respective
literatures through frameworks like the Intellect model (Mussel, 2013).

While the possibility of NFC being a measure of behavioural tendency with idiosyncratic
causes was proposed within this thesis, the possibility of testing this account is beyond the scope
of this program of research. Testing such a model presents some appreciable complexity, where
diverse goals for effortful cognition could each represent sufficient causes for effortful cognition, but none of them necessary causes. In such a situation, particularly where manipulation of possible causes (goals) is not feasible, understanding the foundations of this construct may be fraught. In light of the relatively weak association between NFC and behaviour, other avenues for directly promoting elaborative cognition might be more fruitful enterprises.

As noted in Chapter Five, Implicit NFC as measured by the NFC-IAT may represent a useful predictor of engagement in effortful cognition in ecological settings insofar as it is associated with individual differences in impulsive engagement (Fleichhauer et al., 2013; Fleischhauer et al., 2015). These measures are assessing underlying associational networks and are duly not susceptible to self-perception processes (Bem, 1967; Fazio, Zanna & Cooper, 1977) that might inflate self-reported intrinsic motivation for behaviour. The implicit NFC has been shown to associate with engagement in reflexive cognitive processing, such as the persistence with puzzles and recall of peripheral information; behaviours that are not associated with the explicit NFC (Fleichhauer et al., 2013; Fleischhauer et al., 2015). As such, there is a need to examine the role of implicit measures of NFC in predicting investment of effortful cognition in ecological settings as this may prove an influential motivation for behaviour.

Conclusions

This research program sought to characterise what it is to differ in Need for cognition. While this series of studies was unable to come to a singular representation of motivation in NFC or its ontogeny, there are a number of conclusions to be drawn from this program of research. Principally, the 18-item Need for cognition scale is a better optimised measure of a unidimensional tendency to engage in effortful cognition. However, NFC does not appear to be characterised by enjoyment of effortful cognition, duly this is not likely to be the motivation for
this behaviour. Further, NFC does not appear to be associated with more internally attributed cognitive activity, this suggests differences in how behaviour is attributed to internal or external causes, or alternately that motivation measured by the NFC scale comes proportionately from both internal and external sources. As such, NFC may be better represented as a more generalised statistical tendency to engage in effortful cognition, rather than a motivation in and of itself. Where this is the case, it is suggested that these differences in engagement may promote concomitant differences in strategy use, self-efficacy and critical thinking skills which in turn predict outcomes such as differences in learning or in persuasion domains.

References


Appendix A – Ethics Approval

This Program of research was conducted in accordance with the National Statement on Ethical Conduct in Research Involving Humans (1999). Ethics approval was obtained for all studies conducted in this program of research. Included in Appendix A are the ethics approval for the three Studies that were included in the final thesis as per the following breakdown:

- Chapter 3, Sample 1 – HEAG-H 21_2013
- Chapter 3, Sample 2 – HEAG-H 198_2014
- Chapter 4 – HEAH-H 21_2013
- Chapter 5 – HEAG-H 136_2014
A.1. Ethics Approval for HEAG-H 21_2013

Memo

| To:       | Dr Ben Richardson  
|           | School of Psychology |
| From:     | Secretary - HEAG-H  
|           | Faculty of Health    |
| CC:       | Mr Matthew Ling      |
| Date:     | 26 March, 2013       |
| Re:       | HEAG-H 21_2013: Validating a measure of Cognitive Elaboration Tendency |

Approval has been given for Dr Ben Richardson, School of Psychology, to undertake this project for a period of 1 year from 25 March, 2013. The current end date for this project is 26 March, 2014.

The approval given by the Deakin University HEAG-H is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Secretary immediately should any of the following occur:

- Serious or unexpected adverse effects on the participants
- Any proposed changes in the protocol, including extensions of time
- Any events which might affect the continuing ethical acceptability of the project
- The project is discontinued before the expected date of completion
- Modifications that have been requested by other Human Research Ethics Committees

In addition you will be required to report on the progress of your project at least once every year and at the conclusion of the project. Failure to report as required will result in suspension of your approval to proceed with the project.

HEAG-H may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Human Research (2007). An Annual Project Report Form can be found at [http://www.deakin.edu.au/hmrbo/research/ethics/ethicssubmissionproces.php](http://www.deakin.edu.au/hmrbo/research/ethics/ethicssubmissionproces.php) which you will be required to complete in relation to this research. This should be completed and returned to the Administrative Officer to the HEAG-H, Pro-Vice Chancellor’s office, Faculty of Health, Burwood campus by Tuesday 19th November, 2013 and when the project is completed.

Good luck with the project!

[Signature]
A.2. Ethics Approval for HEAG-H 198_2014

Memo

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<tr>
<th>To:</th>
<th>Dr Ben Richardson</th>
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<td>School of Psychology</td>
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<td>From:</td>
<td>Secretary – HEAG-H</td>
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<td>Faculty of Health</td>
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<td>CC:</td>
<td>Mr Mathew Ling</td>
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<td>Date:</td>
<td>17 December 2014</td>
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<td>Re:</td>
<td>HEAG-H 198_2014 2014: Replication of dimensionality in the need for cognition scale</td>
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Approval has been given for Dr Ben Richardson, School of Psychology, to undertake this project for a period of 1 year from 17th December, 2014. The current end date for this project is 17th December, 2015.

The approval given by the Deakin University HEAG-H is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Secretary immediately should any of the following occur:

- Serious or unexpected adverse effects on the participants
- Any proposed changes in the protocol, including extensions of time
- Any events which might affect the continuing ethical acceptability of the project
- The project is discontinued before the expected date of completion
- Modifications that have been requested by other Human Research Ethics Committees

In addition you will be required to report on the progress of your project at least once every year and at the conclusion of the project. Failure to report as required will result in suspension of your approval to proceed with the project.

An Annual Project Report Form can be found at:

This should be completed and returned to the Administrative Officer to the HEAG-H, Pro-Vice Chancellor’s office, Faculty of Health, Burwood campus by Tuesday 17th November, 2015 and when the project is completed, HEAG-H may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Human Research (2007).

Good luck with the project!
A.1. Ethics Approval for HEAG-H 136_2014

Memo

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<th>To:</th>
<th>Dr Ben Richardson</th>
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<td>School of Psychology</td>
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<td>CC:</td>
<td>Mr Mathew Ling</td>
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<td>Date:</td>
<td>23 April, 2015</td>
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<td>Re:</td>
<td>HEAG-H 136_2014: Construct and convergent validation of the need for cognition scale</td>
</tr>
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</table>

Approval has been given for Dr Ben Richardson, of the School of Psychology, to undertake this project with the modifications that were requested on the 21 April, 2015.

Please note that the current end date for this project is 11 August, 2017.

Steven Sawyer
Secretary
HEAG-H
PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: Participants

Plain Language Statement

Date: 19/10/2012

Full Project Title: Validating a measure of Cognitive Elaboration Tendency

Principal Researchers: Mathew Ling & Dr Ben Richardson

We are interested in exploring the causes of peoples’ tendency to think more or less about all things. Previous studies using a measure called the Need for Cognition Scale have shown that indeed there are differences in this and that they are associated with things such as how persuasive you find certain messages, and how interesting you find different topics; it may be useful in helping people select a job they enjoy. However, we aren’t sure the existing scale is actually accurate, which is important in considering the value of prior research, also this limits investigation into what causes these differences between people.

We are trying to correct this and at the same time try to start on working out what makes people differ in this and would like to invite you to participate in our study. Our study has two parts but if you cannot participate in part two, or only wish to complete part one, that is fine. We would still invite you to be involved in the first component of our research.

Part one will be an online questionnaire. This will ask you questions relating to how much you think about problems but also other things, like your levels of social support, freedom to control your own life, and also how confident you feel about engaging in certain tasks. We expect this questionnaire will take only about 15 minutes.

If you subsequently wish to take part in it, Part two will be an on-site study at Deakin University, Burwood. Participation in this phase will involve completing a number of tasks designed to get you thinking about a particular subject, these will include some puzzles and
watching a series of short videos and answering some questions about them. The scores we obtain from these activities will be then compared to your scores from part one. We expect this part of the study will take an hour and a half, for which you will be reimbursed with a $10 Coles Myer gift voucher.

You will be invited to take part in part two at the completion of part one, again you are not required to do so. If you wish to take up this invitation, you will be asked to provide some contact details so we can organize a time for you to take part. These contact details will be held in a separate location to your results, so your data will remain anonymous. If you accept the invitation, and you subsequently change your mind, you will be free to withdraw from participating in the second component.

Participation in any research project is voluntary. **If you do not wish to take part you are not obliged to.** If you decide to take part and later change your mind, you are free to withdraw at any time up until your results are returned to the researchers. Given the anonymous nature of data collection, it is not possible to withdraw after this time.

Collated results from this study will be used in the preparation of academic publications (no individual data will be used) and the PhD thesis of Mr Mathew Ling. This will allow for ongoing study in this area including research into the causes of these individual differences which may go on to inform educational policy. A summary of the results of this study will be made available to participants upon request via e-mail to Mathew Ling (mlying@deakin.edu.au).

Your scores will be anonymous. Once collected, any digital data will be stored on Deakin University’s secure server and any physical data will be stored in locked cabinets secured within the principal researchers’ offices. Data will be held for a minimum of five years consistent with Deakin University’s data handling policies.

This project has been approved by a human ethics panel at Deakin University. If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Manager, Office of Research Integrity, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, Facsimile: 9244 6581; research-ethics@deakin.edu.au
Please quote project number: HEAG-H 21/2013

Before you make your decision, a member of the research team will be available to answer any questions you have about the research project. If you require further information or if you have any problems concerning this project you can contact the researchers.

The researchers responsible for this project are:

**Mathew Ling**
mlying@deakin.edu.au

**Dr. Ben Richardson**
ben.richardson@deakin.edu.au
School of Psychology
If you wish to take part in this research please click the following button to indicate that you have read and understood the terms of the plain language statement. Pressing the Submit button at the conclusion of the questionnaire will indicate your consent.

If you do not wish to take part, thank you for your time.
PLAIN LANGUAGE STATEMENT

Full Project Title: Replication of dimensionality in the Need for Cognition scale

Principal Researchers: Mr Mathew Ling (PhD Candidate) & Dr Ben Richardson

Thank you for following up on our invitations to seek more information regarding our study, we truly appreciate your interest. Please read on for a description of our study, after which you are invited to participate.

Purpose

This study intends to investigate some measures of “need for cognition”, or tendency to engage with certain types of information, in particular looking at whether these measures are accurately assessing what they are purported to measure.

Demands

This study will utilise a 5-minute online questionnaire, hosted on a Deakin University server. This questionnaire will contain items pertaining to your engagement with complex ideas and issues, a few items about why you engage with these sorts of things, and a brief cognitive performance measure.

Risks and Benefits

No risks are anticipated for any participants, and benefits are likely to be indirect.

Privacy and Confidentiality Protection

Your responses will be collected in a wholly anonymous format, so your privacy and confidentiality is assured.

Data from this study will be stored for a minimum of 5 years, according to Deakin University’s protocols, before being permanently destroyed. Until then, digital data will be stored on Deakin University’s secure server.

Dissemination of Results

It is the intent of the research team to publish the findings of this research in peer-reviewed articles, utilise them in the completion of Mathew Ling’s PhD thesis, and after publication release a summary via Mathew Ling’s blog (http://mathewling.com/). If you would like to receive a summary of results, please contact Mathew at mling@deakin.edu.au.
Incentives
As a reimbursement for your time and efforts you will receive $1.00 as dispensed through the Amazon MTurk service.

Conflicts of interest
The researchers have no conflicts of interest to declare. The research is fully funded internally by the School of Psychology.

Your Rights
This is a voluntary study, so you should feel under no pressure to participate. Further you may withdraw at any time up to the completion of your online questionnaire; after this time, due to our privacy protocols, removal of your responses from the sample may be impossible.

More information?
If you want to know more before participating, or just want to find out more about this research please contact:

Mathew Ling
mling@deakin.edu.au
+61 3 9251 7274

Dr Ben Richardson
Ben.richardson@deakin.edu.au

Complaints
If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Manager, Research Integrity, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: +61 3 9251 7129, research-ethics@deakin.edu.au

Please quote project number HEAG-H 198_2014.

By clicking the "Begin Survey" button below, you are agreeing that you have read and understood the Plain Language Statement and that you are consenting to participate in this research.
You are invited to take part in this research project. This document contains detailed information about the project. Its purpose is to explain to you as openly and clearly as possible all the procedures involved in this project so that you can make a fully informed decision regarding whether or not you are going to participate. Please read this Plain Language Statement carefully. Feel free to ask questions about any information in the document. You may also wish to discuss the project with a relative or friend. Feel free to do this. Once you understand what the project is about and if you agree to take part in it, you will proceed to the online questionnaire. By submitting this questionnaire, you indicate that you understand the information and that you give your consent to participate in the research project. You may print a copy of the Plain Language Statement and Consent Form to keep as a record.

Purpose

There are proposed to be differences in how much people engage in and enjoy complex thinking, by this we mean the sort of secondary reflection on thoughts and free engagement with complex ideas and problems. It is suggested that these might be important in helping people decide on career direction and a range of other outcomes.

However, very little is known about what causes these differences, and in many ways these differences are not very well understood generally. This study intends to address this by assessing where you sit in this tendency to think complexly, both by giving you the traditional measure and then assessing your engagement in these behaviors over a period of one week.

Your involvement

To assess that tendency to think complexly, this study will take the form of a daily diary study. If you wish to participate, you can download our app to your iPhone/Android smartphone. On the first use, you will be invited to complete a baseline questionnaire asking about things like age, education and occupation and a series of self-report measures around your typical engagement in complex thought, how you see yourself intellectually and your curiosity, this should take about 10-15 minutes. After
that, we will periodically ask you to answer some brief questions about your energy, tiredness, thoughtfulness and a random issue 5 times a day over 5 days via the app, these prompts will occur between 9am and 9pm and should take no more than 2 minutes each.

**Risks and Benefits**

No risks are anticipated from being involved, and benefits are likely to be indirect.

**Privacy and Confidentiality Protection**

Your data will be anonymous at all times as the ID code generated by the app will not be connected to your personal details.

Data from this study will be stored for a minimum of 5 years, according to Deakin’s protocols, before being permanently destroyed. Until then, Digital data will be stored on Deakin’s secure server and hard copies of any data will be locked in secure storage at Deakin University.

**Dissemination of Results**

It is the intent of the research team to publish the findings of this research in peer-reviewed articles, utilise them in the completion of Mathew Ling’s PhD thesis, and after publication release a summary via Mathew Ling’s blog (http://mathewling.com/). If you would like to receive a summary of results, please contact Mathew at mling@deakin.edu.au.

**Conflicts of interest**

The researchers have no conflicts of interest to declare. All funding is internal to the School and research team.

**Your Rights**

This is a voluntary study, so you should feel under no pressure to participate. Further you may withdraw at any time by contacting the researchers and giving them the random ID generated by the app.

**More information?**

If you want to know more before participating, or just want to find out more about this research please contact:

Mathew Ling
mling@deakin.edu.au

Dr Ben Richardson
Ben.richardson@deakin.edu.au

03 9244 6024

**Complaints**

If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:
The Manager, Research Integrity, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, research-ethics@deakin.edu.au

Please quote project number HEAG-H 136_2014.

If you wish to take part in this research please enter your user ID found in the “User information” section of the app and click the following button to indicate that you have read and understood the terms of the plain language statement. Pressing the Submit button at the conclusion of the questionnaire will indicate your consent.

If you have not yet downloaded the app it can be found by scanning this QR code or going to this address in the app store.

For iPhone: https://itunes.apple.com/us/app/instant-survey/id955226674?mt=8
For Android: https://play.google.com/store/apps/details?id=au.edu.deakin.psychology.surveyframework

If you do not wish to take part, thank you for your time.
Appendix C – Measures

Measures for the studies are attached as associated with their respective ethics approval.

C.1. HEAG-H 21_2013

Online survey

Please provide the following details about yourself.

Gender:

Age:

Highest level of formalised Education:

Did not complete Secondary School

Completed secondary school

Diploma Level Qualification

Bachelor’s Degree

Post Graduate Qualification

Please describe your occupation:

Please respond to the following items on a scale from 1 (Completely inaccurate) to 7 (Completely accurate).

1. If something puzzles me, I keep reading until I understand it.
2. I think primarily because I have to. *
3. I often succeed in solving difficult problems that I set out to solve.
4. I am an intellectual
5. When I am figuring out a problem, what I see as the solution to a problem is more important than what others believe or say is the solution.
6. It excites me to have a new idea that leads to more new ideas
7. I often read media that report new scientific discoveries
8. I am usually tempted to put more thought into a task than the job minimally requires
9. I would prefer a task that is intellectual, difficult and somewhat important to one that is somewhat important but does not require much thought
10. Thinking is not my idea of fun *
11. If I find a word I don’t know the meaning of, I like to look it up
12. I prefer to think about small, daily projects to long-term ones. *
13. I like to understand how complicated things work
14. I enjoy thinking about an issue even when the results of my thought will have no effect on the outcome of the issue.
15. I feel relief rather than satisfaction after completing a task that required a lot of mental effort. *
16. I prefer to let things happen rather than to understand why they turned out that way.*
17. I often find things interesting that others find mundane
18. Learning new things isn’t very important to me *
19. I don’t reason well under pressure *
20. I am not satisfied unless I am thinking.
21. If I see a complicated piece of machinery, I like to ask how it works
22. The notion of thinking abstractly is not appealing to me*
23. I don’t like to be responsible for thinking of what I should be doing with my life. *
24. I don’t usually think about problems that others have found to be too difficult.
25. The idea of relying on thought to make my way to the top does not appeal to me *
26. I like tasks that require little thought once I’ve learned them *
27. These days, I see little chance for performing well, even in “intellectual” jobs, unless one knows the right people. *
28. I enjoy thinking about (take an interest in) a wide variety of subjects
29. I usually end up deliberating about issues even when they do not affect me personally
30. I find it interesting to think about contradicting ideas
31. When I develop a theory about something I like to test it out.
32. I am generally interested in discovering how things work
33. I take pride in the products of my reasoning.
34. When I learn something new, I like to find out more about it.
35. I prefer my life to be filled with puzzles that I must solve.
36. I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something. *
37. New ideas excite my imagination
38. When faced with arithmetic problems, I enjoy imagining solutions
39. I try to learn something new every day
40. I believe that if I think hard enough, I will be able to achieve my goals in life.
41. I like thinking about different answers to the same question
42. I tend to set goals that can be accomplished only by expending considerable mental effort.
43. I don’t like to have the responsibility of handling a situation that requires a lot of thinking *
44. I am very optimistic about my mental abilities.
45. Simply knowing the answer rather than understanding the reasons for the answer to a problem is fine with me. *
46. I enjoy learning about subjects which are unfamiliar to me.
47. I often have ideas about how to solve problems
48. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities. *
49. When someone answers a question, that makes me even more inquisitive
50. I have difficulty thinking in new and unfamiliar situations *
51. I enjoy the idea of discussing theories with a philosopher
52. It’s enough for me that something gets the job done, I don’t care how or why it works *
53. I really enjoy a task that involves coming up with new solutions to problems
54. When something I read confuses me, I just put it down and forget it. *
55. I think best when those around me are very intelligent
56. I appreciate opportunities to discover the strengths and weaknesses of my own reasoning.
57. More often than not, more thinking just leads to more errors. *
58. Learning new ways to think doesn’t excite me very much *
59. I only think as hard as I have to *
60. I would prefer complex to simple problems.
61. I find it especially satisfying to complete an important task that required a lot of thinking and mental effort.
62. Ignorance is bliss. *
63. I find little satisfaction in deliberating hard and for long hours *
64. I like trying to figure out what led to important historical events
65. I more often talk with other people about the reasons for and possible solutions to international problems than about gossip or tidbits of what famous people are doing.
66. I am easily distracted by interesting ideas or problems to solve
67. If I see an incomplete puzzle, I try to imagine the final solution
68. Simple explanations often leave a lot of questions
69. When I am presented with a riddle, I am interested in solving it.
70. I enjoy exploring new ideas
71. When I see a complex problem, I want to discover a solution
72. I often find myself thinking about problems and new ideas even without meaning to
73. I prefer watching educational to entertainment programs.
74. It is fascinating to learn new information
75. I am hesitant about making important decisions after thinking about them *

Self-efficacy

How difficult or easy do you find the following?

1. I can understand Physics
2. I complete intellectual tasks
3. I solve new problems
4. I can understand Biology
5. I can understand philosophy
6. I can understand the causes of events in world history
7. I can understand economics
8. I can understand technology and computers
9. I can understand Chemistry
10. I can understand Literature
11. I can understand politics
Autonomy (Task / criteria / scheduling)

1. I control when I work on “thoughtful” tasks
2. I am generally free from people interfering with my approach to problem solving
3. I have influence over what a good solution to the intellectual problems in my life.
4. I have choice in how I approach solving problems and thinking about things
5. I only do tasks that are challenging intellectually because I choose to, not because I am made to

Social Support Measure drawn from Vaux et al (1987)

I have friends and family who...

1. Would give me a ride if I needed one
2. Would help me out with a big chore (e.g. moving house)
3. Would loan me a substantial amount of money (e.g. a month’s rent or a mortgage payment)
4. Would look after my belongings (e.g. house, pets, etc.) for a while
5. Would offer me a place to stay for awhile
6. Would loan me money and want me to “forget about it”
7. Would talk to other people, to arrange something for me
8. Would loan me money for a meal if needed it
9. Would help me decide what I wanted to do
10. Would loan me a car if I needed it
11. Would chat with me
12. Would have a good time with me
13. Would be sympathetic to me if I were upset or distressed
14. Would give me encouragement to do something difficult
15. Would show they understood how I was feeling
16. Would listen if I needed to talk something out
17. Would distract me if I was feeling down
18. Show affection toward me
19. Will call just to see how I am
20. Would not pass judgement on me

If you are able to come to Deakin University, Burwood, and would like to participate in the follow up component of this study (on-site) please provide the following details so we can make contact with you.

First name:

Email address or phone number:
Lab Measures

Cognitive Reflection Task

1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? _____ cents
2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days

Please rate how interesting you find the following topics from 1 (Completely uninteresting) to 7 (The most interesting topic in the world). Also, Please rate your capacity to learn information in these areas from 1 (Impossible) to 7 (Extremely simple).

<table>
<thead>
<tr>
<th>Interest</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetics</td>
<td></td>
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<tr>
<td>Geography</td>
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<tr>
<td>Politics</td>
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<td>Sport</td>
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<td>Physics</td>
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<td>Philosophy</td>
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<td>Economics</td>
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<td>History</td>
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<tr>
<td>Linguistics</td>
<td></td>
</tr>
<tr>
<td>Monetary Policy</td>
<td></td>
</tr>
</tbody>
</table>

For Each Puzzle:

Have you seen this puzzle before?
How confident are you that given enough time you could solve this task?
How complex did you find that?
How Enjoyable?
How interesting?

For Each Video:

Have you seen this video before?
Have you ever heard the specific content presented here before?
How complex did you find this video?
How Enjoyable?
How interesting?
Stimulus materials

Puzzles

Videos - 46 min. 1 sec.

1. Intro to genetics (3:45)
   http://www.youtube.com/watch?v=F4wHaORe9-c
2. An overview of the difference between Holland and the Netherlands (4:00)
   http://www.youtube.com/watch?v=eE_IUPInEuC
3. An intro to legislative districts and gerrymandering (2:45)
   http://www.youtube.com/watch?v=jJCaWCgbASI
4. An intro to fencing (4:22) http://www.youtube.com/watch?v=Dr9q645buro
5. On misconceptions regarding temperature (3:58)
   http://www.youtube.com/watch?v=vqDbMEDLiCs
6. On the Chinese room thought experiment (1:16)
   http://www.youtube.com/watch?v=TryOC83PH1g
7. On the role of the Norman conquest of England on the English language (1:17)
   http://www.youtube.com/watch?v=1B8TwBrCIEY
8. A short video on the paradox of thrift (1:21)  
   http://www.youtube.com/watch?v=qrHyDztQLBY
9. On the “dark” ages (12:07) http://www.youtube.com/watch?v=QV7CanyzhZg
10. On the Global financial crisis (11:10)  
    http://www.youtube.com/watch?v=bx_LWm6_6tA
C.2. HEAG-H 198_2014

Just a reminder that your answers here will remain completely anonymous, so please just tell us how you really feel.

Please provide the following details about yourself:

Age:

Gender: Male Female other ______

This scale is intended to measure your tendency to engage with and enjoy complex problems. There are no right or wrong answers, so please respond honestly with regards to how true these are of you.

(This will be measured on a 1-7 metric from “Completely inaccurate” to “completely accurate”)

1. Simply knowing the answer rather than understanding the reasons for the answer to a problem is fine with me.
2. It’s enough for me that something gets the job done, I don’t care how or why it works.
3. I only think as hard as I have to.
4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.
5. I usually end up deliberating about issues even when they do not affect me personally.
6. I find little satisfaction in deliberating hard and for long hours.
7. I really enjoy a task that involves coming up with new solutions to problems.
8. I prefer to let things happen rather than to understand why they turned out that way.
9. When something I read confuses me, I just put it down and forget it.
10. I would prefer complex to simple problems.
11. Learning new ways to think doesn’t excite me very much
12. I am usually tempted to put more thought into a task than the job minimally requires
13. I enjoy thinking about an issue even when the results of my thought will have no effect on the outcome of the issue.
14. I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.
15. I don’t like to have the responsibility of handling a situation that requires a lot of thinking
16. I find it especially satisfying to complete an important task that required a lot of thinking and mental effort.
17. I would prefer a task that is intellectual, difficult and somewhat important to one that is somewhat important but does not require much thought
18. I more often talk with other people about the reasons for and possible solutions to international problems than about gossip or tidbits of what famous people are doing.
19. I am not satisfied unless I am thinking
20. Ignorance is bliss.
21. I don’t usually think about problems that others have found to be too difficult.
22. I prefer my life to be filled with puzzles that I must solve.
23. I prefer watching educational to entertainment programs.
24. I like tasks that require little thought once I’ve learned them
25. More often than not, more thinking just leads to more errors.
26. I appreciate opportunities to discover the strengths and weaknesses of my own reasoning.
27. Thinking is not my idea of fun
28. I have difficulty thinking in new and unfamiliar situations
29. I tend to set goals that can be accomplished only by expending considerable mental effort
30. I take pride in the products of my reasoning.
31. The notion of thinking abstractly is not appealing to me.
32. I am very optimistic about my mental abilities.
33. I am an intellectual.
34. I think best when those around me are very intelligent
35. I am known for thinking about things more than others
36. Thinking about complex ideas is part of who I am
37. I don’t reason well under pressure.
38. I am hesitant about making important decisions after thinking about them.
39. These days, I see little chance for performing well, even in “intellectual” jobs, unless one knows the right people.
40. I often succeed in solving difficult problems that I set out to solve
41. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.
42. I am confident in dealing with complex issues and ideas
43. There are a lot of things I don’t think I could ever understand even if I tried
44. If I am being truly honest, I think I am smarter than average.
45. I don’t like to be responsible for thinking of what I should be doing with my life.
46. The idea of relying on thought to make my way to the top does not appeal to me
47. I prefer to think about small, daily projects to long-term ones.
48. I think primarily because I have to.
49. I believe that if I think hard enough, I will be able to achieve my goals in life
50. When I am figuring out a problem, what I see as the solution to a problem is more important than what others believe or say is the solution.

This is a task designed to briefly assess your cognitive performance. Just answer as best you can.

1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball.
1. How much does the ball cost? _____ cents.
2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes.
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days.

The following items will ask further about why you engage with complex ideas and whether people around you did likewise. Please answer as accurately and honestly as you can.

1. I frequently find myself thinking about complex issues without even meaning to
2. When someone asks a question I don’t know the answer to I MUST find out.
3. I feel compelled to look up things that I don’t know or understand
4. My family always encouraged me to think about the causes of things
5. Generally speaking my education encouraged me to understand, not just memorise.
6. I have found that understanding how technical things work pays off
7. People I know from my childhood tended to get on with things, not think about them at length
8. Someone significant in my youth took the time to explain things to me

Thank you for Participating
**C.3. HEAG-H 136_2014**

**Baseline Survey**

Please enter your study ID. This can be found by clicking on the ‘User Information’ button within the app that you’ve downloaded. The ID is a combination of letters and numbers.

Study ID:

Demographic Data:

Thank you for agreeing to take part in this study. Please read the items carefully and fill in each section, then click the ‘Submit’ button to complete the survey. The questionnaire must be finished in one sitting.

We also need some information to describe our sample; we will be looking at this at the level of the whole group, so you won’t be identifiable.

1. Gender
   - Male/Female/Other (specify)
2. Age
3. Education
   - Did not complete Secondary School
   - Completed secondary school
   - Diploma Level Qualification
   - Bachelor’s Degree
   - Post Graduate Qualification
4. Occupation
5. Nationality

The next set of items assesses your tendency to engage with and enjoy complex problems. There are no right or wrong answers, so please respond honestly with regards to how true these are of you.

Please respond on the 1-7 scale provided how accurate these statements are of you from “Completely inaccurate” (1) to “completely accurate” (7)

4. I would prefer a task that is intellectual, difficult and somewhat important to one that is somewhat important but does not require much thought
5. Thinking is not my idea of fun
6. I prefer to think about small, daily projects to long-term ones.
7. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.
8. The notion of thinking abstractly is not appealing to me.
9. The idea of relying on thought to make my way to the top does not appeal to me.
10. I like tasks that require little thought once I've learned them.
11. I usually end up deliberating about issues even when they do not affect me personally.
12. I prefer my life to be filled with puzzles that I must solve.
13. I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.
14. I don't like to have the responsibility of handling a situation that requires a lot of thinking.
15. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.
16. It's enough for me that something gets the job done, I don't care how or why it works.
17. I really enjoy a task that involves coming up with new solutions to problems.
18. Learning new ways to think doesn't excite me very much.
19. I only think as hard as I have to.
20. I would prefer complex to simple problems.
21. I find little satisfaction in deliberating hard and for long hours.

This is a measure of your general character, please indicate whether these are true or false statements regarding you.

Using the scale below as a guide, write a number beside each statement to indicate how true it is.

+ + + + + + +
1 2 3 4 5 6 7
not true somewhat very true

1. My first impressions of people usually turn out to be right.
2. It would be hard for me to break any of my bad habits.
3. I don't care to know what other people really think of me.
4. I have not always been honest with myself.
5. I always know why I like things.
6. When my emotions are aroused, it biases my thinking.
7. Once I've made up my mind, other people can seldom change my opinion.
8. I am not a safe driver when I exceed the speed limit.
9. I am fully in control of my own fate.
10. It's hard for me to shut off a disturbing thought.
11. I never regret my decisions.
12. I sometimes lose out on things because I can't make up my mind soon enough.
13. The reason I vote is because my vote can make a difference.
14. My parents were not always fair when they punished me.
15. I am a completely rational person.
16. I rarely appreciate criticism.
17. I am very confident of my judgments.
18. I have sometimes doubted my ability as a lover.
19. It's all right with me if some people happen to dislike me.
20. I don't always know the reasons why I do the things I do.
21. I sometimes tell lies if I have to.
22. I never cover up my mistakes.
23. There have been occasions when I have taken advantage of someone.
24. I never swear.
25. I sometimes try to get even rather than forgive and forget.
26. I always obey laws, even if I'm unlikely to get caught.
27. I have said something bad about a friend behind his/her back.
28. When I hear people talking privately, I avoid listening.
29. I have received too much change from a salesperson without telling him or her.
30. I always declare everything at customs.
31. When I was young I sometimes stole things.
32. I have never dropped litter on the street.
33. I sometimes drive faster than the speed limit.
34. I never read sexy books or magazines.
35. I have done things that I don't tell other people about.
36. I never take things that don't belong to me.
37. I have taken sick-leave from work or school even though I wasn't really sick.
38. I have never damaged a library book or store merchandise without reporting it.
39. I have some pretty awful habits.
40. I don't gossip about other people's business.

1. Enjoy hearing new ideas.
2. Believe in the importance of art.
3. Avoid philosophical discussions.
4. Tend to vote for liberal political candidates.
5. Do not enjoy going to art museums.
6. Do not like art.
7. Have a vivid imagination.
8. Am not interested in abstract ideas.
9. Tend to vote for conservative political candidates.
10. Carry the conversation to a higher level.

This is a bell curve showing where people fall on a continuum of “intelligence”, most people score around 100 points, with it being increasingly rare to score at points further and further from 100, as shown by there being less and less space under the curve.
Using that bell curve as a guide, for the 10 types of intelligence below, plus the overall estimate, please give us a number that you think reflects your intelligence.

1. **OVERALL** intelligence
2. *Verbal* or linguistic intelligence (the ability to use words)
3. *Logical* or mathematical intelligence (the ability to reason logically, solve number problems)
4. *Spatial* intelligence (the ability to find your way around the environment, and form mental images)
5. *Musical* intelligence (the ability to perceive and create pitch and rhythm)
6. *Body-kinesthetic* intelligence (the ability to carry out motor movement, e.g., being a surgeon or dancer)
7. *Interpersonal* intelligence (the ability to understand other people
8. *Intrapersonal* intelligence (the ability to understand yourself and develop a sense of your own identity)
9. *Existential* intelligence (the ability to understand the significance of life, the meaning of death and the experience of love)
10. *Spiritual* intelligence (the ability to engage in thinking about cosmic issues, the achievement of a state of being, e.g., achieving trance states, and the ability to have spiritual effects on others)
11. *Naturalistic* intelligence (the ability to identify and employ many distinctions in the natural world, e.g. categorizing species membership

This measures how curious you are as an individual. Please read and respond on the scale provided how accurate these statements are of you from “Completely inaccurate” (1) to “completely accurate” (7)

1. I enjoy exploring new ideas.
2. Difficult conceptual problems can keep me awake all night thinking about solutions.
3. I enjoy learning about subjects that are unfamiliar to me.
4. I can spend hours on a single problem because I just can’t rest without knowing the answer.
5. I find it fascinating to learn new information.
6. I feel frustrated if I can’t figure out the solution to a problem, so I work even harder to solve it.
7. When I learn something new, I would like to find out more about it.
8. I brood for a long time in an attempt to solve some fundamental problem.
10. I work like a fiend at problems that I feel must be solved.

This is a task designed to briefly assess your cognitive performance. Just answer as best you can.
1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? _____ cents.
2. If it takes 5 machines 5 minutes to make 5 widgets. How long would it take 100 machines to make 100 widgets? _____ minutes.
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake. How long would it take for the patch to cover half of the lake? _____ days.
4. If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how long would it take them to drink one barrel of water together? _____ days
5. Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class? ______ students
6. A man buys a pig for $60, sells it for $70, buys it back for $80, and sells it finally for $90. How much has he made? _____ dollars
7. Simon decided to invest $8,000 in the stock market one day early in 2008. Six months after he invested, on July 17, the stocks he had purchased were down 50%. Fortunately for Simon, from July 17 to October 17, the stocks he had purchased went up 75%. At this point, Simon has: a. broken even in the stock market, b. is ahead of where he began, c. has lost money

Thank you for completing Phase 1 of 2 of this study. In Phase 2, the iPhone app you have already downloaded will signal 5 times per day at random intervals across the next 5 days. Please try to complete as many of these assessments as possible. And, please not that these assessments are designed to be as brief and unobtrusive as possible. They can be filled out within 1-2 minutes.
**App measures**

1. How tired are you? (“Not at all” (1) to “Extremely tired” (7))

**Since you last completed an assessment from this app**

2. How busy have you been? (“Not at all” (1) to “Extremely busy” (7))
3. Put more thought into something than required (“Yes” or “No”)
4. Deliberated about an issue that did not affect you personally (“Yes” or “No”)
5. Thought about an issues over which you have no control. (“Yes” or “No”)
6. Tried to understand something complex (“Yes” or “No”)

If the participants respond affirmatively to any of questions 3-6, they will be presented a-f

You answered yes to at least one of the last four questions, indicating you have thought about something in some detail. Regarding whatever you have thought about:

a. How much effort did you feel you put in? (“Not at all” (1) to “a great deal” (7))
b. How much did you enjoy it? (“Not at all” (1) to “a great deal” (7))
c. How distracted by other things were you? (“Not at all” (1) to “Extremely Distracted” (7))
d. To what extent would you say you chose to think (internal) or were made to think by others (external)? (“All internal” (1) to “All external” (7))
e. How anxious/frustrated did you feel about finding an answer or understanding? (“Not at all” (1) to “Extremely anxious/frustrated” (7))
f. How complex was the topic of your thought? (“Trivially simple” (1) to “Extremely complex” (7))

**Behavioural Task**

One issue will be randomly drawn per day, participants will be asked about this at every interval that day in addition to the earlier questions. This is testing the “mere thought” effect as a validation task.

7. How strongly would you agree or disagree with the following statement?

Strongly Disagree (-3) to Strongly agree (3)

- Drugs such as Marijuana should be Decriminalised
- The ratio between the highest and lowest income earners in any company should be capped at 15 : 1. (i.e. the CEO can only earn 15 times as much as the lowest paid employee)
- Genetically Modified Foods should be labelled
- The legal Blood Alcohol Content for drivers should be reduced to 0.02
- The government should provide supportive funding for struggling industries like the manufacturing or automotive sector.
Since doing your first response today, have you looked into this issue outside of the app?

“Not at all” (1) to “A great deal” (7)
Appendix D Research in Conference Proceedings