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ORIGINAL RESEARCH

Performance characteristics of measurement instruments of epistemic curiosity in third-year medical students

Jeremy B. Richards[1], Jordan Litman[2] & David H. Roberts[1]
[1]Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, MA, USA
[2]University of South Florida, St. Petersburg, FL, USA

Abstract
Epistemic curiosity is theorized to underlie the adoption of learning goals, studying strategies, and skill development critical to becoming a successful physician. However, there is relatively little research regarding the measurement of epistemic curiosity in medical learners. We administered the I- and D-type curiosity and Need For Cognition (NFC) scales to assess individual differences in epistemic curiosity, and the Study Processes Questionnaire to measure tendencies to employ "Deep" or "Surface" learning goals and strategies to 90 third-year medical students in academic years 2010 and 2011. The performance characteristics of these instruments were characterized, and path analyses were conducted to examine the relationships between these instruments. Individual differences in I- and D-type curiosity were positively associated with tendencies to set goals and use strategies aimed at developing a deeper understanding of knowledge. NFC was negatively associated with goals and strategies that involved seeking only a surface understanding of new information. Our results demonstrate that in a population of medical learners, I- and D-type curiosity scale scores significantly predict seeking a deeper understanding of new information, while NFC scale scores may be better considered as a marker of avoiding superficial study processes but not necessarily engaging in deeper approaches.

Introduction
Epistemic curiosity is the desire to seek out new information that is expected to stimulate positive states of intellectual interest or reduce undesirable conditions of uncertainty.[1-4] Epistemic curiosity, therefore, refers to a set of internal motivations for learning and could be alternatively referred to as "cognitive curiosity" or "cognitive motivations" for engaging in the work of learning something new. Epistemic curiosity motivates students to approach opportunities for learning, to think about new ideas, ask questions, and solve problems.[1-4] Differences in epistemic curiosity predict students developing learning goals aimed at mastering new material for reasons of both personal enjoyment and achieving superior academic performance through hard work.[5] Semi-structured interviews of college undergraduates revealed that their intellectual curiosity "to discover the unknown" was an important factor in identifying which students chose to pursue a Ph.D., M.D./Ph.D. or M.D. degree with the ultimate goal of doing research.[6] Such studies suggest that epistemic curiosity is associated with setting both short- and long-term learning goals, as well as the pursuit of careers that involve the critical and rigorous analysis of new information.

In this context, our study describes the performance characteristics of a series of psychological measurement instruments that assess different aspects of epistemic curiosity. Specifically, we administered the Interest (I) and Deprivation (D) type curiosity scales, the Need For Cognition scale (NFC), and the Study Process Questionnaire to a cohort of third-year medical students.[2,5,7] In this paper, we describe the performance characteristics of these instruments in this population of learners.

Corresponding authors: Jeremy Richards, MD, MA, Harvard Medical School, 330 Brookline Avenue, KSB-23, Boston, MA 02215 USA, Tel: +1 (617) 667-5864, Fax: +1 (617) 667 -4849, email: jbrichar@bidmc.harvard.edu

Medical students

In medical students and trainees, epistemic curiosity is believed to contribute to setting learning goals aimed at gaining a deeper understanding and mastery of skills that enhance the development of clinical expertise.[8,9] Curiosity likely plays a role in developing meticulous problem solving strategies that reflect "specific, evidence-based approaches" to making diagnoses and caring for patients.[10] These strategies help physicians make challenging diagnoses and take greater intrinsic pleasure in successfully caring for patients.[11-13]

Therefore, as epistemic curiosity helps shape medical students' learning goals and knowledge-gathering strategies, individual differences in epistemic curiosity are theorized to play an important role in achieving a successful, rewarding, and meaningful career in medicine. As such, an improved understanding of the characteristics of instruments used to measure epistemic curiosity in medical students is desirable. Furthermore, describing the relationship between epistemic curiosity and how medical students develop learning goals to achieve a deeper understanding of new knowledge may be important for medical educators.

Although the potential importance of curiosity in medical learners has been acknowledged in the literature, to date relatively little empirical research has been conducted to rigorously describe the performance characteristics of instruments used to measure aspects of epistemic curiosity in medical students.[10,14,15] In addition, the relationships between epistemic curiosity and students setting learning goals or adopting rigorous methods and strategies aimed at gathering and comprehending new information have not been previously described. In the present study, we assessed different aspects of epistemic curiosity in medical learners using 3 reliable and valid questionnaire instruments. We also assessed the degree to which students applied specific goals and strategies aimed at learning course material, and determined associations between these goals and strategies with measurements of epistemic curiosity.

Hypotheses

We hypothesized that epistemic curiosity would be positively associated with using learning goals and strategies oriented towards deep processing and understanding new information. We further hypothesized that epistemic curiosity would be either unassociated or negatively associated with learning goals or strategies aimed at obtaining only a shallow or surface level of understanding.

Context

Third-year Harvard Medical School (HMS) students at the Beth Israel Deaconess Medical Center (BIDMC) enrolled in a year-long longitudinal curriculum for third-year medical students were invited to participate in this study.[16] Students completed self-report instruments that assess individual differences in different aspects of epistemic curiosity and tendencies to engage in either "deep" or "surface" approaches to learning. To assess our hypotheses and describe the performance characteristics of these instruments, the magnitude and direction of the relationships between epistemic curiosity and deep or surface approaches to learning were evaluated with path analysis.

Materials and Methods

Instruments and measures

To assess individual differences in epistemic curiosity, 3 questionnaire measures found to be valid and reliable in previous research were administered to third-year students: The Interest (I) and Deprivation (D) type curiosity scales and the Need For Cognition scale (NFC).[2,5] Each scale measures theoretically distinct, but related, aspects of epistemic curiosity.[17] The I- and D-type curiosity scales assess tendencies to experience different underlying affective states associated with different goals for making use of desired knowledge. For example, I-type curiosity involves learning something new with the expectation of stimulating pleasurable states of interest, while D-type curiosity is characterized by seeking out new knowledge in order to solve a bothersome unsolved puzzle or problem. The NFC scale is a more "general" epistemic curiosity measure that assesses tendencies to approach situations anticipated to be intellectually engaging and to avoid situations where intellectual stimulation is deemed unlikely.

Although the 3 epistemic curiosity measures used in this study assess *theoretically* distinct expressions of this construct, there is some controversy over the extent to which they are *psychometrically* distinct.[17] We conducted an exploratory factor analysis using oblique rotation of responses to all 28 of these items and found clear evidence of 3 factors, one defined by the 5 I-type items, one defined by the 5 D-type items, and one factor defined by the 18 NFC items.

In order to determine the kinds of learning goals and strategies utilized by medical students, we administered the Study Process Questionnaire (SPQ). The SPQ was designed to assess different approaches (i.e., motives and strategies) to learning,

classified as either "Deep" or "Surface" in nature.[7] Deep motives and strategies describe setting learning goals that involve intrinsic interest in learning and a willingness to expend extra time and effort to maximize understanding. Surface motives and strategies involve a fear of failure and task-specific, focused learning efforts that require minimum time and effort.[7] Each of these measures is described in greater detail below.

I-type and D-type Curiosity scales

The I-type and D-type Curiosity scales are 5-item trait-measures of epistemic curiosity.[5] Both types of curiosity are theorized to orient individuals towards different kinds of knowledge-seeking activities. The I-type scale inquires about one's enjoyment of learning about unfamiliar topics (e.g., "I enjoy exploring new ideas"), whereas the D-type scale asks about one's tendencies to feel bothered by having insufficient information and the willingness to exert effort in order to seek it out (e.g., "I can spend hours on a single problem because I just can't rest without knowing the answer"). Scores on the I-type scale are associated with experiences of positive affect, seeking out new information, and mastery-oriented learning. Scores on the D-type scale are associated with the reduction of negative affect, seeking out information that is missing from an existing knowledge set, and performance-oriented learning.[3,5,18] In responding to each I- and D-type scale item, participants are instructed to indicate how they "generally" feel using a 4-point Likert type scale ranging from "almost never" to "almost always". Alphas $\geq$ 0.80 have been reported for these instruments.[18]

Need For Cognition

The NFC scale is an 18-item instrument that assesses general tendencies or preferences regarding opportunities for cognitive stimulation (e.g., "I prefer my life to be filled with puzzles that I must solve") versus avoidance of situations expected to be intellectually boring or tedious (e.g. "I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something", reverse scored).[2] In answering each item, respondents indicate the extent to which they agree with each statement on a 9-point scale ranging from "very strong agreement" to "very strong disagreement". In previous research, alphas $\geq$ 0.90 have been demonstrated.[2]

Study Process Questionnaire

SPQ includes two 10-item scales that assess either "Deep" or "Surface" approaches to learning new knowledge. Each of the 10-item SPQ Approach scales consists of two subscales that assess either "motives" or "strategies" for dealing with new information. The Deep Motives SPQ subscale assesses the extent to which respondents set learning goals based on stimulating their intrinsic interest and achieving personal satisfaction (e.g., "I find that studying academic topics can at times be as exciting as a good novel or movie.") The Deep Strategies SPQ subscale items refer to expending greater time and effort to fully understand information to be learned (e.g., "I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied."). The Surface Motives SPQ subscale items ask about setting learning goals aimed at failure avoidance (e.g. "I see no point in learning material which is not likely to be in the examination.") The Surface Strategies SPQ subscale items assess if respondents prefer to expend as little effort and time as possible in order to learn only what is believed to be absolutely necessary (e.g., "I find the best way to pass examinations is to try to remember answers to likely questions".) In previous research, the SPQ Deep and Surface Approach total scales were found to have alphas of 0.73 and 0.64, respectively, while the brief SPQ subscales were found to have alphas ranging from 0.57 to 0.72.[7]

Experiment

After obtaining verbal informed consent, 90 third-year medical students (41 women), ranging in age from 28 to 30, in the 2010 and 2011 academic years (AY) voluntarily completed the I-type and D-type curiosity scales, the NFC scale, and the SPQ Deep and Surface Approach scales and subscales. Respondents also provided birthdate and gender data. All surveys were on paper, and administered to students in the context of a course evaluation session.

Data were collected by a research assistant not associated with student evaluation, and the survey results were disassociated from individual students' identifying information for data analysis. Data were manually entered into an Excel spreadsheet and checked by two different team members to ensure accuracy. The study protocol was determined to be exempt from review by the HMS IRB.

All statistical analyses were performed using SAS (Release 8.02). Means, standard deviations, and Cronbach's alpha for I- and D-type curiosity, NFC, and SPQ scores as well as Pearson correlations between scores on these instruments were computed (Table 1). Using grouped results from AY2010 and AY2011, path analyses were performed to determine the direction and magnitude of the relationships between I- and D-type Curiosity, NFC,

and Surface- and Deep-SPQ (Figures 1 and 2). Path analyses were specifically performed to identify causal, rather than correlative, relationships between the different instruments. We performed goodness of fit indices assessing overall model fit for each model (Table 2). Specifically, Chi-square analysis was performed to determine if the relationships demonstrated in the path analyses model were a reasonable fit. The comparative fit index (CFI), non-normed fit index (NNFI) and the MacDonald fit index (MFI) are descriptive tools comparing a model to a hypothetical baseline (null) model. The fit indices therefore assess the degree by which a model describes relationships between parameters. Finally, the root mean square error of approximation (RMSEA) assesses model fit by incorporating the Chi-square results, degrees of freedom and sample size, to determine acceptability of fit.

Results

Means, standard deviations, Cronbach's alpha, and correlations between the I- and D-type Curiosity scales, the NFC scale, and the SPQ measures are reported in Table 1. Alphas for all of the scales were adequate ($\geq$0.73), especially taking into consideration that the I- and D-type scales and the SPQ subscales were composed of relatively few items. The correlations between the I- and D-type and NFC scales were positive and very strong, which was expected given that all 3 of these measures are theorized to assess different aspects of epistemic curiosity.[17]

Finding that the NFC scale was significantly more strongly related to I-type than D-type Curiosity (z=2.00, $p\leq$.05), suggested that NFC primarily assesses taking pleasure in cognitive activity rather than being bothered by a lack of knowledge or being motivated to persist in acquiring it.[3] The Deep SPQ scales correlated strongly and positively with all 3 epistemic curiosity scales, whereas the Surface SPQ scales had small to moderately strong negative correlations with the curiosity instruments.

In order to test the hypothesized relationships between I- and D-type Curiosity, NFC, and the Deep and Surface SPQ motives and strategies, the covariance matrix of scores on these instruments was examined with path analysis. In keeping with the view that individual differences in epistemic curiosity underlie the tendency for individuals to set goals and use strategies aimed at learning and understanding new information, the 3 curiosity scales were treated as predictors of SPQ scores. Paths were estimated from each of the 3 epistemic curiosity measures to each of the SPQ scales. Two models were evaluated: the first examined relationships between the 3 epistemic curiosity scales and the 2 SPQ approach total scales (5 variable model), while the second model examined relationships between the curiosity scales and the 4 SPQ strategy and motive subscales (7 variable model).

Goodness of fit indices demonstrate that model fit was generally excellent for the 5 variable model with CFI, NNFI, and MFI all $\geq$0.983. In addition, Chi-square comparison was a non-significant and RMSEA was < 0.08 (Table 2). Model fit was initially poor for the 7 variable model, but by allowing the errors for the Deep and Surface SPQ measures to correlate, more acceptable fit was also achieved on all criteria with the exception of a slightly higher than desirable RMSEA ($\geq$0.08).[19]

Consistent with our hypothesis, the 5 variable model path and error coefficients demonstrate that both I- and D-type Curiosity were significant predictors of engaging in Deep SPQ approaches, but were unrelated to engaging in Surface SPQ approaches (Figure 1). Unexpectedly, the NFC scale was unrelated to engaging in Deep approaches to learning but was significantly negatively associated with engaging in Surface approaches (Figure 1).

In the 7 variable model, which split SPQ measures into their constituent strategy and motive subscales, I-type Curiosity was the only significant predictor of Deep SPQ Motives (Figure 2). D-type Curiosity only significantly predicted engaging in Deep SPQ Strategies. Consistent with the results of the 5 variable model, NFC was not significantly associated with either the Deep SPQ Motive or Strategy subscales, but was significantly negatively associated with both Surface SPQ subscales.

Discussion

In this study, we measured different aspects of epistemic curiosity and tendencies to take a deep or surface approach to learning in third-year medical students. We describe the performance characteristics as well as the nature and degree of effects between the instruments. Specifically, we developed path models describing the relationships between I- and D-type Curiosity and NFC in predicting learning goals and strategies of third-year medical students. Path analyses, rather than multivariate regression analyses, were specifically performed to identify cause and effect relationships between the instruments. The path analyses adequately describe the relationships between the

instruments as demonstrated by acceptable goodness of fit indices (Table 2).

Consistent with our hypotheses, path analyses demonstrate that the I- and D-type Curiosity scales were positively associated with Deep SPQ approaches to learning new knowledge. Additionally, we found evidence of differentiation between the I-type and D-type scales with regard to their relationships to Deep SPQ approaches. Specifically, I-type Curiosity was significantly associated only with Deep SPQ Motives, while the D-type Curiosity scale significantly predicted engaging in Deep SPQ Strategies. In reviewing the content of the items comprising each of the Deep SPQ subscales, all of the Deep SPQ Motive items refer to the enjoyment or appeal of the material to be learned (e.g., "I feel that virtually any topic can be highly interesting once I get into it."), while all of the Deep SPQ Strategy scale items refer to devoting time and effort in order to fully comprehend the material (e.g., "I test myself on important topics until I understand them completely"). These findings are consistent with the theoretical view that I-type Curiosity primarily involves taking pleasure in learning just for the sake of doing so, while D-type Curiosity describes working hard in order to gather accurate and useable information.[5,18]

Interestingly, the NFC scale was unrelated to engaging in Deep SPQ approaches to learning, and was also negatively associated with engaging in Surface SPQ approaches. These results are surprising, as it is unclear what it means for one to actively avoid surface processing while also being disinclined to engage in any deep processing. These findings may indicate that the NFC scale is really assessing tendencies to choose not to engage in much thinking, and should be scored as a measure of individual differences in cognitive laziness by reverse scoring of all the traditionally forward scored items, rather than assessed as a tendency to prefer increased cognitive activity. The implications of these findings will be important to consider in future research with the NFC scale.

Overall, in this study, we have provided a preliminary descriptive assessment of the performance of and relationships between these measurement instruments in medical learners. In using different yet complementary instruments to assess students' curiosity, motivations, and strategies for learning, we have evaluated how each instrument measures different aspects of epistemic curiosity in this population. While the descriptive path analyses will facilitate interpretation of these scales in future studies of medical learners, different relationships between these instruments may be noted in different populations of learners. Our study was a single center study and included a relatively homogeneous cohort of medical students at one medical school that specifically promotes the pursuit of academic careers. Given these considerations, the generalizability of our results must be verified in future studies involving different populations of medical learners.

The results of this study may allow educators to prospectively identify students who may be more responsive to specific methods of learning by measuring I- and D-type Curiosity and NFC, and thereby tailor interventions to an individual student's curiosity traits and approaches to learning. Of course, we do not suggest that curiosity scales be used in isolation to determine educational protocols or interventions. Rather, these tools may be part of an educator's repertoire to provide as complete an assessment of a learner as possible, and to assist in strategizing how to best approach the learner in the context of a specific problem or training experience.

Future work will assess whether higher I-or D-type Curiosity, NFC, or SPQ scores are associated with standard performance measures (i.e., licensing and shelf exam scores) and with career choices (i.e., a career in academic medicine and/or laboratory investigation). In addition, we will assess whether curiosity scores change over the course of medical training, whether they can be modified or enhanced by curricular interventions, and if curiosity is linked to other domains of critical thinking.

Conclusion

In summary, in this study we have described the performance characteristics of the I- and D-type Curiosity scales, NFC, and SPQ in third-year medical students. Path analyses demonstrated that I- and D-type Curiosity predict motivations and strategies associated with learning new knowledge more deeply, as measured by the Deep SPQ, while NFC predicts avoidance of engaging in superficial learning associated with the Surface SPQ. Our results provide evidence of the validity of and utility for using the I- and D-type Curiosity scales and NFC in a complementary fashion to assess medical learners' epistemic curiosity and approaches to learning.

Notes on Contributors

JEREMY B. RICHARDS, MD, MA, is an Instructor in Medicine at Harvard Medical School and the Carl J. Shapiro Institute for Education and Research, Beth Israel Deaconess Medical Center, Boston, MA, USA.

JORDAN LITMAN, PhD, is a visiting research scientist at the University of South Florida Psychology Department, St. Petersburg, FL, USA.

DAVID H. ROBERTS, MD, is an Associate Professor of Medicine at Harvard Medical School and the Associate Director of the Carl J. Shapiro Institute for Education and Research, Beth Israel Deaconess Medical Center, Boston, MA, USA.

Keywords

Epistemic curiosity, need for cognition, medical student learning

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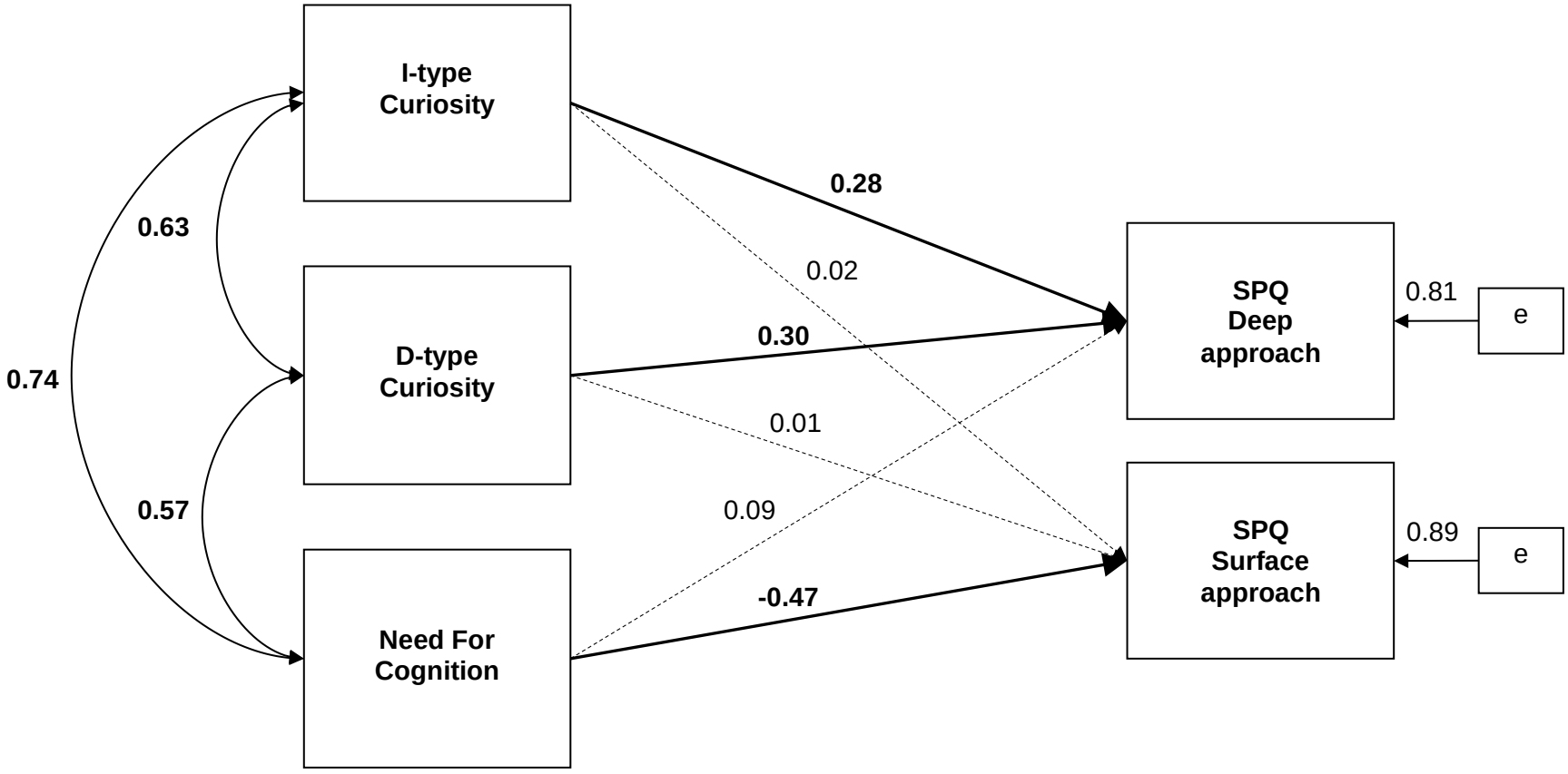
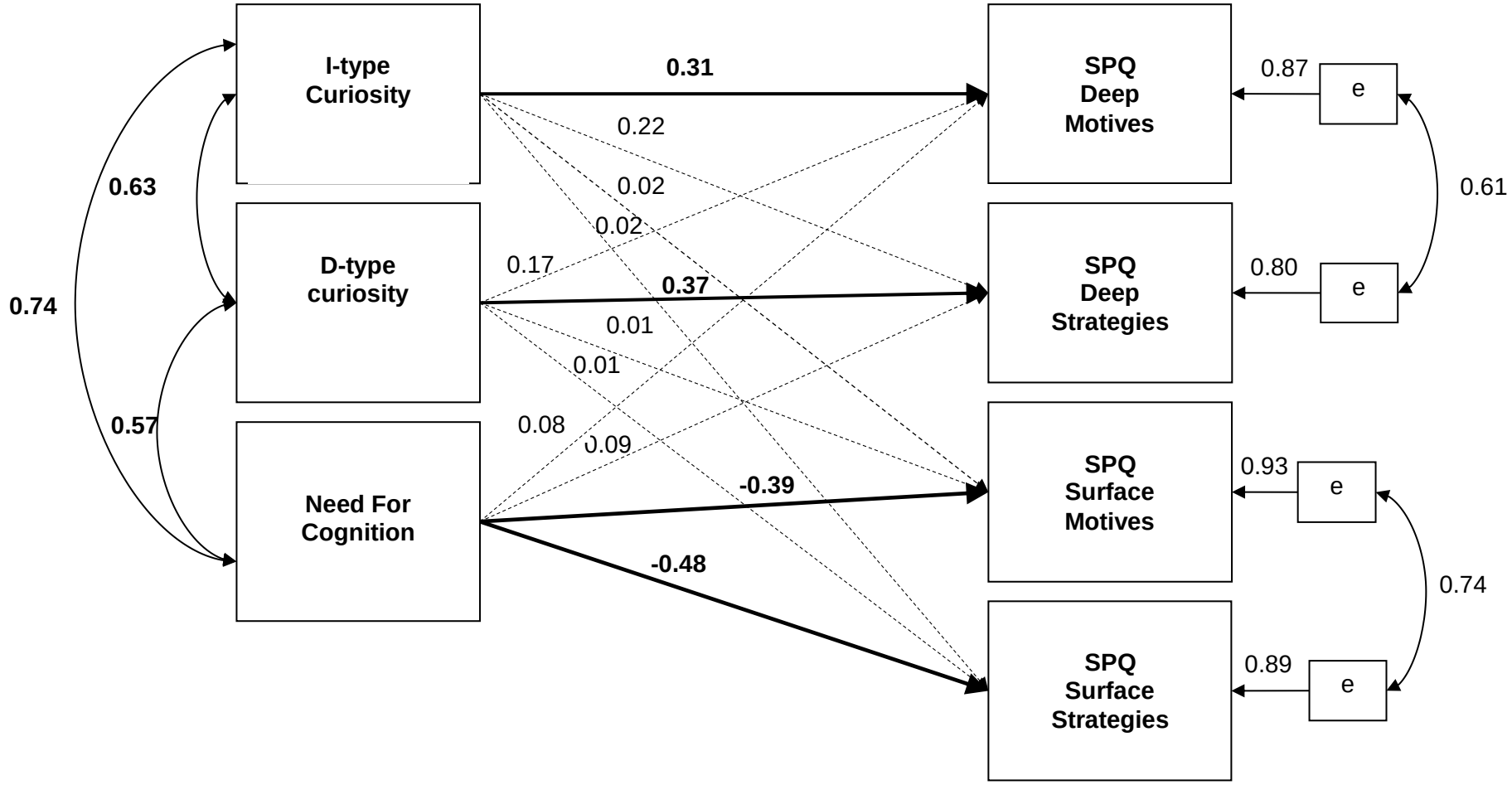
APPENDIX

Figure 1*: Path diagram of the relationships between I- and D-type Curiosity, Need For Cognition, and Deep and Surface Study Processes in 3rd year Medical Students (N=90)*



Significant paths and their coefficients are in bold; nonsignificant paths are dashed.

***Figure 2**: Path diagram of the relationships between I- and D-type Curiosity, Need For Cognition, and Deep and Surface Motive and Strategy Study Processes in 3rd year Medical Students (N=90)*



Significant paths and their coefficients are in bold; nonsignificant paths are dashed.

***Table 1**: Means, standard deviations, Cronbach's alpha, and Pearson product-moment correlations between I- and D-type Curiosity, Need For Cognition, and SPQ Deep and Surface approach, Motives and Strategies in 3rd year Medical Students (N=90)*

		M	SD	1	2	3	4	5	6	7	8	9
1.	I-type Epistemic Curiosity	16.29	2.62	(0.79)								
2.	D-type Epistemic Curiosity	13.30	3.50	0.63	(0.85)							
3.	Need For Cognition	34.62	21.07	0.74	0.57	(0.93)						
4.	SPQ Deep approach	33.02	6.75	0.54	0.53	0.47	(0.85)					
5.	SPQ Deep Motives	17.57	3.45	0.47	0.41	0.40	0.92	(0.73)				
6.	SPQ Deep Strategies	15.46	3.83	0.52	0.56	0.46	0.93	0.72	(0.73)			
7.	SPQ Surface approach	18.81	6.60	-0.31	-0.24	-0.44	-0.29	-0.26	-0.27	(0.86)		
8	SPQ Surface Motives	8.64	3.31	-0.26	-0.20	-0.37	-0.28	-0.29	-0.24	0.94	(0.78)	
9.	SPQ Surface Strategies	10.17	3.69	-0.33	-0.25	-0.46	-0.26	-0.20	-0.27	0.95	0.78	(0.74)

Correlations $\geq$ .24 are significant, $p < .05$

Cronbach's alpha reported on diagonal in parentheses.

***Table 2**: Goodness of Fit Indices for 5-variable (SPQ scales) and 7-variable (SPQ subscales) SEM model of I- and D-type Curiosity, NFC, and Deep and Surface Study Processes (N = 90)*

	Models	
GFI	5-variables	7-variables
χ^2 (*df*)	1.28(1) *n.s.*	7.00(4) *n.s.*
CFI	0.998	0.991
NNFI	0.983	0.991
MFI	0.998	0.984
RMSEA[95% CI]	0.06 [0.00-0.03]	0.09 [0.00-0.02]