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# Linking openness to cognitive ability in older adulthood: The role of activity diversity

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## Abstract

Relatively few studies have examined the reasons older individuals participate in activities that may benefit cognition with aging. Personality traits, particularly, openness to experience, are likely to influence how activities are selected. Openness to experience has also reliably shown to relate to cognitive and intellectual capacities. The current study tested whether diversity in activity helped to explain the overlap between openness to experience and cognitive functioning in an older adult sample (n = 476, mean age: 72.5 years). Results suggest that openness is a better predictor of activity diversity than of time spent engaged in activities or time spent in cognitively challenging activities. Further, activity diversity explained significant variance in the relationship between openness and cognitive ability for most constructs examined. This relationship did not vary with age, but differed as a function of education level, such that participating in a more diverse array of activities was most beneficial for those with less formal education. These results suggest that engagement with a diverse behavioral repertoire in late life may compensate for lack of early life resources.

### Keywords

Personality; Openness; Cognitive ability; Activity; Education

## Introduction

Declines in certain cognitive abilities are normative with aging. An interest in preventing or mitigating these declines has spurred much recent research focused on the possible benefits of adopting an active lifestyle that includes intellectual, physical, and social engagement (Hertzog, Kramer, Wilson & Lindenberger, 2009), all of which are associated with higher levels of cognitive functioning (Hultsch, Hertzog, Small, & Dixon, 1999; James, Wilson,

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Barnes & Bennett, 2011; Jopp & Hertzog, 2007). However, research is needed to identify which older adults are more likely to seek an active lifestyle, and ultimately how these activities play a role in explaining associations between those indicators and cognitive functioning. Given evidence that personality traits influence the behaviors and situations that people seek out (Funder, 2006; Roberts & Jackson, 2008), we investigated how disposition can impact behavior as a pathway to enhancing cognition. One personality trait of particular interest in this regard is openness to experience. Individuals high in openness enjoy aesthetic and intellectually challenging experiences, and seek out novelty in their daily lives (DeYoung, 2014; John, Naumann, & Soto, 2008; McCrae & Sutin, 2009). Thus, individuals high in openness are more likely select into and engage in experiences that are likely to contribute to healthy cognitive aging (Chamorro-Premuzic & Furnham, 2004). In fact, a link between openness and cognitive ability is well-established (e.g., DeYoung et al., 2005; Hultsch et al., 1999; Parisi, Stine-Morrow, Noh, & Morrow, 2009; Schaie et al., 2004), however, the reasons for this relationship are unclear. The focus of the current study was to examine whether the relationship between openness to experience and cognitive ability may be explained by activity engagement.

## The Relationship between Openness and Cognitive Ability

Two explanations for the relationship between openness and cognition have dominated the literature (Ackerman, 2009; Chamorro-Premuzic & Furnham, 2005; DeYoung, 2009). First, openness and cognitive ability may be related because they largely measure the same construct. According to this view, an open disposition and high levels of cognitive ability both index intellectual function. Thus, openness and cognitive ability are not related because potential mediating mechanisms, such as resources available to open individuals that safeguard against declines in cognitive functioning. Consistent with this view is the lack of evidence for openness as a predictor of changes in cognition (Gow, Whiteman, Pattie, & Deary, 2005; Sharp, Reynolds, Pedersen, & Gatz, 2010). In this vein, some theorists suggest that researchers should view openness and intellect as different manifestations of the same construct, and thus focus on identifying and measuring shared psychological and biological substrates (DeYoung et al., 2009).

In contrast, the second explanation for the link between openness and cognitive ability suggests that open individuals seek out intellectually stimulating experiences, which in turn predispose them towards gains (or provide safeguards against declines) in cognitive ability (Ackerman, 1996; Chamorro-Premuzic & Furnham, 2004; Gregory, Nettelbeck, & Wilson, 2010). In other words, habitual selection into novel environments and engagement with cognitively challenging tasks could mitigate declines in cognitive ability by increasing knowledge and the efficiency of cognitive processing (Ackerman, 1996; Chamorro-Premuzic & Furnham, 2004). Consistent with this theory, individuals with higher cognitive ability self-report more frequent engagement in activities involving processing novel information and have a more active lifestyle, characterized as more frequent engagement in physical activity, social activity, and hobbies (Hultsch et al., 1999). Such activities are theoretically related to openness (McCrae & Sutton, 2009).

Following this second hypothesis, one study tested whether behavioral engagement mediates the links between openness and cognitive ability, with a large sample of adults ranging in age from 19 to 86 years (Soubelet & Salthouse, 2010). Specifically, the investigators examined whether the links between openness and cognition, as measured by fluid intelligence, crystallized intelligence, processing speed, and memory, were mediated by the time spent engaging in (1) all activities assessed, (2) only those deemed to be cognitively engaging, or (3) only the activities most highly related to openness. While the study replicated the openness-cognition link, there was no evidence for mediation; in fact, the associations of activity measures with both openness and cognition were quite modest. Therefore, the authors concluded that the relationship between openness and cognitive functioning was not due to activity engagement. In other words, these findings are more consistent with the construct overlap explanation.

## Behavioral Correlates of Openness

The failure to identify behaviors that help explain the openness-cognition link may be due to the way in which activity was (and has been) conceptualized and measured. Few studies have examined what individuals higher on trait openness do in their daily lives. Indeed, a similar claim could be made for most personality traits, as very few studies examine the daily behaviors or activities associated with specific personality traits beyond what is embedded in the questionnaire items (Funder, 2006; Furr, 2009). While an emerging literature is starting to link daily behaviors to specific personality traits, such as with conscientiousness (Jackson et al., 2010) or narcissism (Holtzman, Vazire & Mehl, 2010), of the Big Five traits, openness to experience is the least understood in terms of associated behaviors and activities (DeYoung et al., 2009). The limited research available has focused on intellectually stimulating activities. For example, open individuals are more likely to spend more years in education (Goldberg, et al., 1998) and choose artistic and creative majors and careers (McCrae & Sutin, 2008). Individuals high in openness are also more likely to spend their time engaged in intellectual pursuits, such as reading, writing, and performing crossword puzzles (e.g., Soubelet & Salthouse, 2010). Although these relations are significant, the overall effect size between openness and measures of engagement in specific activities tends to be relatively modest (e.g., $r \sim .15$ at best).

However, an alternative approach is to focus on how openness to experience involves, at its core, a preference for novelty. Earlier approaches focusing on time allocated to specific behaviors (e.g., reading a novel) may be missing a critical piece of the openness-cognition puzzle. Rather, openness may operate by increasing an individual’s overall behavioral repertoire, as measured by a *diversity* of behaviors. For example, though reading a novel or performing a crossword puzzle is associated with openness, any particular activity may not necessarily resonate with everyone. That is, given the numerous ways openness might manifest, it is unlikely that any one behavior would serve as a strong indicator of the trait. Consistent with this Repertoire Hypothesis, individuals high on openness listen to a more diverse array of music and have many different genres of books on their bookshelves (Gosling, Ko, Mannarelli, & Morris, 2002). Accordingly, open individuals may not spend more time on any one task (e.g., reading a novel), relative to individuals lower on openness, because enjoying a wide array of activities may preclude such investment.

A lifestyle rich in many different activities may be favorable to cognitive functioning. For example, the day-to-day management of multiple activities is a nontrivial cognitive exercise in itself, especially in older adulthood. Planning and coordinating a schedule to afford a complex behavioral repertoire can exercise reasoning and memory. A busy life also requires one to be conscious of time so that activities often have to be completed within a certain timeframe, thereby exercising processing speed. Finally, the more activities in which a person engages, the more switching is required among tasks, requiring one to inhibit one task set to activate another. In fact, diversity in activity engagement has been shown to reduce the risk of cognitive impairment in a sample of urban-dwelling older women (Carlson et al., 2011). Collectively, there is good reason to suspect that a diverse behavioral repertoire is associated with both openness and cognitive ability and thus may be a critical mechanism for healthy cognitive aging.

### Current Study

The aim of the current study was to examine the interrelationships between openness, activity engagement, and cognitive functioning, focusing on the benefits of activity diversity. We sought to address four questions in a cross-sectional sample of older adults. First, we examined the specific behaviors associated with openness as a benchmark of comparison with previous research that has shown a small association between activity and cognition (cf. Soubelet & Salthouse, 2010). Second, we sought to add the construct of activity diversity to the discussion of openness, reasoning that repertoire size better captures the behavioral signature of the openness than does the quantity of any particular behavior. Third, we tested the Repertoire Hypothesis, that activity diversity would mediate the openness – cognition relationship. Finally, we examined whether age and education influenced the pathway between openness and cognitive ability. For example, activity engagement might be more beneficial for older and less educated individuals because it is thought to compensate for the lower cognitive functioning found in older and less educated individuals (Lachman, Agrigoroaei, Murphy, & Tun, 2010). Alternatively, it is plausible that activity diversity plays less of a role at older ages, as aging is often found to reduce plasticity – rendering the influence of activity engagement too little, too late (Lövdén, Bäckman, Lindenberger, Schaeffer, & Schmiedek, 2010).

## Method

### Participants

Four hundred seventy-six older adults (73% female) participated in the current study. Participants were recruited from the community to take part in a cognitive intervention (Stine-Morrow et al., 2014), but the current study made use of measures collected at pretest before participants were randomly assigned to a condition. For inclusion, participants had to demonstrate functional cognitive ability and have fewer than 15 hours a week scheduled for standing commitments (e.g., employment, volunteer activities, clubs). Participants ranged in age from 60 to 94 years ($M$ = 72.5, $SD$ = 7.8 years) with an average of 15.0 years of education ($SD$ = 2.7).

## Personality and Activity Measures

**Openness.—**The Big Five personality dimension of openness was measured using 48 items of the IPIP-AB5C openness measure (Goldberg, 1999). These 48 items measure 5 lower-order facets that comprise openness: ingenuity (e.g., Am full of ideas), intellect (e.g., Enjoy thinking about things), quickness (e.g., Catch on to things quickly), creativity (e.g., Ask questions that nobody else does), and competence (e.g., Excel in what I do). Participants rated the items on a five-point scale from strongly disagree (1) to strongly agree (5) (Mean = 3.94, SD = .63). Omega reliabilities were all above .74 in the current sample.

**Activity Questionnaire.—**The Activity Questionnaire consisted of a list of 25 activities (see left column of Table 1). Participants were asked to think about their activities over the last couple of months and to estimate how many hours they engaged in each activity in a typical week. *Activity Diversity* was calculated for each participant as the number of activities for which a nonzero time estimate was provided (mean = 16.8; SD = 3.3; range 8 – 25)[1]. After providing time estimates, participants were given the same list of activities again and asked to rate each one on a 5-point scale of perceived intellectual challenge for any activity on which they reported spending at least some time. Time spent in *cognitively demanding activities* was calculated by taking the top six activities rated as cognitively challenging across the entire sample (working, puzzles, computer, finances, books, hobby) and creating a composite of hours spent performing cognitively challenging activities (Mean = 4.1; SD = 3.0).

## Cognitive Ability Measures

The battery of cognitive measures was administered to participants across two sessions, an individual and group-based testing session, lasting approximately four hours in total. All cognitive ability measures were standardized with a mean of 0 and a SD of 1 before creating composite measures.

**Inductive reasoning.—**Five instruments were used to assess inductive reasoning ($\alpha$ = .90): letter sets, number series, letter series, and word series tasks (Ekstrom et al., 1976), as well as the everyday problem-solving task (Marsiske & Willis, 1995). Collectively, these tasks require participants to identify patterns in a series of items and either generate the next item in the series or decide which item does not adhere to the pattern.

**Divergent thinking.—**Three measures were combined to assess divergent thinking ($\alpha$ = .70): ETS Different Uses, ETS Opposites Test (Ekstrom, French, & Harman, 1976), and the FAS phonemic fluency test (Benton & Hamsher, 1978). These tasks require ideational fluency in generating new exemplars from a stimulus item.

**Processing speed.—**Processing speed ($\alpha$ = .81) was measured with four measures: letter and pattern comparison tests (Salthouse & Babcock, 1991), and the identical pictures and

[1]Calculating activity diversity as the number of activities spent as a proportion of the total number of hours engaged in activities during a week did not significantly change the results of the current study. Given the difficulties in interpreting this proportion we use the straightforward calculation of number of activities performed in a week.

Finding A's tests (Ekstrom et al., 1976). These tasks involve making speeded judgments to simple stimuli.

**Episodic memory.—**Three measures were used to assess verbal episodic memory (α = .64). The composite was made up from the sum of the number of correctly recalled words in the first 3 learning trials of the Hopkins verbal learning test (HVLT; Brandt, 1991; Brandt & Benedict, 2001), the recognition discrimination index (total number of true positives – total number of false positives) from the HVLT, and the number of propositions correctly recalled from a sentence memory task (Stine-Morrow, Milinder, Pullara, & Herman, 2001).

**Visual-spatial processing.—**Two measures were combined to create the visual-spatial processing composite (α = .72): the card rotation and hidden patterns tests (Ekstrom et al., 1976). In these tasks participants identify visual patterns in an array in which spatial rotation and/or visual transformation is required.

**Fluid ability composite.—**Twelve instruments were combined to assess $G_f$ (α = .92). Letter and pattern comparison; letter sets, number series, letter series and word series; everyday problem solving; ETS card rotation, ETS hidden patterns, ETS different uses, and ETS opposites test and the FAS verbal fluency test.

**Crystallized composite.—**Five instruments were combined to assess $G_c$ (α = .90): North American Adult Reading test, ETS Advanced and Extended Range Vocabulary, Exposure to Print, and the Nelson-Denny Reading test.

### Analyses

We conducted a series of correlations, multiple regressions and path models to test our hypotheses. All analyses were conducted in R using the lavaan package (Rosseel, 2012). To test whether correlations were significantly different from one another, correlations were transformed into Fisher z-scores using the psych package (Revelle, 2018). To examine whether indirect effect between openness and cognitive ability was mediated via activity diversity we used bootstrapped mediation tests with 5000 re-samples within lavaan. Effect sizes for indirect effects were calculated by taking the standardized indirect effects and dividing it by the standardized total effects pathway to provide a proportion of possible variance accounted for. Finally, we ran moderated mediation models to test whether age and education changed the indirect pathways (Preacher, Rucker, & Hayes, 2007). Specifically, we examined moderated pathway of activity diversity to cognitive ability (the b path in a standard mediation model). Missing data were handled with Full Information Maximum Likelihood (FIML) to account for missingness. Overall missingness was minimal with less than 2% missingness for all variables.

## Results

### Interrelationships among Openness, Activity, and Cognition

Correlations between openness and hours spent per week performing various activities are presented in Table 1. Openness was moderately associated with time spent in a number of daily activities, such as writing, volunteering, reading magazines, and artistic pursuits (max $r = .18$). As seen in Table 1, the association between daily activities and openness was similar across each of the facets of openness, suggesting that no single aspect of openness is responsible for the association. Overall, the effect sizes were consistent with estimates found in past studies (Soubelet & Salthouse, 2010). To further explore the link between openness and cognitive activity, the six activities participants rated as the most cognitively demanding were combined (working, puzzles, hobbies, computer, finances, and reading books). Openness was related to time spent engaging in these cognitively demanding activities at a level similar to past research ($r = 0.15$, $p < 0.05$, Table 2; Soubelet & Salthouse, 2010). Thus, openness was a relatively modest predictor of time spent both in certain specific activities and in cognitively demanding activities, in line with our predictions. Table 1 also presents correlations between age and time spent in activities; these relationships were negligible.

Table 2 presents the relationships of metrics of activity (activity time, time spent in cognitive demanding activities and activity diversity) with age, openness, and cognitive measures. Notably, the associations between activity measures were minimal, suggesting they assess different constructs. Activity time correlated with both activity diversity and time spent in cognitively demanding activities, $r = .14$ $p < .05$ for each, which were also correlated with each other, $r = .15$, $p < .05$. Consistent with the Repertoire Hypothesis, openness was moderately associated with activity diversity ($r = 0.30$, $p < 0.05$). Indeed, the magnitude of the relationship between openness and activity diversity was significantly higher than that between openness and either total hours of activity ($r = 0.10$; $z = 3.20$, $p < 0.05$) or time spent performing cognitively demanding activities ($r = .15$; $z = 2.42$, $p < 0.05$). Thus, diversity in activity may better reflect what open individuals do in their day-to-day lives compared to measuring time spent in specific types of activities, total hours spent in activities, or time spent in self-defined cognitively engaging activities. Associations with activity diversity were similar across facets of openness, ranging from $r = .18$ for the competence facet, to $r = .23$ for the intellect, ingenuity, and quickness facets, and $r = .21$ for creativity.

Consistent with earlier research (e.g., Hultsch et al., 1999), time spent in activity engagement was weakly predictive of cognitive measures, though this association was most consistent when only cognitively demanding activities were considered. Importantly, the correlations between cognitive ability and activity engagement were uniformly higher when activity was measured as diversity rather than time allocation.

Table 3 provides the correlations between openness and cognition. As expected, openness was associated with all measures of cognitive ability, replicating past research (Schaie et al., 2004). Individuals higher in openness tended to be higher in fluid and crystallized composites, inductive reasoning, divergent thinking, processing speed, memory, and visual-spatial processing.

### Activity as a Mediator of Openness and Cognitive Ability

Total activity time reported did not significantly mediate the relationship between openness and any of our seven indices of cognitive ability, replicating previous findings (Soubelet & Salthouse, 2010). Using the time spent in cognitively demanding activities, however, there were two cases in which activity engagement significantly mediated the openness-cognition link: speed (indirect effect b = 0.04, se = 0.01; proportion of variance explained: .09), and visual spatial ability (indirect effect b = 0.04, se = 0.01; proportion of variance explained: .10). These findings suggest that total time in activity does not explain the openness-cognition link but, rather, that allocating time to cognitively challenging activities may have small, isolated effects.

Results from the bootstrapped mediation tests for activity diversity are presented in Table 4, which reports betas for the direct effect of openness on cognition and the indirect effect through activity diversity. As expected, activity diversity partially mediated the pathway between openness and each measure of fluid ability, with the effect size for indirect effects ranging between 0.13 and 0.40. All of these effect sizes were larger than the isolated indirect effects associated with cognitively demanding activities. At the same time, a significant direct effect of openness remained for all cognitive outcomes, even after accounting for activity diversity. Note, however, that even though the crystallized composite was related to both activity diversity (Table 2) and openness (Table 3), the openness-crystallized ability link could not be explained by activity engagement. Overall, these findings suggest that participating in a diverse array of behaviors may partially be responsible for the association between openness and fluid cognitive ability in older adulthood.

## Who Benefits from a Diverse Behavioral Repertoire?

Given that aging is often found to reduce plasticity (Lövdén, Bäckman, Lindenberger, Schaeffer, & Schmiedek, 2010), it was plausible that activity diversity would play less of a role in mediating the openness-cognition relationship with age. Consequently, age was examined as a potential moderator of the mediation of activity on openness and cognitive ability for all the significant indirect effects reported above. We found no evidence for such moderated mediation. Age did not significantly moderate the effect of openness on speed and visual-spatial ability when mediated by cognitive demanding activities. Similarly, age did not significantly moderate the indirect effect through activity diversity for any of the cognitive ability measures. For example, when fluid ability was the outcome, there was a significant indirect effect for individuals 1 standard deviation below the mean on age, around age 65 ($b = 0.05$, se = 0.02) and a significant indirect effect for individuals who were 1 standard deviation above the mean, around age 80 ($b = 0.06$, se = 0.02). These findings suggest that activity diversity plays the same role at different ages and that its effects may be less constrained by the age-related limitations on plasticity often demonstrated in cognitive training studies.

Given recent findings that activity can serve a compensatory function in cognitive enhancement for those with lower levels of education (Lachman et al., 2010; Stine-Morrow et al., 2014), educational attainment was examined as a moderator of the mediation. Years of education did not significantly moderate any indirect path when cognitively demanding activities served as the mediator. A different story emerged when activity diversity was the mediator: years of education moderated every indirect effect except for the crystallized composite. To illustrate, Table 5 provides the indirect effects for individuals who completed college and for those that only completed high school (corresponding to roughly 1 *SD* above and 1 *SD* below average education level). Across these cognitive ability measures, the indirect path was stronger for individuals who only completed high school (12 years of education) compared to those that completed college (16 years of education). For example, activity diversity only mediated the association between openness and fluid ability (b = 0.11, se = 0.05) among individuals with a high school education, but not for those with a college education (b = 0.01, se = 0.02). Overall, it appears that activity diversity has a stronger effect on cognition among those with lower levels of formal education and, in turn, serves as a better mediator of the openness-cognition link.

## Discussion

The current study contributes to our understanding of the relationship between openness and cognitive ability through a close examination of activity engagement. First, we sought to capture what people high in openness do in their day-to-day lives by using the concept of behavioral diversity, which proved a strong correlate of both openness and cognitive ability. Second, we found that activity diversity helped explain the relationship between openness and cognitive ability, which is consistent with the Repertoire Hypothesis that one advantage an open disposition confers on cognition is a disposition toward engagement in a broad selection of activities in daily life. Moreover, the benefit of activity diversity was strongest for individuals with fewer years of education. Together, these findings suggest a process-oriented relationship between openness and cognitive ability in older adulthood.

### Openness and Activity Diversity

Previous studies examining the outcomes and experiences associated with openness often involved younger adults. Testing these relationships in older adulthood provides novel insights insofar that, as in the current sample, older adults are often retired, and thus have free range on the type of activities they can perform throughout the day. Given our recruitment, we also had an advantage in having data from the low range of activity. Older adults who volunteer for research tend to be active so that typical samples may underestimate the range of activity level (and diversity). It is worth noting that the correlations between openness and frequency of any specific activity were relatively modest in magnitude, similar to past studies (Hogan et al., 2012; Soubelet & Salthouse, 2010; Stephan et al., 2014). Such modest correlations suggest the difficulty inherent in identifying specific behaviors related to openness. These findings indicate that activity diversity may be a better marker of the daily lives of open individuals than hours spent in specific activities.

A number of important consequences arise from the finding that openness is closely related to activity diversity. For instance, our study lends credence to the argument that openness remains perhaps the most difficult Big Five trait to define, given that individuals high in openness perform many different activities and thus tend to spend less time in any specific activity. Instead of focusing on specific activities when assessing openness (e.g., “enjoy discussing literature”; Goldberg, 1999), it may be beneficial to also assess the desire for new experiences or past reports of a multitude of experiences. To our knowledge no broad assessment of openness currently employs this approach. Moreover, given associations between openness and important outcomes such as divorce (Roberts et al., 2007; Solomon &

Jackson, 2014) and health (e.g., Jackson et al., 2014; Turiano et al., 2012; Weston, Hill & Jackson, 2014), research into understanding the processes involved might benefit from utilizing the construct of activity diversity. Compared to the traits of neuroticism and conscientiousness – which have well identified physiological and behavior pathways connecting the trait with life outcomes (e.g., Hill & Roberts, 2011) – the pathway for openness is mostly unknown.

### Activity Diversity and the Association with Openness and Cognitive Ability

Past studies examining the association between activity engagement and cognitive functioning (Aschwanden, Luchetti, & Allemand, 2018; Hogan et al., 2012; Soubelet & Salthouse, 2010), or between activity engagement and changes in cognitive ability (Bielak, Anstey, Christensen, & Windsor, 2012), do not always find that activity engagement plays a role in healthy cognitive aging. The current study suggests that one reason for these non-significant findings is the way in which activity engagement is operationalized and measured. That is, we raise the question of what aspects of activity engagement are psychologically important and what are the best ways to meaningfully assess this construct? Time spent in certain activities might not be meaningful in capturing the beneficial aspects of activity engagement. Detecting the link between activity engagement and successful aging may require different approaches to how we conceptualize and operationalize activity engagement (Bielak, 2010; 2019; Carlson et al., 2011; Stephan et al., 2014). Currently the standard practice is to self-report frequency on an ordinal scale or to add up hours within a certain time frame or only examine activities that are a priori deemed cognitively engaging. Given our results, the more macro-level profile of the repertoire of activities may be profitably considered.

Interestingly, activity diversity mediated the openness-cognition link for fluid abilities but not for crystallized ability. This finding is somewhat counterintuitive because openness is more strongly related with verbal processes and crystallized measures of intelligence during younger adulthood (Ackerman & Heggestad, 1997; Ashton et al., 2000; DeYoung et al., 2005). This overlap has led to the hypothesis that the association between openness and cognitive ability occurs because openness is associated with a motivation to learn (Chamorro-Premuzic & Furnham, 2005). One way of interpreting the present findings within the context of this hypothesis is that activities may play a dual role depending on the stage in the lifespan. Earlier in adulthood, open individuals are more likely to engage in activities that engender growth in knowledge and crystallized ability (which is relatively well preserved with aging), whereas in older adulthood, a diverse activity repertoire is easier to accomplish because of fewer time commitments. Another interpretation of our results concerns age trajectories in cognitive ability. If activity engagement serves to mitigate declines in cognitive abilities (e.g., Crowe et al., 2003; Schooler & Mulatu, 2001), then engagement should be better associated with fluid abilities given that crystallized abilities show far less decline in older adulthood than do fluid abilities. That is, the biggest benefits of engagement would likely come with respect to those cognitive abilities most subject to decline in adulthood.

One important question is what the mechanisms are through which a diverse repertoire of activities would be likely to impact cognitive ability. First, there is considerable evidence from the training literature that experience affects cognitive ability in very specific ways (Ball et al., 2002; Stine-Morrow & Basak, 2011; Willis et al., 2006), such that a lifestyle marked by a diverse array of activities may be more likely to provide practice with a wider range of experiences that can impact cognition.

Another account, as alluded to in the introduction, is that a life filled with many different activities requires some management. In laboratory paradigms, older adults often show deficits in global task-switching, task coordination, and certain aspects of executive control (Braver & West, 2008; Verhaeghen, 2011). Seeing as open individuals take part in a greater variety of activities, they must hold varied goals and subgoals in mind and update the goal structure in response to what has been accomplished, as well as to environmental demands such as calendar changes. Individuals with more activities are also more like to find themselves actively switching between different task sets. Thus, a diverse behavioral repertoire may enhance cognition not only because it affords practice with a wider array of cognitive skills in different contexts, but also because the habit of switching between activities may help sustain executive control functions in older adulthood.

Our results suggest that the cognitive benefits of activity diversity were strongest for individuals with lower levels of educational attainment. Poor educational attainment is a major risk factor for cognitive declines with aging, as well as age-related cognitive pathology (Andel et al., 2006; Livingston et al., 2017). Higher levels of education – and the enriched socioeconomic experiences that go along with higher levels of education – are thought to be protective against age-related deficits because of “cognitive reserve” (Stern, 2002, 2012; Tucker-Drob et al., 2009). The cognitive reserve hypothesis suggests that diversity in activity may not be particularly beneficial for individuals with high levels of educational attainment because they already possess a cognitive reserve. On the other hand, our results suggest that those with lower levels of education may be able to overcome the lack of a cognitive reserve by participating in a diverse array of activities. This pattern is consistent with a previous study where frequent cognitive activity compensated for the disadvantages that lower levels of education confer (Lachman et al., 2010).

## Limitations and Conclusion

Despite the strengths of the study, there were nonetheless limitations that must be taken into consideration. First, the design was cross-sectional, which limits the ability to isolate the direction of causation (Hofer & Sliwinski, 2003; Lindenberger et al., 2011). The interrelationships among openness, activity diversity and cognitive ability are likely more complex than the pathway tested. For example, it may be that relationships are bidirectional such that high cognitive functioning allows one to engage in a greater number of activities (Salthouse, 2006), which in turn could influence levels of openness (Jackson et al., 2012). While the causal direction of the relationship between activities and cognitive functioning is not fully clear (Hertzog et al., 2009), our findings were consistent with the idea that a key component in the relationship between openness and cognitive ability is activity engagement (von Strum, Chamorro-Premuzic & Ackerman, 2011).

Second, activity engagement was self-reported and may be subject to certain memory biases or differences in interpretation across groups. Future research would benefit from informant reports of both activities and openness. Third, our inclusion criteria resulted in a sample of older adults who were relatively inactive in terms of not having jobs or major volunteering commitments. Whether or not these findings extend to working older adults or younger adults needs to be followed up in future work. Fourth, there are likely other characteristics related to activity diversity beyond openness. We also examined other Big Five measures and found that extraversion was the only other personality trait associated with activity diversity (though at lower levels than openness). However, extraversion was only weakly and not significantly associated with cognitive ability measures, suggesting that the link between activity diversity and cognitive ability is uniquely through openness to experience[2].

The current findings provide a valuable step forward in not only our conceptualization of the behavioral signature of openness, but also in underlining potential processes that link openness to cognitive functioning in older adulthood. Diversity in activity was more strongly associated with openness and cognitive ability than time spent in cognitively engaging activities. These results are in accordance with the Repertoire Hypothesis such that one advantage an open disposition confers on cognition is a disposition toward engagement in a variety of activities in daily life.

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## References

Ackerman PL (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. Intelligence, 22, 229–259.

Ackerman PL (2009). Personality and intelligence In Corr PJ & Matthews G (Eds.), The Cambridge handbook of personality psychology (pp. 162–174). New York: Cambridge University Press.

Ackerman PL, & Rolfhus EL (1999). The locus of adult intelligence: Knowledge, abilities, and nonability traits. Psychology and Aging, 14, 314–330. [PubMed: 10403718]

Andel R, Vigen C, Mack WJ, Clark L, & Gatz M (2006). The effect of education and occupational complexity on rate of cognitive decline in Alzheimer's patients. Journal of the International Neuropsychological Society, 12, 147–152. [PubMed: 16433954]

Ashton MC, Lee K, Vernon PA, & Jang KL (2000). Fluid intelligence, crystallized intelligence, and the openness/intellect factor. Journal of Research in Personality, 34, 198–207.

Aschwanden D, Luchetti M, & Allemand M (2018). Are open and neurotic behaviors related to cognitive behaviors in daily life of older adults? Journal of Personality. 10.1111/jopy.12409

Ball K, Berch DB, Helmers KF, Jobe JB, Leveck MD, Marsiske M, … Willis SL (2002). Effects of cognitive training interventions with older adults. Journal of the American Medical Association, 288, 2271–2281. [PubMed: 12425704]

Benton AL, & Hamsher K de S (1976). Multilingual Aphasia Examination Manual. Iowa City, IA: University of Iowa.

Bielak AAM (2010). How can we not 'lose it' if we still don't understand how to 'use it'? Unanswered questions about the influence of activity participation on cognitive performance in older age: A mini-review. Gerontology, 56, 507–519. [PubMed: 19996570]

[2]Please see for https://osf.io/xe9c4/ for these analyses and additional analyses including facets of openness.

Bielak AAM, Anstey KJ, Christensen H, & Windsor TD (2012). Activity engagement is related to level, but not change in cognitive ability across adulthood. Psychology and Aging, 27, 219–228. doi:10.1037/a0024667 [PubMed: 21806303]

Brandt J (1991). The Hopkins Verbal Learning Test: Development of a new memory test with six equivalent forms. Clinical Neuropsychologist, 5, 125–142.

Brandt J, & Benedict RHB (2001). Hopkins Verbal Learning Test—revised. Professional manual. Lutz, FL: Psychological Assessment Resources, Inc.

Braver TS, & West R (2008). Working memory, executive control, and aging In Craik FIM & Salthouse TA (Eds.), Handbook of aging and cognition (Third edition ed., pp. 311–372). New York: Psychology Press.

Buschkuehl M, & Jaeggi SM (2010). Improving intelligence: A literature review. Swiss Medical Weekly, 140, 266–272. [PubMed: 20349365]

Buss D, & Craik K (1983). The act frequency approach to personality. Psychological Review, 90(2), 105–126.

Carlson MC, Parisi JM, Xia J, Xue Q-L, Rebok GW, Bandeen-Roche K, & Fried LP (2011). Lifestyle activities and memory: Variety may be the spice of life: The Women's Health and Aging Study II. Journal of the International Neuropsychological Society, 18, 1–9. [PubMed: 22152338]

Chamorro-Premuzic T, & Furnham A (2004). A possible model for understanding the personality--intelligence interface. British Journal of Psychology, 95, 249–64. doi:10.1348/000712604773952458 [PubMed: 15142305]

Chamorro-Premuzic T, & Furnham A (2005). The relationship between personality traits, subjectively-assessed and fluid intelligence. Personality and Individual Differences, 38, 1517–1528.

Crowe M, Andel R, Pedersen NL, Johansson B, & Gatz M (2003). Does participation in leisure activities lead to reduced risk of Alzheimer's disease? A prospective study of Swedish twins. Journals of Gerontology: Psychological Sciences, 58B, 249–255.

DeYoung CG (2014). Openness/Intellect: A dimension of personality reflecting cognitive exploration In Larsen RJ & Cooper ML (Eds.), The APA Handbook of Personality and Social Psychology, Volume 3: Personality Processes and Individual Differences, 369–399.

DeYoung CG, Peterson JB, & Higgins DM (2005). Sources of Openness/Intellect: Cognitive and neuropsychological correlates of the fifth factor of personality. Journal of Personality, 73, 825–858. [PubMed: 15958136]

DeYoung CG, Shamosh NA, Green AE, Braver TS, & Gray JR (2009). Intellect as distinct from Openness: Differences revealed by fMRI of working memory. Journal of Personality and Social Psychology, 97, 883–892. [PubMed: 19857008]

Ekstrom RB, French JW, & Harman HH (1976). Manual for the kit of factor-referenced cognitive tests. Princeton, NJ: Educational Testing Service.

Funder DC (2006). Towards a resolution of the personality triad: Persons, situations, and behaviors. Journal of Research in Personality, 40(1), 21–34. doi:10.1016/j.jrp.2005.08.003

Furr RM (2009). The study of behavior in personality psychology: Meaning, importance, and measurement. European Journal of Personality, 23, 437–453.

Goldberg LR, Sweeney D, Merenda PF, & Hughes JE Jr. (1998). Demographic variables and personality: The effects of gender, age, education, and ethnic/racial status on self-descriptions of personality attributes. Personality and Individual Differences, 24, 393–403.

Gosling SD, Ko SJ, Mannarelli T, & Morris ME (2002). A room with a cue: Personality judgments based on offices and bedrooms. Journal of Personality and Social Psychology, 82(3), 379–398. doi:10.1037//0022-3514.82.3.379 [PubMed: 11902623]

Hertzog C, Kramer AF, Wilson RS, & Lindenberger U (2009). Enrichment effects on adult cognitive development: Can the functional capacity of older adults be persevered and enhanced? Psychological Science in the Public Interest, 9, 1–65.

Hofer SM, & Sliwinski MJ (2001). Understanding ageing. Gerontology, 47, 341–352. [PubMed: 11721149]

Hogan MJ, Staff RT, Bunting BP, Deary IJ, & Whalley LJ (2012). Openness to experience and activity engagement facilitate the maintenance of verbal ablity in older adults. Psychology and Aging, 27, 849–854. [PubMed: 22708538]

Holtzman NS, Vazire S, & Mehl MR (2010). Sounds like a Narcissist: Behavioral Manifestations of Narcissism in Everyday Life. Journal of Research in Personality, 44(4), 478–484. doi:10.1016/j.jrp.2010.06.001 [PubMed: 20711512]

Hultsch DF, Hertzog C, Small BJ, & Dixon R. a. (1999). Use it or lose it: engaged lifestyle as a buffer of cognitive decline in aging? Psychology and Aging, 14, 245–63. [PubMed: 10403712]

Gow AJ, Corley J, Starr JM, & Deary IJ (2012). Reverse causation in activity-cognitive ability associations: the Lothian Birth Cohort 1936. Psychology and Aging, 27(1), 250–255. doi:10.1037/a0024144 [PubMed: 21644808]

Gow AJ, Whiteman MC, Pattie A, & Deary IJ (2005). The personality–intelligence interface: Insights from an ageing cohort. Personality and Individual Differences, 39, 751–761.

Goldberg LR (1999). A broad-bandwidth, public-domain, personality inventory measuring the lower-level facets of several five-factor models In Mervielde I, Deary I, De Fruyt F, & Ostendorf F (Eds.), Personality psychology in Europe, Vol. 7 (pp. 7–28). Tilburg, The Netherlands: Tilburg University Press.

Gregory T, Nettelbeck T, & Wilson C (2010). Openness to experience, intelligence, and successful ageing. Personality and Individual Differences, 48(8), 895–899. doi:10.1016/j.paid.2010.02.017

James BD, Wilson RS, Barnes LL, & Bennett D. a. (2011). Late-life social activity and cognitive decline in old age. Journal of the International Neuropsychological Society: JINS, 17, 998–1005. doi:10.1017/S1355617711000531 [PubMed: 22040898]

Jackson JJ Connolly JJ, Garrison SM, Leveille MM, & Connolly SL (2015). Your friends know how long you will live: A 75-year study of peer-rated personality traits. Psychological Science, 26, 335–340. [PubMed: 25583945]

Jackson JJ, Hill PL, Roberts BW, Payne BR, & Stine-Morrow EAL (2012). Can an old dog learn (and prefer to experience) new tricks? Cognitive training increases openness to experience in older adults. Psychology and Aging, 27, 286–292. [PubMed: 22251379]

Jackson JJ, Wood D, Bogg T, Walton K, Harms P & Roberts BW (2010). What do conscientious people do? Development and validation of the behavioral indicators of conscientiousness scale (BICS). Journal of Research in Personality, 44, 501–511 [PubMed: 21278818]

John OP, Naumann L, & Soto CJ (2008). Paradigm shift to the integrative Big Five trait taxonomy: History, measurement, and conceptual issues In John OP, Robins RW, & Pervin LA (Eds.), Handbook of personality: Theory and research (3rd ed., pp. 114–158). New York, NY: Guilford

Jopp D, & Hertzog C (2007). Activities, self-referent memory beliefs, and cognitive performance: evidence for direct and mediated relations. Psychology and Aging, 22(4), 811–825. doi:10.1037/0882-7974.22.4.811 [PubMed: 18179299]

Lachman ME, Agrigoroaei S, Murphy C, & Tun PA (2010): Frequent cognitive activity compensates for education differences in episodic memory. American Journal of Geriatric Psychiatry, 18, 4–10. [PubMed: 20094014]

Livingston G, Sommerlad A, Orgeta V, Costafreda SG, Huntley J, Ames D, & Cooper CM (2017). Dementia prevention, intervention, and care. The Lancet, 390, 2673–2734.

Lindenberger U, Von Oertzen T, Ghisletta P, & Hertzog C (2011). Cross-sectional age variance extraction: What's change got to do with it? Psychology and Aging, 26, 34–47. [PubMed: 21417539]

Lövdén M, Bäckman L, Lindenberger U, Schaeffer S, & Schmiedek F (2010). A theoretical framework for the study of adult cognitive plasticty. Psychological Bulletin, 136, 659–676. [PubMed: 20565172]

Marsiske M, & Willis SL (1995). Dimensionality of everyday problem solving in older adults. Psychology and Aging, 10, 269–283. [PubMed: 7662186]

McCrae RR (1993). Openness to Experience as a basic dimension of personality. Imagination, Cognition, and Personality, 13, 39–55.

McCrae RR, & Sutin AR (2009). Openness to experience In Leary MR & Hoyle RH (Eds.), Handbook of individual differences in social behavior (pp. 257–273). New York: Guilford.

Parisi JM, Stine-Morrow EAL, Noh SR, & Morrow DG (2009). Predispositional engagement, activity engagement, and cognition among older adults. Neuropsychology, Development, and Cognition, 16, 485–504. doi:10.1080/13825580902866653

Payne BR, Jackson JJ, Noh SR, & Stine-Morrow EAL (2011). In the zone: Flow state and cognition in older adults. Psychology and Aging, 26, 738–743. [PubMed: 21443348]

Preacher KJ, Rucker DD, & Hayes AF (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. Multivariate Behavioral Research, 42, 185–227. [PubMed: 26821081]

Revelle W (2018) psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, USA, https://CRAN.R-project.org/package=psych

Roberts BW, & Jackson JJ (2008). Sociogenomic personality psychology. Journal of Personality, 76, 1523–1544. [PubMed: 19012657]

Rosseel Y (2012). lavaan: An R Package for Structural Equation Modeling. Journal of Statistical Software, 48(2), 1–36.

Salthouse T (2006). Mental exercise and mental aging evaluating the validity of the "Use It or Lose It" hypothesis. Perspectives on Psychological Science, 1, 68–87. [PubMed: 26151186]

Salthouse TA, & Babcock RL (1991). Decomposing adult age differences in working memory. Developmental Psychology, 27, 763–776. doi:10.1037/0012-1649.27.5.763

Schaie K, Willis S, & Caskie G (2004). The Seattle Longitudinal Study: Relationship between personality and cognition. Aging, Neuropsychology, and Cognition, 11, 304–324.

Schooler C, & Mulatu SM (2001). The reciprocal effects of leisure time activities and intellectual functioning in older people: A longitudinal analysis. Psychology and Aging, 16, 466–482. [PubMed: 11554524]

Sharp ES, Reynolds CA, Pedersen NL, & Gatz M (2010). Cognitive engagement and cognitive aging: Is openness protective? Psychology and Aging, 25(1), 60–73. doi:10.1037/a0018748 [PubMed: 20230128]

Soubelet A, & Salthouse T (2010). The role of activity engagement in the relations between Openness/ Intellect and cognition. Personality and Individual Differences, 49(8), 896–901. doi:10.1016/ j.paid.2010.07.026 [PubMed: 21057659]

Soubelet A, & Salthouse T (2011). Personality-cognition relations across adulthood. Developmental Psychology, 47(2), 303–10. doi:10.1037/a0021816 [PubMed: 21142358]

Stephan Y, Boiché J, Canada B, & Terracciano A (2014). Association of personality with physical, social, and mental activities across the lifespan: Findings from US and French samples. British Journal of Psychology, 105, 564–580. 10.1111/bjop.12056 [PubMed: 24182200]

Stern Y (2002). What is cognitive reserve? Theory and research application of the reserve concept. Journal of the International Neuropsychological Society, 8, 448–460. [PubMed: 11939702]

Stern Y (2012). Cognitive reserve in ageing and Alzheimer's disease. The Lancet: Neurology, 11, 1006–1012. [PubMed: 23079557]

Stine-Morrow EAL, & Basak C (2011). Cognitive interventions In Schaie KW & Willis SL (Eds.), Handbook of the psychology of aging (7th ed., pp. 153–170). New York: Elsevier.

Stine-Morrow EAL, Milinder L, Pullara O, & Herman B (2001). Patterns of resource allocation in reading are reliable among younger and older readers. Psychology and Aging, 16, 69–84. [PubMed: 11302369]

Stine-Morrow EAL, Payne BR, Gao X, Roberts B, Kramer AF, Morrow DG, … Parisi JM (2014). Training versus engagement as paths to cognitive optimization with aging. Psychology and Aging, 29, 891–906. [PubMed: 25402337]

Tucker-Drob EM, Johnson KE, & Jones RN (2009). The cognitive reserve hypothesis: A longitudinal examination of age-associated declines in reasoning and processing speed. Developmental Psychology, 45, 431–446. doi:10.1037/a0014012 [PubMed: 19271829]

Turiano N, Spiro A, & Mroczek DK (2012). Openness to experience and mortality in men: Analysis of trait and facets. Journal of Aging and Health, 24, 654–672. [PubMed: 22219209]

Verhaeghen P (2011). Aging and executive control: Reports of a demise greatly exaggerated. Current Directions in Psychological Science, 20, 174–180. [PubMed: 25866452]

von Stumm S, Chamorro-Premuzic T, & Ackerman PL (2011). Re-visiting intelligence–personality associations: Vindicating intellectual investment In Chamorro-Premuzic T, von Stumm S, & Furnham A (Eds.), The Wiley-Blackwell handbook of individual differences. London: Blackwell.

Weston S, Hill PL & Jackson JJ (2015). Personality traits predict the onset of major disease. Social Psychological and Personality Science, 3, 309–317.

Willis SL, Tennstedt SL, Marsiske M, Ball K, Elias J, Koepke KM, … Wright E (2006). Long-term effects of cognitive training on everyday functional outcomes in older adults. Journal of the American Medical Association, 296, 2805–2814. [PubMed: 17179457]

Ziegler M, Danay E, Heene M, Asendorpf J, & Bühner M, , (2012). Openness, fluid intelligence, and crystallized intelligence: Toward an integrative model. Journal of Research in Personality, 46, 173–183.

**Table 1.**

Correlations of Activity Hours with Age and Openness

| | | | Openness Facets | | | | |
|---|---|---|---|---|---|---|---|
| **Activity** | **Age** | **Openness Total** | **Intellect** | **Ingenuity** | **Competence** | **Quickness** | **Creativity** |
| Commute | **−.11** | −.07 | **−.10** | .00 | −.09 | −.07 | −.05 |
| Work | −.07 | .08 | .05 | .08 | .07 | .06 | **.10** |
| Shop | **−.10** | .01 | .02 | .04 | −.05 | .02 | −.02 |
| Housework | −.04 | −.09 | −.06 | −.07 | −.09 | −.06 | **−.12** |
| Meals | −.03 | −.01 | .03 | .00 | −.02 | −.01 | −.04 |
| Nap | −.00 | .00 | .02 | .01 | −.01 | −.04 | .00 |
| Social | −.06 | .06 | .03 | **.10** | .02 | .08 | .04 |
| Computer | −.19 | **.11** | .09 | **.10** | .07 | **.14** | **.10** |
| Writing | −.09 | **.13** | **.13** | **.12** | .05 | **.12** | **.14** |
| Exercise | .05 | **.11** | **.11** | **.10** | .07 | **.10** | .08 |
| Volunteer | .02 | **.13** | **.11** | **.13** | **.11** | **.12** | **.09** |
| Clubs | −.05 | **.16** | **.10** | **.21** | **.12** | **.14** | **.13** |
| Pray | −.04 | **−.10** | **−.10** | −.04 | −.08 | −.09 | **−.11** |
| Books | −.04 | **.09** | **.14** | .05 | −.01 | **.10** | **.09** |
| Magazine | **.13** | **.12** | **.11** | **.13** | .02 | **.13** | **.11** |
| Newspaper | **.18** | .06 | .07 | .03 | .06 | .05 | .04 |
| TV | −.05 | −.07 | −.05 | −.07 | −.02 | −.08 | −.06 |
| Finances | .00 | .08 | .06 | .09 | .07 | .06 | .07 |
| Lectures | −.05 | **.16** | **.11** | **.18** | **.09** | **.13** | **.17** |
| Artistic | −.02 | **.18** | **.16** | **.18** | **.12** | **.15** | **.17** |
| Hobby | −.02 | .03 | −.01 | .05 | .07 | .03 | −.01 |
| Puzzle | −.04 | .04 | .07 | .03 | .01 | .04 | .01 |
| Card games | −.03 | .03 | .01 | .03 | .03 | .03 | .03 |
| Board games | −.03 | .02 | .03 | .01 | .01 | .03 | .00 |
| Other | .04 | .04 | .03 | .05 | .06 | .01 | .01 |

*Note*. N = 470; All bold numbers are statistically significant at $p < 0.05$

**Table 2.**

Correlations of Activity Measures with Openness and Cognitive Ability Composites

| Activity | Openness | $G_f$ | $G_c$ | Inductive reasoning | Divergent thinking | Speed | Memory | Visual Spatial | Age | Education |
|---|---|---|---|---|---|---|---|---|---|---|
| Total time | **.10** | .06 | .00 | .02 | .05 | **.10** | .05 | .04 | **−.09** | **.09** |
| Time in cognitively demanding activities | **.15** | **.15** | **.15** | **.11** | **.17** | **.17** | **.14** | **.14** | **−.15** | **.10** |
| Diversity in activity | **.30** | **.23** | **.17** | **.24** | **.25** | **.26** | **.21** | **.16** | **−.09** | **.21** |

*Note*. N = 470. All bold numbers are statistically significant at $p < 0.05$.

**Table 3.**

Correlations of Cognitive Composites with Openness, Education, and Age

| | **Openness** | **Intellect** | **Ingenuity** | **Competence** | **Quickness** | **Creativity** | **Education** | **Age** |
|---|---|---|---|---|---|---|---|---|
| $G_f$ | **0.31** | **.27** | .05 | .08 | **.14** | **.19** | **0.32** | **−.39** |
| Inductive reasoning | **0.25** | **.24** | .07 | .10 | **.15** | **.18** | **0.37** | **−.38** |
| Divergent thinking | **0.38** | **.43** | **.24** | **.16** | **.22** | **.34** | **0.44** | **−.25** |
| Speed | **0.22** | **.23** | **.16** | **.14** | **.19** | **.17** | **0.27** | **−.36** |
| Memory | **0.24** | **.50** | .13 | .05 | **.21** | **.32** | **0.48** | **−.36** |
| Visual Spatial | **0.18** | **.43** | **.24** | **.16** | **.22** | **.34** | **0.44** | **−.33** |
| $G_c$ | **0.39** | **.35** | .03 | .03 | **.17** | **.19** | **0.22** | .02 |

*Note*. N = 470. All bold numbers are statistically significant at $p < 0.05$.

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**Table 4.**

Parameter Estimates for Models of Activity Diversity Mediating the Effect of Openness on Cognitive Composites

| | Direct | Indirect | 95% CI | Effect Size |
|---|---|---|---|---|
| $G_f$ | **.33 (.06)** | **.06 (.02)** | [.02, .09] | .17 |
| $G_c$ | **.61 (.08)** | .02 (.02) | [−.02, .07] | .04 |
| Inductive reasoning | **.30 (.07)** | **.08 (.02)** | [.04, .13] | .28 |
| Divergent thinking | **.52 (.07)** | **.07 (.03)** | [.02, .12] | .13 |
| Speed | **.22 (.07)** | **.09 (.02)** | [.05, .13] | .40 |
| Memory | **.27 (.07)** | **.06 (.02)** | [.02, .11] | .23 |
| Visual Spatial | **.25 (.08)** | **.04 (.02)** | [.00, .09] | .17 |

*Note*. N = 470. All bold numbers are statistically significant at $p < 0.05$. CI reflects the confidence interval for the indirect effect. Effect size estimates are the proportion of variance accounted for by the mediator.

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**Table 5.**

Indirect Effect of Diversity Mediating the Effect of Openness on Cognitive Abilities at Different Levels of Educational Attainment

| Education | $G_f$ | $G_c$ | Inductive reasoning | Divergent thinking | Speed | Memory | Visual Spatial |
|---|---|---|---|---|---|---|---|
| High school | **.11 (.05)** | .01 (.03) | **.08 (.04)** | **.11 (.04)** | **.15 (.04)** | **.08 (.04)** | **.05 (.03)** |
| College | .01 (.02) | −.01 (.02) | **.04 (.02)** | .02 (.02) | **.04 (.02)** | .03 (.02) | .01 (.02) |

*Note*. N = 470. All bold numbers are statistically significant at $p < 0.05$.