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The role of activity engagement in the relations between Openness/Intellect and cognition

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ABSTRACT

The current project investigated why people with high levels of Openness/Intellect tend to have higher levels of cognitive functioning than people with lower levels of Openness/Intellect. We hypothesized that the positive relationship between Openness/Intellect and cognition might be attributable to more open people being more likely to engage in cognitively stimulating activities that are beneficial for cognitive functioning. Three conceptualizations of activity engagement based on: (a) self ratings of duration and intensity of engagement; (b) perceived routineness of one's activities; and (c) disposition to engage in cognitively stimulating activities, were investigated as possible mediators of the Openness/Intellect–cognition relations. Although several of the relevant simple correlations were of moderate size and statistically significant, we found little evidence that activity engagement mediated the relations between Openness/Intellect and cognition.

1. Introduction

One of the most robust relations between aspects of personality and cognitive functioning is that between the personality dimension of Openness/Intellect and various measures of cognition (e.g., Ackerman & Heggestad, 1997; DeYoung, Peterson, & Higgins, 2005; Fleischhauer et al., 2010; Gow, Whiteman, Pattie, & Deary, 2005; Gregory, Nettelbeck, & Wilson, 2010). Although apparent across samples of different ages and with different measures of cognition, the reasons why people who describe themselves as more open tend to perform better on many cognitive tests than people with lower ratings of Openness/Intellect are not yet known.

People with higher levels of Openness/Intellect are described as intellectually curious individuals, who seek cognitive stimulation, pursue manifold interests and have appreciation for a variety of experiences. Investment theories, and in particular the model of the personality-intelligence interface developed by Chamorro-Premuzic and Furnham (2004), postulate that people with high levels of Openness/Intellect engage more in intellectual activities that provide learning opportunities and that this engagement improves crystallized abilities (for a review of theories on personality-intelligence associations and investment traits, see von Stumm, Chamorro-Premuzic, & Ackerman, 2011). In contrast, the relation between Openness/Intellect and fluid abilities is assumed in this model to operate from fluid abilities to Openness/Intellect (Chamorro-Premuzic & Furnham, 2004). That is, high levels of fluid abilities could be a prerequisite for high levels of Openness/Intellect and the development of curious personalities, which in turn may lead to the development of crystallized ability.

Although the causal direction from Gf to Openness/Intellect is plausible, it is also possible that people with high levels of Openness/Intellect more frequently engage in intellectual activities which not only increase the amount of knowledge, but also improve the efficiency of fluid abilities and other aspects related to information processing. That is, people high in Openness/Intellect may engage more frequently in activities that stimulate and enhance several aspects of their cognitive functioning, including both crystallized and fluid abilities. Consistent with this idea, Openness/Intellect has been found to be associated with more involvement in activities (e.g., Hultsch, Hertzog, Small, & Dixon, 1999), and activity engagement has been found to be associated with level of both crystallized and fluid abilities and also memory and speed components of cognition (e.g., Hultsch et al., 1999; Jopp & Hertzog, 2007). However, there have apparently not been any direct tests of the mediational role of activity engagement on the relation between Openness/Intellect and cognitive functioning, and this was a primary aim of the current project.

Several aspects of cognition were assessed in this project, i.e., crystallized ability and fluid ability as well as memory and speed of processing. Activity engagement was assessed with an activity

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inventory consisting of a list of 22 activities (i.e., Salthouse, Berish, & Miles, 2002). The research participants were asked to estimate the number of hours engaged in each activity, and for activities with at least some engagement, to also rate the cognitive demands of the activity. Unlike some prior studies of activity engagement, participants did not merely indicate whether they engaged in each activity, but instead reported the amount of time they spent engaged in each activity in a typical week. Furthermore, participants provided ratings of the cognitive demands of each activity, which allowed us to examine engagement only for activities with the highest rated cognitive demands, in addition to total amount of engagement across all activities.

It is possible that it is not activity engagement, per se, that is critical in the relation between Openness/Intellect and cognition, but rather how the activities are perceived in terms of being routine or demanding. We therefore investigated the role of subjective perceptions of amount of activity engagement with the Environmental Demands questionnaire (Martin & Park, 2003), which assesses feelings of busyness and routine in everyday life.

The compound label of Openness/Intellect derives from an old debate on how best to describe the content of this personality trait (e.g., Johnson, 1994). Recent studies have provided evidence that the trait is comprised of two somewhat distinct aspects (e.g., De Young, Quilty, & Peterson, 2007; see also DeYoung, Shamosh, Green, Braver, & Gray, 2009); engagement in sensation and perception (e.g., "See beauty in things that others might not notice"), and intellectual engagement and perceived intelligence (e.g., Avoid philosophical discussions" [reversed]). Because the Openness/Intellect measure used in the current project consisted of only 10 items (from the 50-item version of the Big-Five 5 Broad Domains, Goldberg, 1992), we were not able to make distinctions between the two components. However, we were interested in the possibility that at least some of the relations between Openness/Intellect and cognition are attributable to a specific disposition to seek out cognitive stimulation and engage in effortful cognitive processing. We measured this disposition with the Need for Cognition scale (Cacioppo, Petty, Feinstein, & Jarvis, 1996), which was specifically designed to assess people's need for complex thinking and effortful reasoning.

Although the Need for Cognition and Openness/Intellect constructs are similar in some respects, Openness/Intellect can be considered to be a broader personality trait that encompasses more dimensions (e.g., affective, sensory, attitudes, and preferences) than the Need for Cognition disposition. Consistent with this idea, Fleischhauer et al. (2010) provided evidence for a strong relation of Need for Cognition to the Openness to Ideas facet ($r = 0.67$), but small to moderate relations of Need for Cognition to other facets of Fantasy, Aesthetics, Feelings, Actions and Values (all $r \leqslant 0.26$) of the NEO-PI-R of Costa and McCrae (1992). The authors also suggested that Need for Cognition assesses individual differences in cognitive resource allocation to a greater extent than does Openness/Intellect. We were interested in determining whether the tendency to exert more cognitive effort and seek out information processing might be the primary mechanism responsible for the relation between Openness/Intellect and cognition, and therefore Need for Cognition was examined as a potential mediator of the Openness/Intellect–cognition relation.

The primary method used to investigate our hypotheses was mediational analysis. For each potential mediator (X) our examination of mediation consisted of three steps. First, we examined the relations between Openness/Intellect (O/I) and the hypothesized mediator (i.e., O/I-X). Next, we examined the relation of the hypothesized mediator to the measures of cognition (i.e., X-Cog). Finally, we examined whether the relations between Openness/Intellect and cognition were reduced after controlling the variance in each potential mediator (i.e., [O/ICog]·X). Indirect effects were estimated with the bootstrap procedure described by Preacher, Rucker, and Hayes (2007).

The sample in the current project consisted of over 2200 adults who performed a comprehensive battery of cognitive tests and completed questionnaires assessing aspects of engagement in activities, perceived busyness or routine, the "Big Five" dimensions of personality and Need for Cognition. A broad assessment of cognition was obtained from 16 variables representing four abilities (crystallized ability, fluid ability, memory ability and speed ability). Prior research (e.g., Salthouse, Pink, & Tucker-Drob, 2008) has established that the cognitive variables are both reliable and valid, and all of the self-report scales had good reliabilities (i.e., mean of 0.88 and range from 0.80 to 0.93). The sample included adults ranging from 18 to 96 years of age, and because age is correlated with both Openness/Intellect and cognitive ability, all analyses included age as a covariate.

2. Method

2.1. Participants

The sample consisted of 2257 adults between 18 and 96 years of age who all had Mini Mental Status Exam (Folstein, Folstein, & McHugh, 1975) scores of 27 or greater, thereby minimizing the likelihood that any of the participants were demented. Participants were recruited through newspaper advertisements, flyers and referrals from other participants. Further descriptions of the participants, and the methods of recruitment, are provided elsewhere (e.g. Salthouse et al., 2008). Characteristics of the sample are presented in Table 1. It can be seen that the mean age was 50.3 (SD = 18.6) and that 64.6% of the participants were female. Most of the participants had at least some college education, with a mean of nearly 16 years of formal education, and reported themselves to be healthy, with a mean of about two on a self-report scale ranging from 1 (for excellent) to 5 (for poor).

2.2. Materials and procedure

Three 2-h sessions were conducted in the laboratory by trained research assistants. During these sessions, participants were administered several cognitive tests designed to assess one of four cognitive abilities. The questionnaires described below were completed at home.

Cognitive tests: The cognitive tests were designed to assess Fluid Intelligence (Gf) with tests of reasoning (Matrix Reasoning, Shipley Abstraction, Letter Sets) and spatial visualization (Spatial Relations, Paper Folding, Form Boards), Crystallized intelligence (Gc) with tests of vocabulary (WAIS Vocabulary, Picture Vocabulary, Synonym Vocabulary, Antonym Vocabulary), Episodic Memory with verbal memory tests (Word Recall, Paired Associates, Logical Memory), and Perceptual Speed with substitution and comparison tests (Digit Symbol, Letter Comparison, and Pattern Comparison).

Table 1
Means and standard deviations of the sample characteristics.

	Mean	SD	Age *r*
N	2257		
Age	50.3	18.6	
Female (%)	64.6		0.01
Years of education	15.8	2.7	0.22*
Health rating	2.2	0.9	0.12*
Activity limitation	1.8	0.9	0.24*
Openness/Intellect	36.7	6.2	−0.06*

Note: Health rating on a scale ranging from 1 (excellent) to 5 (poor). Health-related activity limitation was rated on a scale ranging from 1 (very little) to 5 (very much).
* $p < 0.01$.

Descriptions of the tests, and their sources, are contained in other articles (e.g., Salthouse, 2004; Salthouse, et al., 2008).

Openness/Intellect: Personality, and of particular relevance in the current report, Openness/Intellect, was assessed with the "Intellect" scale from the 50-item version of the Big-Five 5 Broad Domains (from the International Personality Item Pool; 50-item version; Goldberg, 1992, 1999). This scale is labeled Intellect, but we refer to it with the compound label of Openness/Intellect because it likely has overlap with typical measures of Openness. The internal consistency (coefficient alpha) of the Openness/Intellect scale was .80.

Activity Inventory: The Activity Inventory (Salthouse et, al., 2002) contains 22 activities. For each activity the participant was asked to report the number of hours spent engaged in the activity during a typical week. Furthermore, for activities with at least some reported engagement the participants also rated the cognitive demands of the activity, on a 5-point scale ranging from 1 (absolutely no cognitive demands) to 5 (high cognitive demands).

Need for Cognition questionnaire (Cacioppo et al., 1996): The 18-item version of the Need for Cognition scale was used. The internal consistency of the scale for the sample was .90.

The Environmental Demands questionnaire (Martin & Park, 2003): The Environmental Demands questionnaire consists of 11 items, with the first seven postulated to assess feelings of busyness (e.g., "How busy are you during an average day?"), and the last four items postulated to assess feelings of routine (e.g., "How often does your day follow a basic routine?"). Responses were on a 5-point scale ranging from "not at all' or "never," to "very often" or "extremely". The correlation between the busyness and routine scales was −0.31, and the coefficient alpha reliabilities were .88 for the busyness scale, and 0.81 for the routine scale.

Health ratings: Participants were asked to rate their health on a scale ranging from 1 (excellent) to 5 (poor) and their health-related activity limitation on a scale ranging from 1 (very little) to 5 (very much).

3. Results[1]

Prior confirmatory factor analyses (e.g., Salthouse, et al., 2008) revealed that all of the cognitive variables had moderately high loadings on their respective factors, and therefore composite variables were created by averaging the *z* scores for the variables representing their ability.

The mean levels of the four cognitive composites as a function of Openness/Intellect score are portrayed in Fig. 1. After controlling for the age-related variation in the Openness/Intellect and cognition measures, the correlations with Openness/Intellect were 0.45 for crystallized ability (Gc), 0.26 for fluid ability (Gf), 0.23 for memory ability and 0.13 for speed ability.

Correlations between the self-report measures of the current study are reported in Table 2. Except for the moderately strong correlation between Openness and Need for Cognition, correlations between the self-report variables of the current study ranged from −0.02 to −0.23, suggesting (in conjunction with the moderate reliabilities), that they seem to be assessing different constructs.

Activity engagement: The activities, and the mean and standard deviation of hours per week devoted to each, are reported in Table 3. It can be seen that the mean number of hours people reported spent engaged in activities per week was 92. Because this corresponds to approximately 13.1 h per day, these activities presumably occupy much of the typical participant's waking hours.

Reports of time devoted to various activities in the current project were comparable to values recently reported in the national

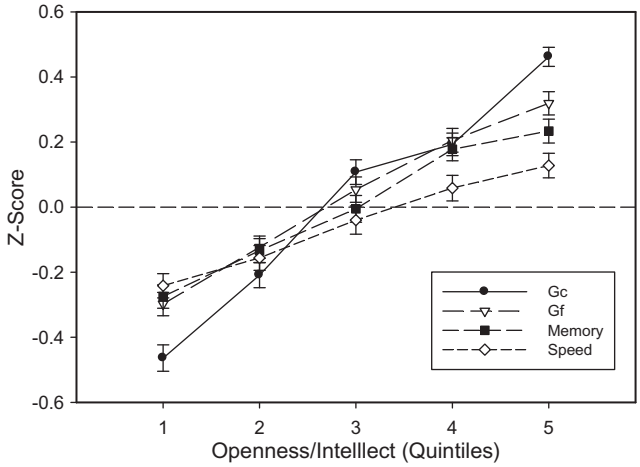

Fig. 1. Relations of Openness/Intellect to composite measures of cognitive functioning (*z* scores). Error bars represent standard errors.

Table 2
Age-partialled correlations between the self-report measures of the current study.

	1	2	3	4	5
1. Intellect	1				
2. Activity hours	0.04	1			
3. Busyness	0.05	0.05	1		
4. Routine	−0.02	−0.02	−0.23*	1	
5. Need for Cognition	0.62*	0.07	0.09*	−0.03	1

* $p < 0.01$.

American Time Use Survey (Bureau of Labor Statistics, 2009). Specifically, estimated hours per day in the national survey and in the current project, were, respectively: Housework, 0.6 and 0.7; Gardening, 0.2 and 0.3; Volunteering, 0.15 and 0.25; Eating and drinking, 1.2 and 0.8; Purchasing goods and services, 0.8 and 0.4, and Watching television, 2.5 and 1.6 h.

Simple correlations of the time devoted to various activities with Openness/Intellect and with the composite cognitive measures were examined to determine the plausibility of activity engagement as a mediator of the Openness/Intellect–cognition relation. The relevant correlations with activity assessed as the sum of hours spent engaged in all activities, the sum of hours spent engaged in the seven activities with the highest rated cognitive demands, and the sum of hours spent engaged in the six activities with highest correlations with Openness/Intellect, are presented in Table 3. The high-cognitive-demand activities were reading newspapers, using a computer, driving a car, reading nonfiction books, working on crossword puzzles, handling finances, and writing. The six activities with highest correlations with Openness/Intellect were writing, reading nonfiction and novels, playing music, playing chess and using a computer.

Although Openness/Intellect was not related to the total number of hours engaged in all activities, it was significantly associated with the number of hours spent engaged in the seven most cognitively demanding activities, and with the number of hours spent engaged in several individual activities. The number of hours spent engaged in the six activities with strongest relations to Openness/Intellect was the only indicator of engagement that was related to the four cognitive abilities. The total number of hours spent engaged in activities was not related to cognitive measures, and engagement in the seven most cognitively demanding activities was only related to speed.

The relations of Openness/Intellect to the cognitive abilities before and after controlling for the amount of time spent engaged in

[1] Because of the large sample size, an alpha of .01 was used in all analyses.

Table 3
Correlations of measures of activity engagement with Openness/Intellect and with four composite cognitive variables.

Activity measure	Mean	(SD)	Openness/Intellect	Gc	Gf	Memory	Speed
All activities	92.1	29.9	0.04	−0.05	−0.01	0.01	0.01
High cognitive activities	38.6	21.7	0.12*	0.00	−0.01	−0.01	0.05*
Six act most related to O/I	28.6	18.8	0.25*	0.14*	0.10*	0.08*	0.10*
Need for Cognition	63.0	12.7	0.63*	0.33*	0.30*	0.19*	0.14*
Perceived busyness	20.5	5.5	0.04	−0.04	−0.04	0.05	0.01
Perceived routine	13.5	3.3	−0.01	0.11*	0.03	0.05	0.05

Note: High cognitive activities refers to the sum of hours spent engaged in the seven activities with higher ratings of cognitive demands, and six act most related to O/I refers to the six activities with strongest relations to Openness/Intellect.
* $p < 0.01$.

the activities were examined next. The relevant simple correlations (top row) and standardized regression coefficients (remaining rows) are presented in Table 4. Examination of the entries in the table indicates that there was no attenuation of the Openness/Intellect–cognition relations after controlling the time spent engaged in all activities, the time spent in the most cognitively demanding activities, or the time spent in the six activities with highest relations with Openness/Intellect. Furthermore, the estimates of the indirect effects were not significant. The only exception was a slight decrease in the relation of Openness/Intellect to speed ability after controlling for the sum of hours spent engaged in the six activities with strongest relations with Openness/Intellect.

Need for Cognition: Relations between Openness/Intellect, Need for Cognition and cognitive abilities were next examined. As expected, the results in Table 3 indicate that there was a strong positive correlation between Openness/Intellect and Need for Cognition, and that higher levels of Need for Cognition were associated with higher scores on all four cognitive abilities. Moreover, the results in Table 4 indicate that the estimates of the relation between Openness/Intellect and cognitive abilities were significantly reduced after controlling for the variance in Need for Cognition (e.g., the Openness/Intellect–speed relation was reduced by 41.4%, and the Openness/Intellect–Gf relation was reduced by 48.9%), which is consistent with the possibility of mediation.

Because the Openness/Intellect and Need for Cognition constructs are similar in certain respects, we were interested in investigating the overlap between the two constructs in the prediction of the cognitive abilities. Commonality analysis (Pedhazur, 1982) was therefore used to partition the variance in each cognitive abilities into portions uniquely associated with each construct, in addition to a portion shared between the two constructs. There are three noteworthy aspects about these variance proportions, which are reported in Table 5. First, a substantial proportion of the variance in each cognitive composite was shared across the Openness/Intellect and Need for Cognition measures. This shared variance may reflect content overlap of the two constructs. Second, Openness/Intellect was associated with a much larger proportion of unique variance than Need for Cognition in the prediction of Gc, and also to a lesser extent in the prediction of Speed and Memory. The stronger relations for Openness/Intellect are consistent with the possibility that Openness/Intellect represents a broader tendency to acquire knowledge than the Need for Cognition construct. And third, Need for Cognition had a somewhat larger proportion of unique variance for Gf than Openness/Intellect, which suggests that the Need for Cognition disposition may be more closely linked to novel problem solving of the type assessed by Gf than Openness/Intellect.

Table 5
Estimates of proportions of shared and unique variance of Openness/Intellect and Need for Cognition in cognitive abilities.

	Gc	Gf	Memory	Speed
Openness/Intellect	0.116*	0.023*	0.036*	0.012*
Need for Cognition	0.008*	0.040*	0.005	0.006*
Shared	0.036*	0.038*	0.024*	0.012*
Total R^2	0.160*	0.101*	0.065*	0.030*

* $p < 0.01$.

Perceived busyness and routine: The possible mediating role of the indicators of perceived engagement, i.e., perceived busyness and perceived routine, were next examined. The values in the bottom of Table 3 indicate that neither the busyness score nor the routine score was related to Openness/Intellect, and there was also little evidence of relationships between these indicators of perceived engagement and cognitive abilities. As expected from these weak relations, the results in Table 4 indicate that there was little change in the relation between Openness/Intellect and cognitive abilities after controlling the variance in these measures, and there was no evidence from bootstrap analyses of any significant mediated or indirect effect. Furthermore, the pattern of results was similar after controlling for the variance related to several indicators of

Table 4
Standardized relations of Openness/Intellect to composite cognitive measures before (top row) and after (remaining rows) control of each potential mediator. Unstandardized estimates of indirect effects are in parentheses.

	Gc			Gf			Memory			Speed		
	Coef.	(I.E.)	% red.	Coef.	(I.E.)	% red.	Coef.	(I.E.)	% red.	Coef.	(I.E.)	% red.
Alone	0.45*			0.26*			0.23*			0.13*		
After control of:												
All activities	0.45*	(0.0)	−0.4	0.26*	(0.0)	−0.3	0.23*	(0.0)	0.0	0.13*	(0.0)	0.1
High cognitive activities	0.45*	(0.0)	−1.1	0.27*	(0.0)	−1.6	0.23*	(0.0)	1.7	0.13*	(0.0)	2.8
Six act related to O/I	0.44*	(0.0)	1.5	0.26*	(0.0)	2.5	0.22*	(0.0)	2.4	0.12*	(0.002*)	8.9
Need for Cognition	0.40*	(0.007*)	9.6	0.13*	(0.017*)	48.9	0.18*	(0.006*)	20.7	0.08*	(0.008*)	41.4
Busyness	0.45*	(0.0)	−0.3	0.26*	(0.0)	−0.5	0.22*	(0.0)	0.7	0.13*	(0.0)	0.2
Routine	0.45*	(0.0)	0.0	0.26*	(0.0)	0.0	0.23*	(0.0)	0.0	0.13*	(0.0)	0.1

Note: High cognitive activities refers to the sum of hours spent engaged in the seven activities with higher ratings of cognitive demands and six act related to O/I refers to the six activities with strongest relations to Openness/Intellect.
* $p < 0.01$.

actual engagement (i.e., the sum of hours spent engaged in activities, the total number of hours spent engaged in the seven most demanding activities, the total number of hours spent engaged in the six activities with strongest relations to Openness/Intellect and with positive relations to cognitive abilities).

4. Discussion

The purpose of the current project was to investigate why people who describe themselves as more open tend to have higher levels of cognitive functioning. Consistent with many earlier studies, we found moderate positive relations between the personality trait of Openness/Intellect and performance on several types of cognition, including crystallized abilities, fluid abilities, memory and speed.

In accordance with previous reports which suggested relations between Intellect and activities, higher levels of Openness/Intellect were moderately associated with more engagement in certain activities such as writing and reading. However, the relations between activity engagement and performance on the different cognitive abilities were weak. Moreover, there was little evidence that the relations of Openness/Intellect to cognitive abilities were attributable to differential engagement in intellectually stimulating activities because there were only slight reductions of the Openness/Intellect–cognition relations after controlling the variance in activity engagement.

It is possible that stronger relations between Openness/Intellect and activity engagement or between activity engagement and cognitive functioning might have been found with a more comprehensive survey of activities. However, the average time reported for activities in the current project was about 13 h, which leaves little time for other activities if it is assumed that about 8 h was devoted to sleep. It should also be noted that the estimates in the current project appear credible because they were consistent with recent results of the American Time Use Survey (Bureau of Labor Statistics, 2009).

The results with the Need for Cognition measure were complex, likely in part because of substantial content overlap between the Openness/Intellect and Need for Cognition constructs. There was evidence that Need for Cognition statistically mediated some of the Openness/Intellect–cognition relations, and particularly Gf ability. However, the commonality analyses summarized in Table 5 were informative in indicating how the Openness/Intellect and Need for Cognition constructs were distinct. In particular, Openness/Intellect had stronger unique relations on the Gc composite, whereas Need for Cognition had somewhat stronger unique relations on the Gf composite. In line with recent reports (Fleischhauer et al., 2010), these results are consistent with the idea that Need for Cognition may reflect a more specific disposition to seek out for effortful thinking and complex reasoning, in contrast to the broader Openness/Intellect trait which may involve a component related to knowledge acquisition.

We did not find any evidence that perceived busyness or routine scales functioned as mediators of the Openness/Intellect–cognition relations. Despite moderately high reliabilities, the perceived busyness and routine measures had very weak relations with both Openness/Intellect and the cognitive composites.

Contrary to our hypothesis, we found little evidence that greater engagement in cognitively stimulating activities mediates the relations between Openness/Intellect and cognitive functioning. It is important to note that the failure to support the hypothesis was not attributable to a weak test of the hypothesis because the sample was quite large, the variables all had good reliability, and multiple conceptualizations of activity engagement and cognitive functioning were examined. However, the Goldberg's scale used in the current project did not allow us to make any distinction between the two sub-dimensions of Openness and Intellect and one cannot dismiss the possibility that the two dimensions are not equally reflected by this scale.

If, as our results suggest, the Openness/Intellect–cognition relation is not attributable to differential activity engagement, then the question naturally arises as to what is responsible. At least two possibilities should be considered. One is that activity engagement is important, but that people varying in Openness/Intellect differ with respect to the return per unit of time spent in the activity, rather than in the amount of time devoted to the activity. This interpretation might be investigated by determining if the same amount of time spent engaged in a particular activity has the same cognitive impact on people with varying degrees of Openness/Intellect. A second possibility is that the Openness/Intellect–cognition relation is attributable to some other factor related to both Openness/Intellect and cognition, but independent of activity engagement. The challenge in investigating these hypotheses will be in obtaining measures of "cognitive yield" for a given amount of activity time, and specifying the factor that affects Openness/Intellect and cognition without affecting amount of cognitively stimulating activity.

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