Does Intraindividual Variability in Cognition Mediate the Relationship between Socioeconomic Status and Academic Achievement?

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Abstract

Individuals from lower SES backgrounds tend to perform relatively poorly on markers of academic achievement. Mechanisms underlying this influence are, at least in part, neurologically based: Associations between SES and brain development are present in utero, and persist throughout childhood and adolescence. Recently, numerous studies have described associations between intraindividual variability (IIV; fluctuations in the performance of an individual on a single measure administered over multiple occasions) and the presence and severity of brain-based disorders, such as multiple sclerosis and dementia. Individuals with higher IIV across measurement occasions tend to experience more functional difficulties. However, no study has investigated whether the relationship between SES and academic achievement might be mediated by IIV in cognitive performance. This pilot study (N = 7) laid the groundwork for a larger investigation of that question. I recruited undergraduate students, gathered data on their familial SES and recent academic achievement, and tested their cognitive performance on three occasions spread over 3 weeks. SES and academic achievement were significantly positively correlated, r = .81, p = .013, but hierarchical regression analyses detected no significant mediating effects of IIV in reaction time or working memory. Despite this negative result, this pilot study can be considered a success: It gave insight into the shortcomings of SES measures in undergraduates, and into the problems inherent in retaining participants in an extended IIV paradigm. Furthermore, the presence of some promising correlational trends in the data, trends consistent with findings from other studies, suggest there might be value in a larger investigation of the relationship between SES, academic achievement, and IIV in cognitive performance.

Keywords: academic achievement; cognition; intraindividual variability; reaction time; socioeconomic status; working memory.

Does Intraindividual Variability in Cognition Mediate the Relationship between Socioeconomic Status and Academic Achievement?

Socioeconomic status (SES) is defined as an individual's "access to financial, social, cultural, and human capital resources" (Cowan et al., 2012, p. 4). Research spanning over at least nine decades suggests that SES is inversely related to cognitive performance, and to academic achievement. Although these bivariate relationships are well-established, in general the literature in this field has not considered whether a multivariate relationship, involving intraindividual variability (IIV) in cognitive performance, might exist. That is, could IIV in cognitive performance (that is, variability in the performance of an individual on a particular cognitive measure that is administered on several different occasions) mediate the relationship between SES and academic achievement? The research described here is a pilot study that aimed to set the stage for a large-scale investigation into this question.

The review below starts with an overview of the extant literature on how SES is measured in psychological research studies. It then proceeds to examine recent literature on the associations between SES and cognitive performance, and between SES and academic achievement. It then discusses, briefly, basic literature on IIV in cognitive performance, and concludes with a statement of how a multivariate analysis of the type described above might fill some important gaps within the literature

Indicators of SES

Although there are some disagreements about the conceptual definition of SES, there appears to be some consensus around the idea that, for children, adolescents, and even young adults, the three main indicators of SES are parental income, parental education, and parental occupation (Cirino et al., 2002; Shavers, 2007).

Social scientists use these three indicators to describe how much SES impacts academic, social, cognitive, and behavioral outcomes of children and adolescents (Bradley & Corwyn, 2002). Taking these parameters together provides a reasonably full picture of the family's resources and opportunities for achievement and advancement (Sirin, 2005). Parental income influences overall cognition, as well as on academic achievement. Low-income families cannot afford books, computer equipment, tutors or other materials that are necessary for adequate cognitive stimulation. Without these materials, achieving better school outcomes becomes more

difficult (Willingham, 2012). Parental education is an important contributor to the overall development of the child, via several mechanisms. For instance, parents with higher education levels typically have greater access to childrearing resources (Wickrama & O'Neal, 2013). Hence, these parents might experience lower levels of stress, frustration, hopelessness, helplessness, and anger in their interactions with their child(ren), meaning they might be able to parent more effectively and provide a more cognitively stimulating environment. More directly, parental educational level is strongly related to children's literacy competence: Parents with higher levels of education tend to expose their child to books, magazines, and other forms of literature more frequently than do parents with lower levels of education, even during the preschool years (Fuller et al., 1999; Heath et al., 2014; Leslie & Allen, 1999). Furthermore, parents who do not have an adequate level of education are less likely to be involved in their child's educational process, which often results in the child earning lower grades and tests scores (Hartas, 2011). Parental occupation is similarly important because it is frequently predicted by education and is predictive of income, and so it provides useful information about the household (Sirin, 2005; Bradley & Corwyn, 2002).

Associations of SES with Cognitive Performance and with Academic Achievement

A large literature suggests that lower SES is associated with poorer cognitive performance and with lower academic achievement (Hurst, Stafford, Cooper, Richards, & Kuh, 2012; Ladas, Carroll, & Vivas, 2015; Piccolo, Sbicigo, Rodrigo Grassi-Oliveira, & Fumagalli de Salles, 2014; Rochette & Bernier, 2014; Wu, Prina, & Brayne, 2014; Piccolo, Arteche, Fonseca, Grassi-Oliveira, & Salles, 2016).

Regarding associations between SES and the brain substrates that underlie cognitive performance, several studies (e.g., Jednorãg et al., 2012; Bradley & Corwyn, 2002) suggest that SES has an influence on brain development in utero, and that this influence persists throughout childhood and adolescence. Otero and colleagues (1997) used an electroencephalogram (EEG) to examine whether there were any physiological disparities in brain development due to SES. They found a maturational lag within the prefrontal cortex in children from a low socio-economic background, aged 18-36 months. Similarly, Hackman and Farah (2009) found, using functional magnetic resonance imaging (fMRI) and a sample of children aged 6-9 years, that the left fusiform gyrus was more active during performance of reading in lower SES children compared to their higher SES counterparts. Because this region of the brain is active in the buffering

process for visual word recognition and phonological awareness (both key components of reading ability), the authors interpreted their finding as evidence for the fact that recognizing words during reading tasks requires more neural effort in lower-SES children. Consistent with these results, Piccolo et al. (2015) found, in a structural neuroimaging study of a sample of 10-year-olds, that there were positive associations between parental education and cortical thickness and surface area.

The fact that SES affects neural growth for many years post-natally is particularly important because brain regions responsible for high-level cognitive functioning continue to mature throughout childhood and adolescence. Hence, it is not surprising that lower SES is associated with relatively poor performance on cognitive tests (for reviews, see Ursache & Noble, 2016; von Stumm & Plomin, 2015). For instance, McCoy and colleagues (2015) found that, in a Zambian cohort, children from low-income families had lower levels of cognitive stimulation within the home environment, and, perhaps consequently, performed more poorly on tasks assessing cognitive development. Numerous similar studies have focused on the association between SES and test performance within discrete cognitive domains. Lee and Kim (2012) focused on language in 5- and 6-year-olds, arguing that vocabulary size, in particular, is key for learning and development as the child matures (e.g., learning new vocabulary is vital for developing higher-language skills and for understanding of literature). They found that socioeconomic and environmental variables impacted directly on children's vocabulary, even at 5 years old. They also found that a negative parenting style, associated with lower socioeconomic status, was significantly negatively associated with vocabulary size.

Numerous studies suggest that socioeconomic status plays a mediating role in development of executive functioning. Children and adolescents from low SES backgrounds tend to perform poorly on tasks assessing executive function domains such as cognitive control, working memory, and selective attention (Fatima, Sheikh, & Ardila, 2016; Sarsour et al., 2010). Linking the domains of language and executive function, Corso and colleagues (2016) found that executive function mediated the association between SES and comprehension: 52% of variability in reading comprehension within a sample of Brazilian 4^{th}-6^{th} grade children, of various SES levels, could be attributed to executive functioning skills, as assessed by standardized test performance.

In summary, the extant literature suggests that early experiences of individuals (which are determined, to a great degree, by SES) are important for the structural development of the brain and, consequently, for cognitive development. Because difficulties within any discrete cognitive domain (e.g., attention, memory, language, executive function) can make even simple tasks difficult to perform, cognitive systems must function optimally for the individual to achieve adequate academic performance (Jednorãg et al., 2012; Jensen, 2009).

Regarding these associations between SES and academic achievement, Liu and Lu (2008) suggest that a major reason why students from higher SES backgrounds perform better academically is that their parents can pay for resources (e.g., tutors, textbooks, etc.) to support their child's academic undertakings. Such resources might not be available to children from lower SES backgrounds. In a similar vein, Adbu-Raheem (2015) found that students from rural, urban, and suburban schools who experienced "maternal and paternal deprivations" (p. 124) reported poorer academic performance than those who experienced no such deprivations. These deprivations included a lack of financial resources (leading to difficulty purchasing textbooks and paying school fees), the loss of a parent, or parental separation/divorce. Independent research confirms that the presence of such deprivation is associated with relatively poor development of cognitive competencies, which might in turn potentiate premature school exit (Adeyemo & Babajide, 2012; Sirin, 2005; Wickrama & O'Neal, 2013).

Socioeconomic Status and Intraindividual Variability

Research on the association between SES and cognitive performance, and between SES and academic achievement, has tended to focus on the average difference between groups. An average difference between groups simply means that two variables are measured to see whether or not they are related, or if there is any association between them (Hale, 2011). Within this dominant measurement paradigm, differences within and between individuals are viewed as noise, or as measurement errors (Borella, Chicherio, Sensini, & Cornoldi, 2011). Over the last three decades, however, researchers have begun to pay more attention to within-person performance variability (intraindividual variability, or IIV), viewing it as an important source of information in understanding individual differences in cognitive performance.

IIV refers to fluctuations in the performance of an individual on a single measure that is administered over multiple occasions. These occasions, or testing sessions, might be separated by minutes, hours, days, or weeks (Hultsch, MacDonald, & Dixon, 2002). Inconsistent

performance on relatively simple cognitive tasks is often a marker of problematic variability in central nervous system (CNS) functioning, with consequent impairments in information processing and executive control systems (MacDonald, Nyberg, & Bäckman, 2006; Ram, Rabbitt, Stollery, & Nesselroade, 2005). Although the particular neural mechanisms of IIV remain largely unexplored, it appears that fluctuation within the connectivity of neural pathways, or dysfunction of particular neurotransmitter systems, might be involved (Borella, Chicherio, Sensini, & Cornoldi, 2011).

Regardless of what those mechanisms actually are, researchers have noted that, by measuring performance on particular tasks more than once, they can detect whether some individuals reach a level of inconsistency that is much higher than that of others. Using such designs, psychological research studies have shown IIV is an effective predictor of poorer cognitive performance associated with neurological disorders such as multiple sclerosis, of age-related cognitive decline, and of cognitive and functional change following traumatic brain injury (McCoy, 2004; Wegesin & Stern, 2004; Wensing, Levasseur-Moreau, & Fecteau, 2014; Wojtowicz, Berrigan, & Fisk, 2012).

There are, however, no published studies examining the relationship between SES and intraindividual variability (IIV) in cognitive function. This knowledge gap should be addressed given that, as noted previously, there is a large literature examining the effects of SES on mean differences in cognitive performance.

Summary, Rationale, and Aims

A relatively large literature suggests that the effects of SES on cognitive development, and on cognitive performance from childhood through young adulthood, can have major effects on academic achievement and, subsequently, occupational attainment. A separate stream of literature suggests that IIV is an important indicator of longitudinal cognitive change, and yields important information about cognitive functioning (particularly within the domain of executive functioning) within many neurological, neuropsychiatric, and neuropsychological disorders.

There are, however, no published studies examining whether SES is associated with IIV in cognitive performance. Such studies are warranted because lower SES is associated with altered brain structure and atypical cognitive development, even in very young children. Such alterations and atypicality might be reflected in unusually high IIV in cognitive performance; in

turn, this unusual variability might manifest, over the long term, as poorer academic achievement.

The research described here is a pilot investigation into the relationship between SES, IIV in cognitive performance, and academic performance. Specifically, I aimed to assess whether a particular design, methodological framework, and analytic technique would be adequate to address the question of that relationship. Hence, I recruited individuals from varying socioeconomic backgrounds, administered tests of cognitive functioning (in particular, measures of cognitive control) to them in an IIV paradigm, and collected information about their academic performance at university. Data analyses then tested whether IIV in cognitive performance mediates the relationship between SES and academic performance. To my knowledge, no published study has considered this possible multivariate relationship.

Methods

Design and Setting

This pilot study used a measurement burst design. These designs feature multiple repeated assessments (i.e., measurement bursts) of a single measure administered to each individual over various time-scales (e.g., over hours, days, or weeks; Sliwinski, Almeida, Smyth, & Stawski, 2009). Measurement burst designs allow for an intrinsic look into performance variation associated with short- or long-term change within individuals. Hence, participants were tested three times (once a week across a 3-week period). The first testing session proceeded only after participants had undergone a thorough screening process.

Participants

I used convenience sampling, via the University of Cape Town Department of Psychology's Student Research Participation Programme (SRPP), to recruit undergraduate students. I sent out an email (see Appendix A) inviting students to sign up for this study if they meet the eligibility criteria described below.

Eligibility criteria. These specified that all participants should be aged 18-25 years, and should all be current undergraduate students. Individuals with a history of psychological, psychiatric, or neurological illness, or who were using psychoactive medications, were not eligible for participation.

Attrition. Twenty-four people responded to the email announcement. All met the eligibility criteria. Five did not appear at the appointed time for their screening session, and did not contact me again regarding study enrolment. Of the remaining 19, 12 completed at least the screening session and the first test session before withdrawing (e.g., because of scheduling conflicts, or an unwillingness to undertake further testing). Hence, the final sample consisted of 7 participants (2 men and 5 women).

Measures

Screening measures. These measures provided information pertinent to the study's eligibility criteria, and to the participant's SES.

Sociodemographic questionnaire. This questionnaire (see Appendix B) provided information regarding the participant's basic biographic and sociodemographic characteristics (e.g., age, sex, home language, years of completed education). It also included an asset index (Myer, Stein, Grimsrud, Seedat, & Williams, 2008) that asks questions about household material wealth. This index has proven to be an effective estimate of SES in low- and middle-income countries where many people participate in informal economic activities (e.g., bartering and community sharing of resources). Hence, I used scores on this index, which can range from 0-17 (where higher scores indicate ownership of more material resources), as my measure of SES.

Health index. This questionnaire (see Appendix C) provided background regarding, for instance, whether participants had experienced any head injuries, whether they had received any psychological or psychiatric services, and whether they experienced any chronic medical illnesses.

Beck Depression Inventory-Second Edition. The BDI-II is a 21 item self-report questionnaire screens for any recent depressive symptomology. For each item, respondents are required to pick, from four different options, the statement that describes best how they have felt over the past 2 weeks. The scores are then tallied up and the higher the score, the greater the presence of depressive symptoms. The conventionally defined score ranges are: 0-13, minimally depressed; 14-19, mildly depressed; 20-28, moderately depressed; and 29-63, severely depressed (Beck, Steer, & Brown, 1996). Regarding psychometric properties, the BDI-II has a high level of internal consistency (α = .91; Dozois, Dobson, & Ahnberg, 1998), good test-retest reliability (α = .93; Beck et al., 1996), and adequate factorial and content validity (Dozois, Dobson, & Ahnberg 1998).

Shipley-2 IQ Test. This instrument (Shipley, Gruber, Martin, & Klein, 2009) is a brief measure of general intellectual functioning. A standard administration of the Shipley-2 includes a Vocabulary scale, used to measure crystallized intelligence, and one of an Abstraction or a Block Patterns scale, used to measure fluid reasoning (Kaya, Delen, & Bulut, 2012). Summing the scores of Vocabulary and one of the other scales yields an estimate of IQ. In the current study, I used Vocabulary and Abstraction. The Vocabulary scale includes 40 items, with each requiring the participant to choose a word, out of four options, that is closest in meaning to a target word. The Abstraction scale has 25 sequence-completion items. Administration time is 20-25 minutes,

The Shipley-2 has strong psychometric properties. It has good internal consistency reliability for all scales, and good convergent validity with other tests of general intellectual functioning (Kaya et al., 2012; Lodge, 2013).

Test measures.

Reaction time tests are used commonly in IIV-based research studies, including those that have focused on dementia and age-related cognitive decline, traumatic brain injury, and attention-deficit/hyperactivity disorder (MacDonald, Nyberg, & Bäckman, 2006; (Burton, Hultsch, Strauss, & Hunter, 2002; Koscik et al., 2016; Kuntsi & Klein, 2012). Performance levels from each participating individual can be measured precisely by computing a timed measure. There are two different types of reaction time tests: simple and choice. In a simple reaction time (SRT) test, there is one stimulus and one response, whereas n a choice reaction time (CRT) test, there are multiple stimuli and multiple responses (Jain, Bansal, Kumar, & Singh, 2015). One reason I used reaction time tests in the current study is that neuropsychological tests using time-derived scores yield superior test-retest reliability when compared to tests for which accuracy-based scores are used (Lemay, Bédard, Rouleau, & Tremblay, 2004). To prevent practice effects, the current design presented the reaction time tasks in a random sequence (Saleh & Bonnet, 1998).

SRT and CRT tasks. I used the computer-based Deary-Liewald Reaction Time Task (Deary, Liewald, & Nissan, 2010) to present participants with an SRT and a four-choice CRT task. The open-source software that runs the task is available for download at http://www.software.ccace.ed.ac.uk/new-page-2.html. The task was presented on a standard desktop computer, running a Windows operating system, with a 19-inch screen.

In the SRT, the computer monitor presented a blue background with a white box in the centre. Every 1-3 seconds (the exact inter-stimulus interval was randomized), the letter *X* appeared within the white box. When the letter appeared, the participant was required to press the spacebar as quickly as possible. The letter remained on the screen until the participant pressed the spacebar, signalling the end of the trial (Deary, Liewald, & Nissan, 2010).

In the CRT, the monitor again presented a blue background, but this time there were four white squares positioned in a horizontal line in the middle of the screen. Each square corresponded to a key on the keyboard: the *X* key corresponded to the far left square, the *C* key to the second from the left square, the *B* key to the square second from the right, and the *N* key to the square on the far right. Every 1-3 seconds (again, the exact inter-stimulus interval was randomized), the letter *X* appeared within one of the four boxes. The position of the letter was randomized across trials by the software. When the letter appeared, the participant was required to press the appropriate key as quickly as possible. The letter remained on the screen until the participant pressed the spacebar, signalling the end of the trial (Deary, Liewald, & Nissan, 2010).

The SRT consisted of 30 trials, and the CRT of 40. Participants received detailed task instructions before the beginning of each block of trials, and were allowed a practice block of both SRT and CRT trials to allow them to understand their task and to resolve any task-related questions. Administration time was approximately 10 minutes.

n-back task. I used two *n-back* conditions (a 1-back and a 2-back) were used to measure working memory capacity. The task was presented on a standard desktop computer, running a Windows operating system, using E-prime version 2.0 (Psychology Software Tools, 2002, Pittsburgh, Pennsylvania), and was modified from an *n*-back script downloaded from http://step.psy.cmu.edu/scripts-plus/.

In the *n*-back task, participants were presented with a random series of letters. In the 1-back condition, the target letter is that identical to the one presented immediately before. In the 2-back condition, the target letter is that identical to the one presented 2 turns before (Miller, Price, Okun, Montijo, & Bowers, 2009). Participants were required to hit a response key (*F*) on the keyboard when the target letter was presented, and a different key (*J*) when a non-target was presented.

Participants completed one block each for the 1- and 2-back conditions, and then another 2-back block. Each block consisted of 33 trials, and 1/3 of the letters presented within each block

were target stimuli. Participants also completed 10 practice trials for each of the *n*-back conditions before starting with the test itself. Administration time was approximately 15 minutes.

Academic achievement. I accessed all participants' marks for the previous semester only after each participant agreed, by ticking a box on the informed consent document, that I could do so. To derive a single score reflecting academic achievement, I followed the following procedure: For the 4 of the 7 participants who had taken four courses during the previous semester, I averaged their percentage marks on those courses to derive a single academic achievement score. The other 3 participants had taken three courses during the previous semester, and so I added to that pool the course on which they had performed best during the semester before that, and then averaged all those scores to derive a single academic achievement score.

Procedure

All participants were tested in the ACSENT Laboratory in the UCT Department of Psychology.

Screening and first test session. Immediately upon entering the venue, the participant was asked to read and sign a consent form (see Appendix D). After the participant read and signed the consent form, and had all questions answered satisfactorily, the screening session began. I first administered the sociodemographic questionnaire, then the Health Index, then the BDI-II, and then the Shipley-2.

If the screening materials confirmed that the participant was eligible to continue, I proceeded with the first test session immediately. Hence, I administered 2 blocks of the SRT, 2 blocks of the CRT, and the entire *n*-back task, as described above. The participant was then dismissed, with a reminder that the second test session was scheduled to be completed 7 days hence.

Second and third test sessions. Each of these test sessions was identical to the first test session, with each separated from the other by 7 days. At the end of the third test session, I debriefed the participants completely.

Data Management and Statistical Analyses

Dealing with SRT and CRT outliers. Data from RT tasks is particularly vulnerable to outliers: Responses that appear extremely fast or extremely slow may be a result of participants becoming distracted or impatient, or pressing a key accidentally. Hence, I examined all of the

raw scores for values lower than 150ms (Thorpe, Fize, & Marlot, 1996) and higher than 3 SD above the mean for the block of trials in question. There were no values below that lower bound, but there were several above the upper bound. These latter values were removed from the dataset. I then recalculated the mean RT for that block of trials, and replaced the offending values with that mean value.

Deriving *n*-back outcome variables. For each participant, I calculated a single RT score for each block of *n*-back trials. This score was based on the average RT to both target and non-target stimulus items, regardless of whether the response itself was correct or incorrect. Data for trials where the participant hit neither the *F* nor the *J* key were not recorded, and so were not part of the analysis.

Examining datasets for missing values. Due to an experimenter error, one participant was administered only 20 trials during the first administration of the SRT task within Test Session 1. The 10 missing values were not replaced. There were no other missing values.

Calculating the coefficient of variation. For each test measure (i.e., for each of the SRT, CRT, and *n*-back tests), I had to calculate a measure of IIV. The literature presents one with many options for which measure to use as an index of within-person inconsistency. The one I chose to use, the coefficient of variation (CoV), expresses the IIV standard deviation as a percentage of mean performance levels. It is particularly useful in designs such as the current one because it (a) allows one to compare IIV estimates across both outcome variables and groups, and (b) controls well for potential confounds, including practice effects (Hultsch & MacDonald, 2004).

For each participant, I calculated a CoV for each test at three time scales, or levels: block, session, and interval. Figure 1 shows how the test procedure is divided into each of those time scales, or levels. At the *block level*, I took the standard deviation for each block (30 trials) of the SRT task, and divided that value by the mean reaction time across the trials – this then is the CoV at the block level, and there would be two such values within each test session. I followed the same procedure for the CRT, 1-back, and 2-back tasks. At the *session level*, I took the average of the CoV for Blocks 1 and 2 for each test – this then is the CoV at the session level, and there would be three such values for each test. At the *interval level*, I took the average of the CoV for Test Session 1, Test Session 2, and Test Session 3 – this then is the CoV at the interval level, and there would be one such value for each test.

<table>
<tr><td colspan="2">Test Session 1</td><td colspan="2">Test Session 2</td><td colspan="2">Test Session 3</td></tr>
<tr><td>Block 1
SRT (30 trials)
CRT (40 trials)
1-back (33 trials)
2-back (33 trials)</td><td>Block 2
SRT (30 trials)
CRT (40 trials)
2-back (33 trials)</td><td>Block 1
SRT (30 trials)
CRT (40 trials)
1-back (33 trials)
2-back (33 trials)</td><td>Block 2
SRT (30 trials)
CRT (40 trials)
2-back (33 trials)</td><td>Block 1
SRT (30 trials)
CRT (40 trials)
1-back (33 trials)
2-back (33 trials)</td><td>Block 2
SRT (30 trials)
CRT (40 trials)
2-back (33 trials)</td></tr>
<tr><td colspan="2">Average
Within-Person, Within-Session 1
239 trials</td><td colspan="2">Average
Within-Person, Within-Session 2
239 trials</td><td colspan="2">Average
Within-Person, Within-Session 3
239 trials</td></tr>
<tr><td colspan="6">Average
Across-session (Interval)
717 trials</td></tr>
</table>

Figure 1. Time-scale measurements of intra-individual variability and calculation of the coefficient of variation. SRT = Simple Reaction Time; CRT = Choice Reaction Time.

Mediation analyses. I used SPSS version 23.0 to conduct these analyses. The analyses, based on Baron and Kenny's (1986) causal-steps test, set out to determine whether IIV in cognitive performance mediated the relationship between SES and academic achievement. Because cognitive performance was captured by four separate tests (SRT, CRT, 1-back, and 2-back), I conducted four separate analyses, one for each of the interval-level CoVs. The first step in the Baron and Kenny mediation analysis is to test, using simple linear regression, the magnitude of the relationship between the independent variable (IV; in this case, SES) and the dependent variable (DV; in this case, academic achievement). This step determines whether there is a significant relationship that may be mediated by a third variable. Thus, the four separate mediation analyses may only continue once it has been established that the IV and DV are significantly associated. If that relationship is not statistically significant, the mediation analysis cannot proceed further.

If the IV-DV relationship is statistically significant, the analysis proceeds to the second step. This step involves determining, again via simple linear regression, the magnitude of the relationship between the IV (in this case, SES) and the mediating variable (in this case, IIV in

cognitive performance). Again, the mediating analysis may only continue once it has been established that the IV and MV are significantly associated. If the relationship is not statistically significant, the mediation analysis cannot proceed further.

If the IV-DV and IV-MV relationships are both statistically significant, the analysis proceeds to the third step. This step involves building a hierarchical regression model that examines whether the relationship between the IV and the DV is changed when the MV is introduced as a predictor. If there is such a change, the Sobel test (Sobel, 1982) is commonly used to examine the statistical significance of this mediating effect.

Figure 2 captures the proposed mediating relationship.

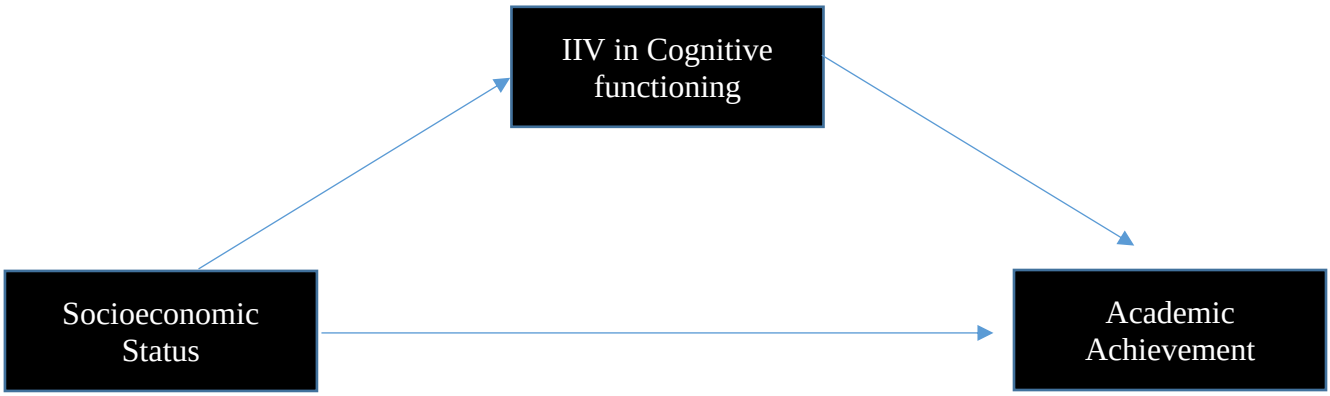

Figure 2. The hypothesised mediation of the relationship between socioeconomic status and academic achievement by IIV (intraindividual variability) in cognitive functioning.

Ethical Considerations

Consent and confidentiality. As noted above, all participants were required to sign an informed consent document. This document outlined important information about the study, as well as anything that could affect an individual's decision to participate in the study. Participants were assured that they could withdraw from the study at any stage during the testing, without penalty. All participants and results of their scores are being kept confidential. All questionnaire and test sheets are kept in a safe space, to which only I have access. These precautions are upheld carefully to ensure that participants do not incur harm or continue to have minimal apprehension about their involvement in the study.

Risks and benefits. There were no inherent physical, emotional, or social risks involved in study participation. There were two direct benefits to participants. First, on completion of the study procedures they earned 3 SRPP points. (SRPP is set up so that each undergraduate student

who studies a psychology module must participate in a research study within the Department. One SRPP point is awarded for each 30 minutes of participation, and each undergraduate need to collect 3 points per semester.) Second, they were entered into a draw for a raffle, with prizes being a R1000 gift certificate, a R500 gift certificate, and a R250 gift certificate.

Results

Sample Characteristics

Table 1 presents a summary of the sample's sociodemographic characteristics, as well as average scores on the BDI-II and Shipley-2. The sample consisted of 2 men and 5 women, all of whom were undergraduate students. All had a home language of English, except for one, whose home language was isiXhosa. Regarding depressive symptomology, all participants' BDI-II scores fell within the range conventionally described as "minimal depression." Regarding Shipley-2 scores, although participants tended to perform better on the Abstraction scale than on the Vocabulary scale, the overall IQ score for each participant fell within the range conventionally described as "average" (i.e., between 85 and 110, on the orthodox IQ scale where $M = 100$ and $SD = 15$).

Table 1.
Sample Sociodemographic Characteristics and Scores on Screening, Predictor, and Outcome Variables (N = 7)

Variable	*M*	*SD*	Range
Age (years)	20.14	0.90	19-21
Education (years)[a]	13.00	1.00	12-14
SES	14.71	1.38	13-17
Academic Achievement	66.75	7.80	56.50-76.75
BDI-II score	1.57	2.94	0-8
Shipley-2			
Vocabulary	94.86	9.44	81-105
Abstraction	104.29	9.64	86-114
IQ score	100.71	4.65	93-107
SRT	.13	.01	.11-.15
CRT	.17	.01	.15-.19
n-back			
1-back	.33	.09	.22-.43
2-back	.38	.06	.32-.45

Note. [a]Years of completed education (e.g., 12 years = completed high school, currently a first-year undergraduate). SES = socioeconomic status; BDI-II = Beck Depression Inventory - Second

Edition; SRT = Simple Reaction Time task; CRT = Choice Reaction Time task. Scores on the SRT, CRT, and *n*-back variables are coefficients of variation.

Mediation Analysis, First Step: Associations between SES and academic achievement

A correlational analysis, using Pearson's *r* coefficient, detected a significant positive association between SES and academic achievement, $r = .81$, p (one-tailed) = .01. Table 2 shows the complete results of the linear regression model featuring SES as the predictor variable and academic achievement as the outcome variable. As can be seen, SES was a significant predictor of academic achievement, $B = 4.59$, $SE = 21.76$, $\beta = .81$.

Table 2.
Linear Regression Analysis: SES as a predictor of academic achievement (N = 7)

				Change Statistics				
R	R^2	Adjusted R^2	Std. Error of the Estimate	ΔR^2	ΔF	*df*1	*df*2	Sig. ΔF
.81	.66	.59	4.98	.66	9.72	1	5	.03*

Note. SES = socioeconomic status.
*$p < .05$.

Regarding the assumptions underlying the regression model, all observations were independent and the dependent variable was continuous. Academic achievement scores were almost normally distributed, although there was a higher concentration of scores to the left (see Figure 3). The value for Cook's distance was 0.55, which suggests that there were no cases in the data that had a large effect on the regression model. The value for Mahalanobi's distance was 2.74, which is large and is therefore of concern. This statistic shows how far a case is away from the average value of the predictor variable. A large distance can reduce the reliability of the regression model by influencing the line of best fit. In models with small sample sizes, large values for this statistic are expected. In terms of homoscedasticity, the scatterplot in Figure 4 shows a linear formation with little spread in the data, which suggests that homoscedasticity is present. That scatterplot also shows there was one outlier in the dataset. I chose not to remove it from the analysis given that the sample size was already small, and given that Cook's distance was < 1.

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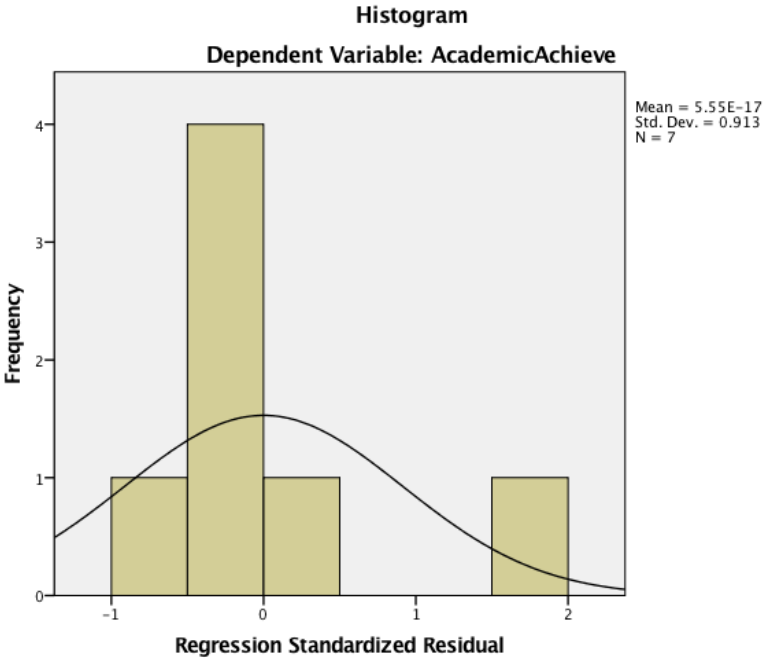

Figure 3. Histogram showing the standardized residuals of the Academic Achievement outcome variable (*N* = 7).

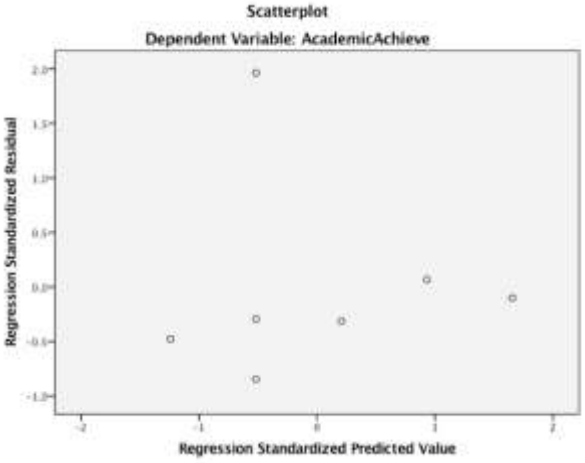

Figure 4. Scatterplot of standardized residuals versus standardized predicted values for the Academic Achievement outcome variable (*N* = 7).

Other bivariate correlations. Given that this was a pilot study, I conducted a complete set of bivariate correlations to follow up on the promising result described above, and to examine whether the associations between the variables of interest were of noteworthy magnitude and/or in the expected direction. Table 3 presents the results of this series of correlational analyses. As can be seen, SES was significantly positively correlated with academic achievement and with IIV in SRT performance, and academic achievement was significantly negatively correlated with IIV in CRT performance. In fact, academic achievement was negatively correlated with IIV on all other cognitive tests, and with the Shipley-2 IQ estimate, although none of those associations reached statistical significance. Of note here too is that none of the cognitive measures were significantly associated with one another.

Table 3.
Correlation Matrix: Bivariate associations between SES, academic achievement, general intellectual functioning, and IIV in cognitive performance on four tests (N = 7)

	1	2	3	4	5	6	7
1. SES	1.00	**.81 (.01*)**	**-.83 (.01*)**	-.56 (.10)	-.31 (.25)	.27 (.28)	.17 (.36)
2. Academic Achievement		1.00	-.62 (.07)	**-.79 (.02*)**	-.23 (.31)	-.04 (.47)	-.25 (.29)
3. IIV in SRT			1.00	.33 (.23)	.45 (.16)	-.54 (.10)	-.10 (.42)
4. IIV in CRT				1.00	.39 (.19)	-.10 (.42)	.21 (.33)
5. IIV in 1-back					1.00	-.42 (.17)	.13 (.39)
6. IIV in 2-back						1.00	.62 (.07)
7. Shipley-2 IQ							1.00

Note. Data presented are Pearson's *r* correlation coefficients, with associated *p*-values in parentheses underneath. Statistically significant correlations are presented in boldface font. SES = socioeconomic status; IIV = intraindividual variability; SRT = Simple Reaction Time. CRT= Choice Reaction Time.
*$p < .05$. **$p < .01$. All reported *p*-values are one-tailed.

Mediation Analysis 1: IIV in SRT performance as a potential mediator of the SES-academic achievement association

Table 4 shows the complete results of the linear regression model featuring SES as the predictor variable and IIV in SRT as the outcome variable. As can be seen, SES was a significant predictor of IIV in SRT, $B = 4.59$, $SE = 21.76$, $\beta = .81$. Hence, I could continue with the mediation analysis by examining whether IIV in SRT mediates the relationship between SES and academic achievement.

Table 4.
Linear Regression Analysis: SES as a predictor of intraindividual variability on the SRT task (N = 7)

				Change Statistics				
R	R^2	Adjusted R^2	Std. Error of the Estimate	ΔR^2	ΔF	*df*1	*df*2	Sig. ΔF
.83	.69	.63	.01	.69	11.33	1	5	.02*

Note. SES = socioeconomic status; SRT = Simple Reaction Time.
*$p < .05$.

Table 5 is a correlation matrix showing the set of bivariate correlations between SES, academic achievement, and IIV in SRT. As can be seen, IIV in SRT was significantly negatively correlated with both SES and academic achievement, suggesting that as scores on these latter variables increased, variability in performance on the reaction time task decreased.

Table 5.
Correlation Matrix: Associations between SES, academic achievement, and IIV in SRT (N = 7)

	1	2	3
1. SES	1.00	**.81 (.01*)**	**-.83 (.01*)**
2. Academic Achievement		1.00	-.62 (.07)
3. IIV in SRT			1.00

Note. Data presented are Pearson's *r* correlation coefficients, with *p*-values (one-tailed) in parentheses. Statistically significant p-values are presented in boldface font. SES = socioeconomic status; IIV = intraindividual variability; SRT = Simple Reaction Time.
*$p < .05$.

Tables 6 and 7 present the results of the hierarchical regression analysis testing for a possible mediation effect. The model summary (Table 6) suggests that IIV in SRT did not mediate the relationship between SES and academic achievement. Hence, although some data presented in Table 7 are useful in confirming previous results (e.g., in showing that SES has a positive beta value, meaning that as SES increases, so academic achievement improves), the

mediation effect was non-significant and so there is no need for further analysis or comment regarding IIV in SRT.

Table 6.
Hierarchical Regression Analysis 1: IIV in SRT as a potential mediator of the SES-academic achievement association (N = 7)

					Change Statistics				
Model	*R*	R^2	Adjusted R^2	Std. Error of the Estimate	ΔR^2	ΔF	*df*1	*df*2	Sig. ΔF
1 [a]	.81	.66	.59	4.98	.66	9.72	1.00	5.00	.03*
2 [b]	.82	.67	.51	5.48	.01	.13	1.00	4.00	.74

Note. IIV = intraindividual variability; SRT = Simple Reaction Time; SES = socioeconomic status. [a]Predictors: (Constant), SES. [b]Predictors: (Constant), SES, SRT.
*$p < .05$.

Regarding the assumptions underlying the regression model, all observations were independent and the dependent variable was continuous. IIV in SRT scores were almost normally distributed, although there was a higher concentration of scores towards the middle (see Figure 5). The value for Cook's distance was 0.36, which suggests that there were no cases in the data that had a large effect on the regression model. The value for Mahalanobi's distance was 2.74, which is large and is therefore of concern. As noted earlier, though, in models with small sample sizes, large values for this statistic are expected. In terms of homoscedasticity, the scatterplot in Figure 6 shows a that a pattern may be forming, which suggests that homoscedasticity may not be is present as the data is spread over the graph. That scatterplot also shows there was one outlier in the dataset. I chose not to remove it from the analysis given that the sample size was already small, and given that Cook's distance was < 1.

Table 7.
Hierarchical Regression Analysis 1: Statistics for the full regression model (N = 7)

							Correlations			Collinearity Statistics	
	Model	*B*	*SE*	*β*	*t*	*p*	95% CI for *B*	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-0.84	21.76		-.04	.97	-56.79 - 55.10					
	SES	4.59	1.47	.81	3.12	.03*	0.81-8.38	.81	.81	.81	1.00	1.00
2	(Constant)	-27.77	78.69		-.35	.74	-246.25-190.72					
	SES	5.47	2.93	.97	1.87	.14	-2.67 - 13.61	.81	.68	.54	.31	3.27
	IIV in SRT	106.77	297.27	.19	.36	.74	-718.60 - 932.13	-.62	.18	.10	.31	3.27

Note. SES = socioeconomic status; IIV = intraindividual variability; SRT = Simple Reaction Time.
*$p < .05$.

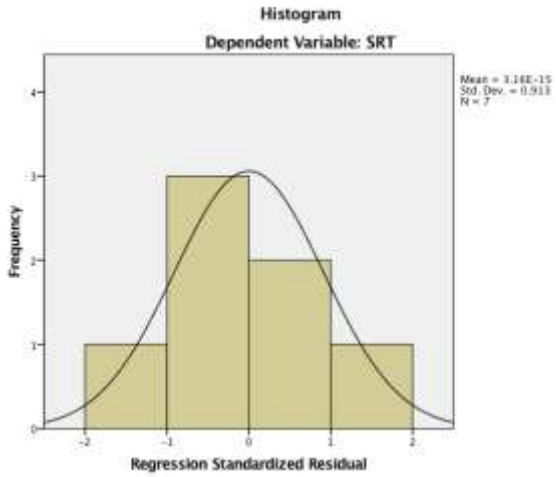

Figure 5. Histogram showing the standardized residuals of the IIV in SRT (intraindividual variability in performance on the Simple Reaction Time task) mediating variable (N = 7).

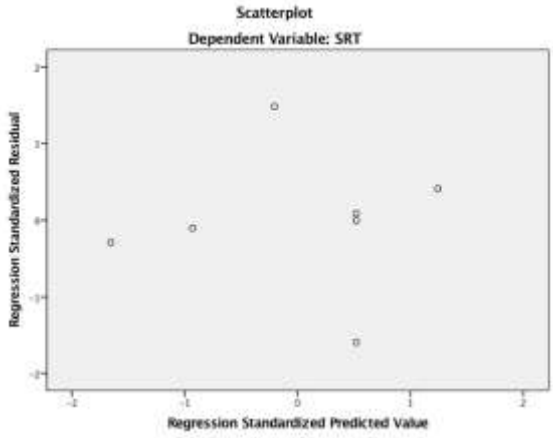

Figure 6. Scatterplot of standardized residuals versus standardized predicted values for the IIV in SRT (intraindividual variability in performance on the Simple Reaction Time task) mediating variable (N = 7).

Mediation Analysis 2: IIV in CRT performance as a potential mediator of the SES-academic achievement association

Table 8 shows the complete results of the linear regression model featuring SES as the predictor variable and IIV in CRT as the outcome variable. As can be seen, the model was not significantly predictive, B = -.01, SE = .25, β = -.56.

Table 8.
Linear Regression Analysis: SES as a predictor of intraindividual variability on the CRT task (N = 7)

				Change Statistics				
R	R^2	Adjusted R^2	Std. Error of the Estimate	ΔR^2	ΔF	*df*1	*df*2	Sig. ΔF
.56	.31	.17	.01	.31	2.25	1	5	.19

Note. SES = socioeconomic status; CRT = Choice Reaction Time.

Regarding the assumptions underlying the regression model, all observations were independent and the dependent variable was continuous. CRT scores were almost normally distributed, except for one of the values that is a cause for concern (see Figure 7). The value for Cook's distance was 0.81, which confirms that there is a case in the data that has a large effect on the regression model. The value for Mahalanobi's distance was 2.74, which is large and is therefore of concern. As noted earlier, however, in models with small sample sizes, large values for this statistic are expected. In terms of homoscedasticity, the scatterplot presented in Figure 8 shows no discernible pattern, which suggests that homoscedasticity may not be present as the data is spread over the graph. In models with small sample sizes, this is expected.

These concerns about the validity of the regression model are tempered by the fact that it delivered a non-significant result in any case. Furthermore, given that non-significant result at this stage of the mediation analysis, there is no need for further analysis or comment regarding IIV in CRT.

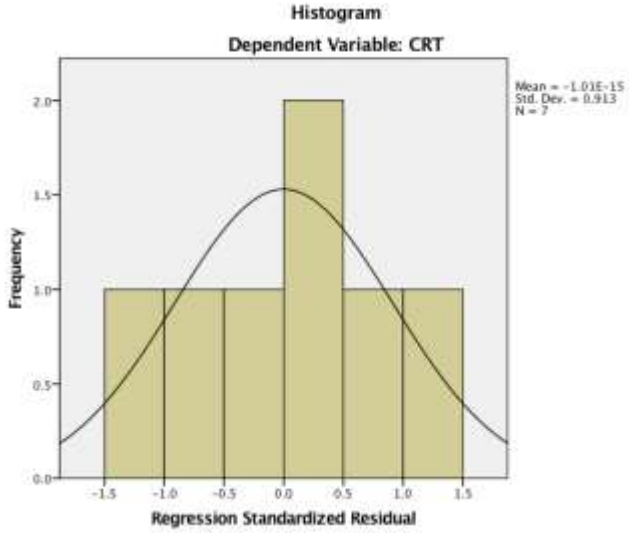

Figure 7. Histogram showing the standardized residuals of the IIV in CRT (intraindividual variability in performance on the Choice Reaction Time task) mediating variable (N = 7).

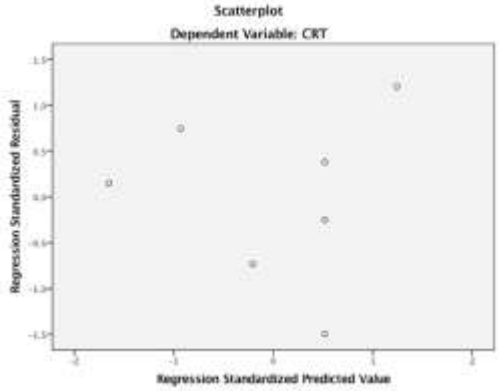

Figure 8. Scatterplot of standardized residuals versus standardized predicted values for the IIV in CRT (intraindividual variability in performance on the Choice Reaction Time task) mediating variable (N = 7).

Mediation Analysis 3: IIV in 1-back performance as a potential mediator of the SES-academic achievement association

Table 9 shows the complete results of the linear regression model featuring SES as the predictor variable and IIV in 1-back performance as the outcome variable. As can be seen, the model was not significantly predictive, B = -.02, SE = .40, β = -.31.

Table 9.
Linear Regression Analysis: SES as a predictor of intraindividual variability in 1-back performance (N = 7)

				Change Statistics				
R	R^2	Adjusted R^2	Std. Error of the Estimate	ΔR^2	ΔF	*df*1	*df*2	Sig. ΔF
.31	.10	-.08	.09	.10	.54	1.00	5.00	.49

Note. SES = socioeconomic status.

Regarding the assumptions underlying the regression model, all observations were independent and the dependent variable was continuous. Scores on the 1-back task were almost normally distributed, except for one of the values that is a cause for concern (see Figure 9). The value for Cook's distance was 0.75, which confirms that there is a case in the data that has a large effect on the regression model. The value for Mahalanobi's distance was 2.74, which is large and is therefore of concern. As noted earlier, however, in models with small sample sizes, large values for this statistic are expected. In terms of homoscedasticity, the scatterplot presented in Figure 10 shows no discernible pattern, which suggests that homoscedasticity may not be present as the data is spread over the graph. In models with small sample sizes, this is expected.

Again, these concerns about the validity of the regression model are tempered by the fact that, in any case, it delivered a non-significant result. Furthermore, given that non-significant result at this stage of the mediation analysis, there is no need for further analysis or comment regarding IIV in 1-back performance. Of potential interest, however, is the fact that IIV in 1-back performance was negatively correlated with SES, Pearson's r = -.31, p (one-tailed) = .25. This piece of data suggests that as SES increased, variability in performance on the working memory task decreased.

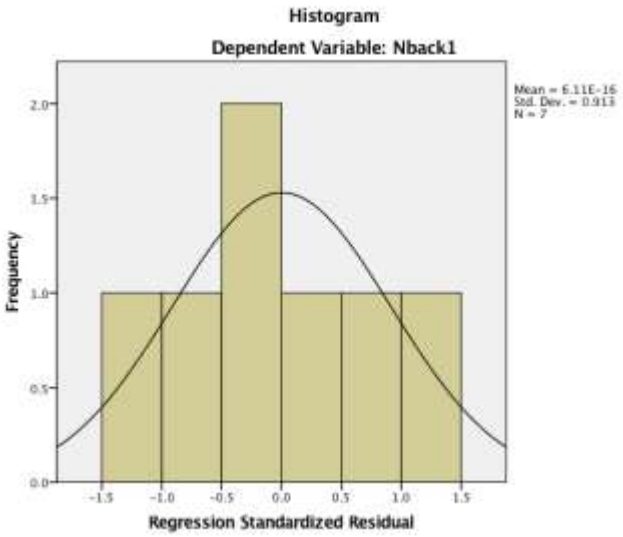

Figure 9. Histogram showing the standardized residuals of the IIV (intraindividual variability) in 1-back mediating variable (N = 7).

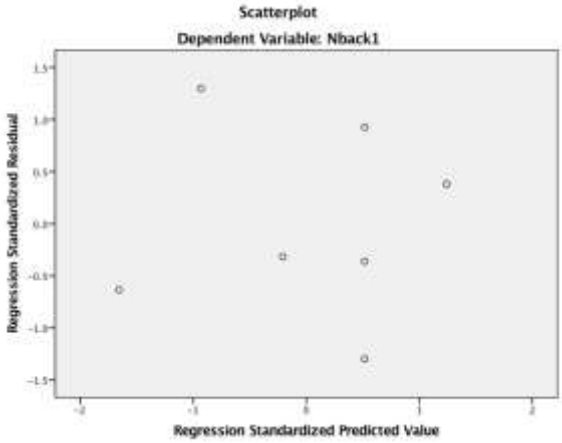

Figure 10. Scatterplot of standardized residuals versus standardized predicted values for the IIV (intraindividual variability) in 1-back mediating variable (N = 7).

Mediation Analysis 4: IIV in 2-back performance as a potential mediator of the SES-academic achievement association

Table 10 shows the complete results of the linear regression model featuring SES as the predictor variable and IIV in 2-back performance as the outcome variable. As can be seen, the model was not significantly predictive, B = .28, SE = .40, β = -.27.

Table 10.

Linear Regression Analysis: SES as a predictor of intraindividual variability in 2-back performance (N = 7)

				Change Statistics				
R	R^2	Adjusted R^2	Std. Error of the Estimate	ΔR^2	ΔF	*df*1	*df*2	Sig. ΔF
.27	.07	-.11	.06	.07	.39	1	5	.56

Note. SES = socioeconomic status.

Regarding the assumptions underlying the regression model, all observations were independent and the dependent variable was continuous. Scores on the 2-back task were not normally distributed, as there is a higher concentration of scores to the right. The value for Cook's distance was 0.88, which confirms that there is at least one case in the data that might have a large effect on the regression model (see Figure 11). This is a cause for concern. The value for Mahalanobi's distance was 2.74, which is large and is therefore of concern. As noted earlier, however, in models with small sample sizes, large values for this statistic are expected. In terms of homoscedasticity, the scatterplot presented in Figure 12 has some sort of pattern to it, which suggests that homoscedasticity may be present. There are 3 outliers in the figure and because of the large value of Cook's distance, these outliers could be influencing the overall graph.

Once again, these concerns about the validity of the regression model are tempered by the fact that, in any case, it delivered a non-significant result. Furthermore, given that non-significant result at this stage of the mediation analysis, there is no need for further analysis or comment regarding IIV in 2-back performance.

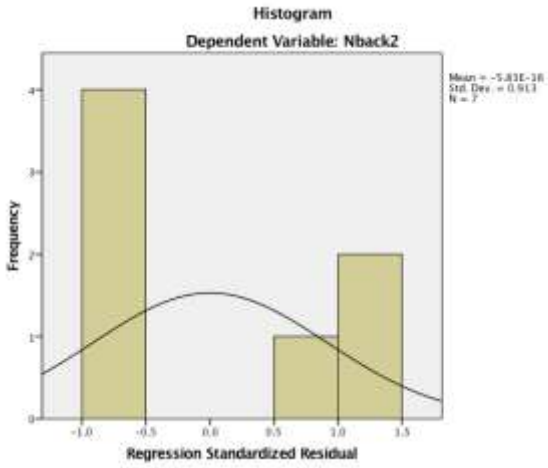

Figure 11. Histogram showing the standardized residuals of the IIV (intraindividual variability) in 2-back mediating variable (N = 7).

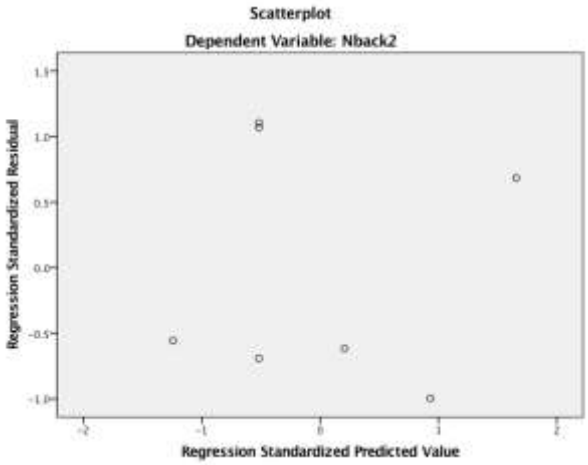

Figure 12. Scatterplot of standardized residuals versus standardized predicted values for the IIV (intraindividual variability) in 2-back mediating variable (N = 7).

Discussion

The aim of this pilot study was to lay the groundwork for an in-depth investigation of the relationship between socioeconomic status (SES), academic achievement, and intraindividual variability (IIV) in cognitive performance. More specifically, this study sought to determine whether a particular set of methods and assessment tools (e.g., recruitment of an undergraduate population, an asset index as a measure of SES, reaction time and working memory measures of cognitive performance), a particular design (a

measurement-burst design, extended over a period of weeks), and a particular analytic technique (the Baron-Kenny causal steps approach) would be suitable for examining whether the association between SES and academic achievement is mediated by IIV in cognitive performance.

Given those aims, the structure of this Discussion section will abandon the conventional organization, which focuses on the observed results and places them in the context of the extant literature. Rather, I will use this section to evaluate the pilot study, dissecting its strengths and weaknesses. Such evaluation and dissection will allow me to conclude by making recommendations for how future research into the question of interest might be conducted.

Regarding the recruitment method, this pilot study used convenience sampling, via the SRPP mechanism, and offered no incentives other than being awarded SRPP points and being entered into a raffle. Given the low uptake rate (only 24 individuals responded to the advertising email), this recruitment strategy seems flawed. Future studies might consider recruiting from a bigger population than a single department's undergraduate pool, and might put bigger incentives in place.

Future studies might also consider using stratified, rather than convenience, sampling. The current pilot study identified major weaknesses of using the latter sampling method for the purposes of answering the question of interest. The seven individuals who eventually completed the study procedures and whose data were included in the final analyses were all of relatively similar SES (i.e., they all fell within the high SES range, as defined by the Myer et al. (2008) asset index). A stratified sampling strategy would allow researchers to target the recruitment of individuals from different socioeconomic strata, and to thus avoid the restricted range problem faced by the current statistical analyses.

No matter what the sampling strategy is, the question of how to avoid high rates of attrition will still need to be addressed by future studies. The current pilot study showed that a measurement-burst design, with three test sessions spread over 3 weeks, might be problematic for undergraduate participants. Of the 19 participants who met the eligibility criteria and who were subsequently enrolled in the study, only 7 completed the entire protocol. Reasons for drop-out ranged from scheduling difficulties to illness to simple unwillingness to participate further. This high rate of attrition (70%) presents a serious threat to the study's internal validity (Rosenthal & Rosnow, 2008). To attenuate this difficulty,

future studies might consider increasing the incentives to participate (e.g., offer each participant some financial reward at the end of each test session), or decreasing the burden of participation (e.g., conduct fewer test sessions, or spread the test sessions over a shorter period of time). Some researchers have taken the latter option, with success (see, e.g., Flehmig, Steinborn, Langner, Scholz, & Westhoff, 2007). Another way to attenuate attrition is to retain the measurement-burst design and the 1-week separation between test sessions, but to administer the cognitive tests to groups of participants (see, e.g., Colom & Quiroga, 2009).

Regardless of how future studies recruit participants, and regardless of how the attempt to attenuate attrition, obtaining an adequate sample size is, naturally, a critical matter. Underpowered studies proliferate in psychological research journals (Button et al., 2013), and do a disservice to readers, to public policy, and to the scientific enterprise. A power analysis for the multiple regression design, using a medium effect size ($f^2 = 0.13$), with α set at .05, and a minimum desired power of .80, revealed that a sample size of 78 would be a minimum requirement in this context (Faul, Lang, & Buchner, 2007).

Regarding the cognitive assessment tools used in the current study, the participants understood the reaction time and working memory tasks easily, and completed them without any major problems. No individual discontinued participation in the middle of a cognitive test, and no-one intimated that the tests were distressing. Hence, one might conclude that these tests were well tolerated by the participants, even when administered on multiple occasions. It is for these reasons that such tests are used commonly within IIV paradigms (see, e.g., Allaire & Marsiske, 2005; Hultsch et al., 2002), and hence my recommendation is that they are retained in future studies addressing the question of interest.

Those future studies should, however, consider carefully how they measure SES. As noted in the Introduction, research studies across the social sciences use many different scales, questionnaires, and indices to capture SES (Bradley & Corwyn, 2002; Cirino et al., 2002; Shavers, 2007). In this pilot study, I chose to use the asset index developed by Myer et al. (2008). I did so because it is a locally developed instrument, with particular applicability to communities where there is frequent participation is informal economies. Myer et al. (2008) provide psychometric support for using the asset index as an SES proxy in low- and middle-income countries, in particular, and several previous South African studies have used the index to measure SES (see, e.g., Stein et al., 2015).

Using this asset index as a continuous measure of SES, analyses detected, as expected, a statistically significant positive relationship between SES and academic achievement. This finding is consistent with results from other, larger, studies (see, e.g., Hurst, Stafford, Cooper, Richards, & Kuh, 2012; Ladas, Carroll, & Vivas, 2015; Piccolo, Sbicigo, Rodrigo Grassi-Oliveira, & Fumagalli de Salles, 2014; Rochette & Bernier, 2014; Wu, Prina, & Brayne, 2014). This consistency suggests that the current measure of SES (and that of academic achievement) might be adequate for the purposes for which they have been employed here.

Arguing against that suggestion, however, is the fact that a series of correlational analyses detected no significant association between SES and any of the IIV in cognitive performance measures, or between SES and the Shipley-2 IQ scores. Previous studies (Fatima, Sheikh, & Ardila, 2016; von Stumm & Plomin, 2015; Finn et al., 2016) suggest that such associations should be present. Hence, one must account for their absence here. One strong possibility is that the current measure of SES is inadequate. The score range of the asset index is limited, and it is perhaps best used when one seeks to categorize participants into low-, medium-, and high-SES categories. When one seeks a continuous measure of SES that has a large range and is sensitive to variation within categories, household income, for instance, might be a better option.

Regarding the analytic technique, this pilot study describes in detail how one might proceed with a mediation analysis exploring the relationship between SES, academic achievement, and IIV in cognitive performance. The application of the Baron-Kenny technique, and the Sobel test, is not recommended for small sample sizes ($N < 200$; Fritz & MacKinnon, 2007), and hence it is not surprising that none of the hierarchical regression models detected a significant mediating effect. Nonetheless, this pilot study provided a detailed description of how that analytic technique might be applied to data collected within an IIV paradigm, and hence it is useful as a guide for future studies featuring larger samples.

Finally, the bivariate table was done so to see if there were any other associations between the predictor, dependent and mediating variables. Also, to see if there were any relationships between the four mediators as any non-significant relationships may show that each test is looking at different cognitive performances. From table 3, we can see that each of the IIV test paradigms (SRT, CRT, 1-back and 2-back) were not significantly correlated with each which is a great result as it means they test different cognitive performances. The table

also shows that SES and academic achievement are significant with each other and have a very high correlation. Even though the mediation analysis didn't prove the mediation, (this is not to say that this mediation relationship may not exist but there are grounds for a larger study required and an increased number of participants may provide improved results), the results from the bivariate table is important to note because it can push this pilot study in the right direction for future studies to be conducted.

Summary and Conclusion

The overall purpose of this pilot study was to determine if a particular design, methodological framework, and analytic technique would be adequate to address the question the relationship between SES, IIV in cognitive performance and academic achievement. The pilot study hasn't found this relationship yet as this is first study that has ever looked at these variables together, this relationship may exist. There were many problems identified in this study that could have attributed to this non-significant result. I have given a few recommendations that future researchers could use to get the best result for this study. As there is numerous literature looked that have found that SES does in fact influence cognitive performance which in turns impacts academic achievement and has future implications for individual throughout their lives. This pilot study has however found a significant relationship between SES and academic achievement which is consistent with other studies. The future direction that this study can contribute to the real word is something that should be invested in. This study can be used in Universities or Government agencies because it can help in understanding individual differences in cognitive performance which is important especially in countries that are still developing. This study can have real world uses and this study provides an important starting point in determining if there is a relationship between SES, IIV in cognitive performance and academic achievement.

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Appendix A

Emailed Announcement to Undergraduate Students for Recruitment

Announcement

Subject Get your SRPP points for the semester from this study!

Organiser Meelan Vanmali

Hi Everyone,

I am an honours student who is a running a psychometric research study through the Department of Psychology. This project is a first of its kind and it attempts to see if variation in cognition and one's socioeconomic status can impact their academic achievement.

In order to participate in this study, you need to:

1. Be a 1st-year undergraduate student at UCT

2. Be between the ages of 18-25

3. Have no history of psychological, psychiatric or neurological illness.

If you meet the above criteria, you can sign up on the 'Sign-up' tab on this site. Please do not sign- up if you are not eligible. Please take note of the time and date of your slot if you sign-up.

If you decide to participate in this study, you will be asked to complete several paper-and-pencil questionnaires and cognitive tests. These questionnaires will gather general information about your background (your age, where you grew up, etc.) and your mood. The tests will focus on things like memory and problem-solving. You will also be asked to complete some computerised cognitive tests. This should take about 45-60 minutes and you will receive **2 SRPP points**.

Thereafter, if you ARE found to be eligible for the study, you will be asked to schedule times when you will return for a second and a third test session. At those sessions, you will complete the same cognitive tests as before. These sessions should take about 30 minutes and you will receive **1 SRPP points** for your participation.

If you have any further questions, please don't hesitate to email me: vmeelan@gmail.com.

Thanks!

Regards

Meelan Vanmali

Psychology Honours Student

Appendix B

Sociodemographic Questionnaire

QUESTIONNAIRE AND ASSET INDEX

GENERAL INFORMATION

Full name ():	
Telephone:	Work: ( ) Home: ( ) Cell:
How would you describe your ethnicity / race?	1. Black 2. Coloured 3. White 4. Asian 5. Other(specify):
Home Language:	
Gender:	M F
Date of Birth:	

HOUSEHOLD INCOME: (Please circle appropriate number)

Household income per year:	1. R0 2. R1 – R5 000 3. R5001 – R25 000 4. R25 000 – R100 000 5. R100 001+

PARENTAL EDUCATION: (Please circle appropriate number)

	Biological mother	Biological father	Guardian
Highest level of education reached? Mark one response for each person as follows:			
1. 0 years (No Grades / Standards) = No formal education (never went to school)	1.	1.	1.
2. 1-6 years (Grades 1-6 / Sub A-Std 4) = Less than primary education (didn't complete primary school)	2.	2.	2.
3. 7 years (Grade 7 / Std 5) = Primary education (completed primary school)	3.	3.	3.
4. 8-11 years (Grades 8-11 / Stds 6-9) = Some secondary education (didn't complete high school)	4.	4.	4.
5. 12 years (Grade 12 / Std 10) = Secondary education (completed senior school)	5.	5.	5.
6. 13+ years = Tertiary education (completed university / technikon / college)	6.	6.	6.
7. Don't know	7.	7.	7.

PARENTAL EMPLOYMENT: (Please circle appropriate number)

Hollingstead categories:	Biological mother	Biological father	Guardian
1. Higher executives, major professionals, owners of large businesses)	1.	1.	1.
	2.	2.	2.

2. Business managers of medium sized businesses, lesser professions (e.g. nurses, opticians, pharmacists, social workers, teachers)	3.	3.	3.
3. Administrative personnel, managers, minor professionals, owners / proprietors of small businesses (e.g. bakery, car dealership, engraving business, plumbing business, florist, decorator, actor, reporter, travel agent)	4.	4.	4.
4. Clerical and sales, technicians, small businesses (e.g. bank teller, bookkeeper, clerk, draftsperson, timekeeper, secretary)	5.	5.	5.
5. Skilled manual – usually having had training (e.g. baker, barber, chef, electrician, fireman, machinist, mechanic, painter, welder, police, plumber, electrician)	6.	6.	6.
6. Semi-skilled (e.g. hospital aide, painter, bartender, bus driver, cook, garage guard, checker, waiter, machine operator)	7.	7.	7.
7. Unskilled (e.g. attendant, janitor, construction helper, unspedified labour, porter, unemployed)	8.	8.	8.
8. Homemaker	9.	9.	9.
9. Student, disabled, no occupation			

MATERIAL AND FINANCIAL RESOURCES (ASSET INDEX): (Please circle appropriate number)

Which of the following items, in working order, does your household have?

Items	Yes	No
1. A refrigerator or freezer	1.	1.
2. A vacuum cleaner or polisher	2.	2.
3. A television	3.	3.
4. A hi-fi or music center (radio excluded)	4.	4.
5. A microwave oven	5.	5.
6. A washing machine	6.	6.
7. A video cassette recorder or dvd player	7.	7.

Which of the following do you have in your home?

Items	Yes	No
1. Running water	1.	1.
2. A domestic servant	2.	2.
3. At least one car	3.	3.
4. A flush toilet	4.	4.
5. A built-in kitchen sink	5.	5.

6. An electric stove or hotplate	6.	6.
7. A working telephone	7.	7.

Do you personally do any of the following?

Items	Yes	No
1. Shop at supermarkets	1.	1.
2. Use any financial services such as a bank account, ATM card or credit card	2.	2.
3. Have an account or credit card at a retail store	3.	3.

Appendix C

Health Index

Health

1. **Have you ever experienced a head injury (e.g., being hit on the head with an object and losing consciousness as a result)?**

   YES NO

   If yes, please give details of the injury:

   _____

   _____

2. **Have you ever been involved in a motor vehicle accident?**

   YES NO

   If yes, how old were you at the time?

   _____

   If yes, how serious was it? (LOC?, PTA?, admitted to hospital, other injuries?)

   _____

   _____

3. **Have you ever been referred to a Psychologist/Psychiatric service?**

   YES NO

   If yes, please elaborate on the nature of the referral:

   _____

   _____

4. **Are you diabetic (high blood sugar)?**

   YES NO

   If yes, what type of diabetes do you have? How long have you had it? Is it under control?

   _____

   _____

5. **How often do you consume:**
   - **a.** Alcohol _____
   - **b.** Cigarettes _____
   - **c.** Other, please specify _____

6. **Do you now, or have you ever, experienced any of the following medical conditions:**
   - **a. Allergies**

     YES NO

     If yes, please specify:

     _____

   - **b. Asthma**

     YES NO

   - **c. Tuberculosis**

     YES NO

   - **d. Hypertension (high blood pressure)**

     YES NO

   - **e. Epilepsy (i.e., seizures or fits)**

     YES NO

f. Neurological problems (i.e., Parkinson's, Huntington's, stroke, etc.)

YES NO

If yes, please specify:

_____

g. Depression

YES NO

h. Memory problems

YES NO

If yes, please specify:

_____

i. Learning difficulties (dyslexia, ADD/ADHD)

YES NO

If yes, please specify:

_____

j. Problems with your vision

YES NO

If yes, please specify:

_____

k. Problems with your hearing

YES NO

If yes, please specify:

_____

l. Do you have any family history of any of the above medical conditions?

YES NO

If yes, please specify:

_____

m. Are you currently taking any prescription medication(s)?

YES NO

If yes, please specify:

Appendix D

Informed Consent Document

Consent Form

University of Cape Town

Intraindividual Variability, Cognitive Performance, and Academic Achievement

Purpose

I am a UCT Psychology Honours student. My research investigates intraindividual variability (IIV) in cognitive performance (in other words, how people perform differently every time they take a cognitive test, even when the test is the same from occasion to occasion). What I want to do in this study is see how IIV in cognitive performance is related to academic achievement. I am also interested in how individual factors (e.g., your schooling, where you grew up, etc.) influence that relationship.

Procedure

If you decide to participate in this study, you will be asked to complete several paper-and-pencil questionnaires and cognitive tests. These questionnaires will gather general information about your background (your age, where you grew up, etc.) and your mood. The tests will focus on things like memory and problem-solving. You will also be asked to complete some computerised cognitive tests. This should take about 45-60 minutes.

At the end of the session, you will be asked to schedule times when you will return for a second and a third test session. At those sessions, you will complete the same cognitive tests as before. Those sessions should take about 30 minutes.

As part of the study, we would like to have access to your first-semester course marks. Please indicate below whether you give us permission to access those marks.

Possible Risks

There are no risks of social, psychological, or physical harm.

Possible Benefits

If you complete all 3 test sessions, you will receive 3 SRPP points and you will be entered into a prize-giving draw. First prize is a R1000 Cavendish gift voucher; second prize is a R500 voucher; third prize is a R250 voucher.

Voluntary Participation

Participation in this study is completely voluntary. You are free to refuse to answer any question without giving reasons for your refusal. Your decision regarding participation in this study will not affect your grades or academic career. If you decide to participate, you are free to change your mind and stop participation at any time without any negative consequences.

Confidentiality

Information about you obtained for this study will be kept confidential. Your name and other identifying information will not be kept with the interview information. It and this consent form will be kept in separate, locked file cabinets, and there will be no link between the consent form and the questionnaires and cognitive tests. The results of the cognitive tests will not be available to your university or any current or future employers, nor will it be made available to anyone else. Any reports or publications about the study will not identify you or any other study participant.

Questions

Any study-related questions, problems or emergencies you can contact me:

Meelan Vanmali vmeelan@gmail.com

If you have questions about your rights as a study participant, or any comments or complaints about the study, please contact Rosalind Adams at the UCT Department of Psychology, 021 650 3417, rosalind.adams@uct.ac.za.

I have read the above and am satisfied with my understanding of the study and its possible benefits and risks. My questions about the study have been answered. I hereby voluntarily consent to participation in the research study as described.

Please check one box:

☐ Yes, I give permission to the researchers to view my first-semester course marks

☐ No, I do not want the researchers to view my first-semester course marks

_____

Name of Participant

_____ _____

Signature of Participant Date