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Latent profile analysis of working memory capacity and thinking styles in adults and adolescents

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ABSTRACT

This study of adults ($n = 269$) and adolescents ($n = 308$) applied latent profile analysis to preference for rational and/or experiential cognition, coupled with working memory capacity (WMC). A 4-profile solution comprising *rationally dominant*, *experientially dominant*, *dual preference*, and *disengaged* groups was retained for both adult and adolescent samples. Our solution indicated that high WMC was associated with both preference and ability to engage in rational processing. Profile membership significantly discriminated both adults and adolescents on several reasoning tasks and measures of cognitive biases. Overall our results indicate that cognitive processing styles and WMC can be combined to create a typology that distinguishes between four types of thinkers who significantly differ in their performance on reasoning tasks.

1. Introduction

Effective day-to-day decision-making in areas as diverse as personal relationships, finances, education, and the workplace, requires individuals to navigate through a host of decision points and select options that are most likely to yield desirable outcomes. Dual process theories of cognition suggest that such decision-making involves the interplay of two distinct systems or processing modes (for a review, see Evans, 2008). System 1, also referred to as the experiential system, is believed to be the default mode of processing, automatically activated through interaction with the environment. It is fast, pre-conscious, and closely linked with intuition and affect. System 2, the rational system, is slower and deliberative and draws on logical, empirical justification in decision-making (Pacini & Epstein, 1999).

Individuals have been shown to differ in their capacity (ability) for use of one or both of these systems and also in their proclivity to do so (engagement). Individual differences in rationality and experientiality have been reported across different age groups (Sladek, Bond, & Phillips, 2010) and different cultures (Witteman, van den Bercken, Claes, & Godoy, 2009). Some people favour the experiential mode, relying on intuition and their confidence in following gut feelings and instincts. Some favour the rational mode, are confident in their ability to analyse effectively and enjoy applying logical rules to everyday situations. Others are either confident or uncomfortable with both experiential and rational modes of thinking. Overall, this pattern indicates that preference for the two modes is independent of each other (Pacini & Epstein, 1999).

Studies have shown that individual differences in preference for these two systems are reliably associated with decision outcomes (Handley, Newstead, & Wright, 2000; Marks, Hine, Blore, & Phillips, 2008; Pacini & Epstein, 1999; Shiloh, Salton, & Sharabi, 2002; Toyosawa & Karasawa, 2004; Witteman et al., 2009). Across these studies, higher rationality has been positively associated with superior reasoning skills, open-minded thinking and openness to experience, and negatively associated with superstitious beliefs and cognitive biases. In contrast, higher experientiality has been positively associated with susceptibility to cognitive biases, superstitious beliefs and greater emotional expressivity.

Typological methods of measuring individual differences are often found in educational, business and medical settings, to facilitate the easy identification of individuals with differing traits and as a guide for administering interventions. For example, Robins, John, Caspi, Moffitt, and Stouthamer-Loeber (1996) classified three personality types (undercontrolled, overcontrolled and resilient) using data from the dimensional Big Five personality inventory. Researchers have emphasised that the 'types' are to be considered complementary (not competing) descriptions of the data, and although not always superior to their dimensional counterparts, they have been successfully applied to different populations (including adolescent and adult), cross-culturally, and in the prediction of different behavioural, emotional and academic outcomes (Robins et al., 1996) and for multiple health outcomes over a 40-year span (Chapman & Goldberg, 2011).

Attempts to categorise these individual differences have met with only limited success. A common approach employed has been

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to split rationality and experientiality scores at the median, thereby categorising participants into four separate groups of high rationality/low experientiality, low rationality/high experientiality, high rationality/high experientiality, and low experientiality/low rationality (e.g. Shiloh et al., 2002). Unfortunately, the median is sample-dependent and can reduce generalisability across studies (Pastor, Barron, Miller, & Davis, 2007). It can also diminish effect sizes due to creation of non-homogenous groups. The usual methods to overcome such problems involve splitting the sample into more than two groups (e.g., low, medium, and high) or deleting middle-scorers and using only those participants who fall into extreme groups. However, using extreme groups can have the obvious disadvantages of reducing sample sizes, inflating effect sizes, or failing to capture potentially important characteristics that exist only in the discarded data (Preacher, Rucker, MacCallum, & Nicewander, 2005). Another method involves subtracting the experientiality scores from rationality score to obtain a 'difference score' (Bartels, 2006). Although indicating the importance of interactions in thinking styles, this method violates the dual process assumption of two independent constructs.

A further problem with these approaches is that they do not allow for differences that might exist in the ability and engagement subscales of rationality and experientiality. Although it is common practice to combine ability and engagement sub-scales into a single index of ''preference'', studies have shown that some behaviour is associated with only one of the sub-scales (e.g. Pretz, Totz, & Kaufman, 2010).

A more suitable method would be to use the participants' data in its entirety and to form 'natural' groupings according to the homogeneity of the participants' responses. An example of this approach is a study conducted by Wolfradt, Oubaid, Straube, Bischoff, and Mischo (1999) in which the authors applied cluster analysis to the 10-item short form of the REI. They identified four distinct cognitive styles linked to dual process theory: participants high on both rationality and experientiality, low on both scales and those high on rationality but not experientiality, and vice versa. Participant membership of the four styles was predictive of some schizotypal traits, intolerance of ambiguity, self-efficacy and anomalous experiences (Wolfradt et al., 1999).

The current study extends Wolfradt et al.'s (1999) work in three important ways. First, whereas Wolfradt et al. employed the short-form of the REI to create their typology, we used the more reliable 40-item REI (Pacini & Epstein, 1999) that incorporates engagement and ability subscales for experientiality and rationality. Importantly, the subscales of engagement and ability have been shown to have discriminant validity, with independent predictions of other variables such as Big Five traits, some basic beliefs, and categorical thinking (Pacini & Epstein, 1999). Some examples of these relationships are: *rational engagement* has been positively correlated with openness to experience whereas *rational ability* was negatively related; *experiential ability* is positively related to polarised thinking, whereas *experiential engagement* is negatively related. Also, the two ability subscales (rational and experiential) are significant predictors of neuroticism and conscientiousness whereas the two engagement subscales are predictors of distrust of others and intolerance. In order to establish the optimal typology for thinking styles, we retained the subscales to allow for the possibility that individuals could group differentially along the subscales (of ability and engagement) as well as the major scales (of rationality and experientiality) of the REI.

A second important extension is that we will use latent profile analysis (LPA) instead of cluster analysis. Latent profile analysis is a type of latent variable mixture model, in which participants are assigned profile membership along dimensions of interest. It is well suited to this type of investigation. LPA examines individuals' data on a set of continuous variables and, in contrast to other techniques such as factor analysis and regression, the method is considered 'person-centred'. This is because the technique groups individuals into categories based on shared characteristics that distinguish one group of members from another group, rather than 'variable-centred' analyses such as regression and factor analytic techniques, that focus on how the variables covary (Muthen & Muthen, 2000).

LPA also enables the researcher to compare various sets of profile models in terms of statistical fit, theoretical plausibility, parsimony, uniqueness of profiles and sizes of profiles (Pastor et al., 2007). The final number of profiles is not predetermined, but is inferred, *a posteriori*, from fit statistics. When conducting an LPA, the researcher specifies a number of profiles to be tested (ranging from 2 profiles upwards). For each number of profiles, the analysis attempts to assign membership on the basis of probabilities of shared characteristics and takes membership uncertainty into account. The fit statistics are consulted for establishing the optimum number of profiles to retain. LPA has the advantage over cluster analysis of being a model-fitting procedure and having formal statistical fit criteria that enable more objective decision-making over profile selection (Muthen & Muthen, 2000).

Finally, the current study also builds upon the work of Wolfradt et al. (1999) by integrating working memory capacity (WMC) into the dual process, cognitive style profiles. Recent theories suggest that individual differences in WMC are likely to affect individuals' preferred mode of information processing, and in turn, affect decision-making outcomes (Feldman Barrett, Tugade, & Engle, 2004; Fletcher, Marks, & Hine, 2011). The ability to engage in rational processing is thought to be constrained by attentional control, a key aspect of WMC. It is particularly important in situations of distraction, interference, in novel contexts and under time pressure where attentional control is most taxed. This indicates that people with higher WMC are likely to be more successful in the types of processing associated with rationality than those with low WMC. Further, it follows that people with higher WMC are more likely to enjoy and feel comfortable processing in the rational mode. Given WMC is believed to be intimately tied to rational processing, inclusion of a WMC measure would be prudent in the profiling of thinking styles.

In this study, we sought to identify profiles of thinking styles and WMC using latent profile analysis (LPA) with data from separate groups of adults and adolescents. First, we hypothesised that the LPA would identify at least four distinct thinking style subtypes (i.e., high rational/low experiential; high rational/high experiential; low rational/high experiential; and low rational/low experiential). Given high correlations between ability and engagement subdimensions of the REI (Pacini & Epstein, 1999), we did not expect separate ability/engagement subtypes to emerge. Nevertheless, as outlined previously, we thought it was important to include the separate ability and engagement subscales to allow for the possibility of unexpected profiling along those dimensions. We also predicted that profiles characterised by high rationality would also exhibit high WMC, and profiles with low rationality would exhibit lower WMC, supporting the viewpoint that good attentional control is an important contributor to developing an ability and preference for rational processing (Feldman Barrett et al., 2004).

Second, we hypothesised that profile membership would be predictive of performance on a number of reasoning tasks and cognitive biases. Specifically, profiles with higher rationality and lower experientiality would perform better on a syllogistic reasoning task, score lower in gambling biases and be less superstitious than the other profiles. Conversely, profiles with higher experientiality and lower rationality would be expected to perform poorly on the syllogistic reasoning task and gambling biases, and be more superstitious.

Third, past studies have shown that rationality and experientiality have been negatively associated with categorical thinking