Fine Distinctions within Cognitive Style Predict Forecasting Accuracy

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Leveraging data from over 1,000 users in the System for Prediction, Aggregation, Display and Elicitation (SPADE) research program, we present preliminary data on the factor structure of individual variation in decision making ability and the associations of this variance with errors in cognitive reasoning and accuracy in making socio-political forecasts. Generally, prior research has identified two factors, or styles—intuitive and analytic—that account for significant variance in how individuals reach solutions to complex numerical and logical problems. Though sometimes named differently across research programs, an intuitive style is a tendency to use instincts, experiential knowledge, and intuition to solve problems, where an analytic style is a tendency to apply formal logic, methods of inquiry and theory to confront problems. Within a large research sample, factor analytic techniques define finer distinctions among these styles. In particular, we find distinctions within the analytical style, such that certain measures of analytic style (REI; Norris, Pacini, & Epstein, 1998) capture variance related to tendencies to express a deep interest in complex problem solving and openness to new information. In contrast, other measures (CSI; Allinson et al., 1996) capture variance related to tendencies to solve problems that are driven by a need for closure and conscientiousness. Subsequent correlation analysis suggests that the latter tendency covaries with susceptibility to commit errors in logical reasoning and poor performance on socio-economic forecasts elicited through the iSPADE system. Future work will clarify the relationship between cognitive styles and errors in reasoning and forecasting behavior through multi-level modeling techniques.

Introduction

A wide range of research suggests that individuals may take different routes to achieving the appropriate solution to the same problem. Knowing how to identify the core personality and cognitive dimensions that might predict individuals' tendencies to take one route over another is therefore critical for discovering novel methods for elicitation and presentation of problem sets that fit the unique capabilities and styles of individuals. Previous research into this topic has identified two core dimensions of "cognitive style"—one an intuitive styles and one an analytic (Allinson & Hayes, 1996; Norris, et al., 1998). The former represents a tendency to use experiential knowledge, or "gut" instinct in problem solving. In contrast, the analytic style represents a tendency to apply formal logic, theory, and prescribed methodology to solve problems. Using a similar classification borrowed from noted essayist Isaiah Berlin (1953), Tetlock (Tetlock, 2006) finds that differences in cognitive style predict abilities to forecast the outcome of political contests.

Though a number of questionnaires and metrics have been developed to account for individual differences in cognitive style, and have characterized the distinctions among these styles similarly (i.e., intuitive vs. analytical, experiential vs. rational, fox vs. hedgehog), it is unclear whether or not these metrics capture the same underlying dimensions, or whether there are additional distinctions among cognitive styles. As part of a larger effort designed to elicit and aggregate socio-political forecasts, we examined the factor structure among cognitive style variables, as they are measured by different measures, and measures of personality. Moreover, we examined whether factor scores from the resulting solutions were related to a susceptibility to errors in formal reasoning and forecasting behavior.

Methods

Participants

Participants were currently enrolled members of the SPADE project (N = 691), recruited from fliers, posting to professional listservs, and Craigslist advertisements. Eligibility for participation was restricted to persons 18 years of age or older, US citizens, and non-members of legally protected groups (i.e., incarcerated individuals, etc.).

Materials & Procedures

As part of the SPADE project, participants first completed a comprehensive battery of intake questionnaires which included measures of personality traits (Big Five Inventory; John, Donahue, & Kentle, 1991) and cognitive style, including the Cognitive Style Index (CSI; Allinson & Hayes, 1996), Rational-Experiential Inventory (REI; Norris, et al., 1998), , Need for Cognition (NFC; Cacioppo, Petty, & Kao, 1984; measured as part of the REI), as well as the Isaiah Berlin (1953) “Hedgehog-Fox” item (adapted from Tetlock, 2006). Participants also completed both the Behavioral Activation/Inactivation Scales (BISBAS; Carver & White, 1994) and Need for Cognitive Closure (NFCL; Roets & Heil, 2011; Webster & Kruglanski, 1994) as measures of individual differences in motivation. As a final part of the intake questionnaire, participants were asked to answer 6 word problems regarding logical and numerical reasoning designed to assess tendencies to commit various cognitive biases (i.e., sunk-cost-fallacy, conjunction fallacy, etc.; c.f. Kahneman & Tversky, 1983)

Additionally, participants were asked to make forecasts of future socio-politico events (i.e., “Which of Kim Jong Il’s sons will be named his successor) on a monthly basis. Participants completed approximately 30 such forecasts and then judged on the accuracy of these forecasts following the closure of each forecast.

Results

Factor Analysis

We examined the underlying factor structure of prevailing measures of cognitive styles. We first computed all prescribed subscales from each measure of cognitive style. Second we entered these variables as well as Big Five Inventory personality dimensions, motivational traits such as the BIS/BAS NFCL. These variables were entered to provide clarity in labeling and describing cognitive style dimensions. Factor analysis proceeded using the Principle Axis Factoring extraction method and Varimax rotation for an orthogonal solution. Factor loadings are presented in Table 1.

Variable Name	F 1	F 2	F 3	F 4
CSI_Intuitive	**.761**			-.416
BAS	**.655**		.136	.161
REI_Experiential	**.556**	-.173		-.158
BFI_Extraversion	**.497**	-.275	.167	
Hedgehog vs. Fox	**.261**		.107	-.134
BFI_Neuroticism		**.924**		
BIS		**.595**		.273
BFI_Agreeableness		**-.407**		.161
Need for Cognition		-.120	**.790**	
Need for Cognitive Closure	-.113	.361	**-.553**	**.497**
BFI_Openness	.352		**.549**	
CSI_Analytic	-.229		-.107	**.705**
BFI_Consc.		-.398	.196	**.437**

Table 1. **Factor loadings by variable**. Note: Extraction method: Principal Axis Factoring. Rotation method: Varimax with Kaiser Normalization

Factor loadings suggest that intuitive style subscales from different measures load on the same factor; the intuitive subscale of the CSI and experiential subscale of the REI load on the same factor (F1). Moreover, the Isaiah Berlin Hedgehog-Fox question loaded most heavily on this factor (adapted from Tetlock, 2006). Because this item was presented on a single, bipolar scale it is most likely the case that this pattern was observed because participants were more likely to report “Fox-like” tendencies, which are close in kind to those of an intuitive cognitive styling.

Analytical style subscales from different measures loaded on *different* dimensions, however; NFC—used as the rational style subscale in the REI—and the analytic subscale from the CSI loaded on two separate factors. The NFC loaded on the same factor as trait Openness to Experience (F3) whereas the analytic subscale of the CSI loaded on the same factor as trait Conscientiousness and Need for Cognitive Closure (F4).

Correlation Analysis

Correlation analyses were preformed to examine the associations between factor scores (regressive) extracted from the initial factor solution (presented above) and outcome measures: cognitive bias word problems and forecasting accuracy. First, we computed the sum total of correct answers to cognitive bias word problems. Second, composite variables were computed to provide aggregated, characteristic metrics for participants’ accuracy in their socio-politico forecasts. To do so, we aggregated across participants’ Brier score for each forecast; the Brier score is a proper score function that measures the accuracy of a set of probability assessments as the mean squared difference between predicted probabilities for a set of events and their outcomes. *Lower Brier scores represent higher accuracy.* The correlations between these variables was significant, such that persons that performed well on the cognitive bias task also showed more accuracy in their forecasting behavior ($r = -.175$, $p < .001$).

These variables were then correlated with factor scores from each of the four factors identified in the initial solution (above). See Table 2 for correlation coefficients.

Results from correlation analyses indicate different trends between Factors 3 and 4. The former encompassed one analytic style characterized by a need for cognition and openness to experience and, while the latter encompassed another analytic style characterized by a need for cognitive closure and conscientiousness. Unlike the former, the latter was associated with poor performance on measures of cognitive bias susceptibility and associated with poor aggregated performance on the forecasting task.

Variable	Cog Bias Correct	Average Brier
Factor 1 Score	-0.03	0.01
Factor 2 Score	$-.094^{*}$	0.01
Factor 3 Score	$.092^{*}$	0.00
Factor 4 Score	$-.181^{**}$	$.103^{*}$

***Table 2.* Correlations between factor scores and outcome measures**. Note: “**” indicates significant at $p < .01$, “*” indicates significance at $p < .05$.

Discussion

These preliminary findings support previous research on the dimensional structure of cognitive styles—generally, variables claiming to measure similar constructs (intuitive/analytic styles) across different cognitive style instruments show overlap in the variance they explain. However, our findings suggest fine distinctions between variables claiming to measure analytic styles, which are clarified by the factor loadings of personality trait scores and motivational tendencies. One analytic style sub-type (Analytic 1; A1) is captured by the REI ('Rational' Subscale; Norris, et al., 1998) and/or Need for Cognition scale (Cacioppo, et al., 1984; they are substitutes for one another). This sub-type appears to be motivated by a need for cognition—a desire for a rich mental life and challenges (Cacioppo, et al., 1984) as well as openness to experience, suggesting that this sub-type is willing to contemplate or pursue a variety of stimuli (John, et al., 1991). In contrast, the other sub-type (Analytic 2; A2) is captured by the CSI ('Analytic' Subscale; Allinson & Hayes, 1996). This sub-type appears to be motivated by a need for cognitive closure—an intense desire for predictability and resolution of ambiguity (Roets & Heil, 2011; Webster & Kruglanski, 1994)—as well as a conscientious mind—disciplined and methodical (John, et al., 1991).

We also find that these fine distinctions among analytical subtypes have different predictive value with respect to outcome variables. Participants with high factor scores on the A2 subtype showed poor performance on both measures of cognitive bias susceptibility and on socio-political forecasting tasks. This trend was remarkably different from participants with high factor scores on the A1 subtype, who performed slightly better than average on the cognitive bias susceptibility test, but performed no better than average on forecasting tasks.

One possible explanation for this pattern of findings is that the different motivations underlying the two analytic style sub-types (A1, A2) plays an important role in how they approach problem solving. The pattern of co-loadings with each factor that is representative of them (F3, F4) suggests that these two subtypes may circumscribe substantively different goals when solving a problem; one seems motivated to seek out new challenges and information because based on a need to foster a rich mental life (A1), while the other seems motivated to reduce ambiguity through disciplined practice of prescribed methodology (A2). In this respect, it may be the case that because the A1 subtype is motivated to capitulate on diverse information, they may be robust to falling victim to a number of cognitive biases. If true, being robust to cognitive bias did not improve aggregated forecasting performance. However, this null-effect may be driven by sample characteristics and demands of the study itself, which requires a high-level academic achievement and specialized knowledge to continually deliver reasonable forecasts.

In contrast to the A1 subtype, the A2 subtype showed poor performance on both the cognitive bias susceptibility test and forecasting task. Given that F3 co-loadings implicate this subtype as being highly methodical and disciplined, and motivated to reduce ambiguity, it may be the case that this subtype is *predisposed* toward errors in judgment. Unlike the A1 subtype, the A2 subtype may “satisfice” with the first available and plausible solution to a problem without exploring alternative hypothesis given a motivation for closure over diversity. Additionally, the overlap between the A2 subtype and conscientiousness may suggest that the A2 subtype is predisposed to express fixedness in the methods through which they go about solving problems, again failing to account for other plausible alternative methods.

By and large, our preliminary findings show promise for uncovering additional ways to characterize individuals and their unique capabilities in problem solving and judgment. Future efforts will be directed at resolving the relationship between analytic style subtypes, cognitive bias susceptibility and forecasting performance. While the associations between the A2 subtype and outcome variables (as well as covariation between the outcome variables themselves) suggest that there may be a complex pattern of moderation/mediation effects that accounts for their shared variance. These effects may be undetectable at the moment, however, because we have previously relied on aggregation techniques, summing across performance on individual forecast tasks delivered at various points across data collection. Future analyses will attempt to evaluate the existence of these effects with multi-level modeling techniques that sufficiently account for both within- and between-subjects variation in forecasting performance. By accurately representing the data’s inherent nesting structure and account for the potential effects of knowledge level with respect to particular forecast questions, we may discover the pathways through which differences in analytic style affect judgments about future events, perhaps by virtue of a susceptibility to cognitive bias.

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