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Investigating the relationships between verbal fluency, processing speed and demographic variables in a multilingual South African Sample.

By

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Abstract

This study examined the association between phonemic and semantic verbal fluency as measured by the Controlled Oral Association Test (COWAT-FAS and animals) test, and demographic variables (age, years of education, language experiences, and socioeconomic status) and further the moderating effect of processing speed measured by the Symbol Digit Modality Test (SDMT) on the relationship between verbal fluency performance and demographic variables. The study comprised a sample of 97 healthy adults between 20 to 60 years from diverse educational backgrounds with multiple language experiences. Pearson's correlation revealed a significant positive associations between the COWAT F trial and SDMT ($r = 0.302$; $p < 0.01$) and COWAT A trial SDMT ($r = 0.633$; $p < 0.0001$). A moderate positive association was found between SDMT ($r = 0.424$; $p < 0.0001$) on COWAT S trial. A negative association was observed between the COWAT Animals trial and SDMT Oral and Written scores. The results showed that when processing speed was introduced as a moderator, years of education and English as a first language in the COWAT F trial were not significant. Processing speed moderated the association of Years of education, number of languages, and English as a first language on the COWAT A trial. The findings highlight that demographic variables contribute to verbal fluency performance. However, processing speed plays a dominant role in the performance outcome, changes in verbal fluency due to aging and low education may be linked to reductions in cognitive efficiency

Keywords: processing speed, verbal fluency, demographic variables, cognitive performance, multilingualism.

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List of Abbreviations

VF	Verbal Fluency
COWAT	Controlled Oral Word Association Test
SDMT	Symbol Digit Modality Test
PS	Processing Speed
YED	Years of Education
LSM	Living Standard Measure
NL	Number of languages
EFL	English as First Language

Chapter 1: Theoretical and conceptual background

1. Introduction

Verbal fluency is the capacity to form and articulate words according to specific criteria, which holds significance for effective communication and overall functioning (Wysokinski et al., 2010). In a broader context, verbal fluency demonstrates an understanding of human interaction through language and communication (Francisco et al., 2022). Individuals engaging in verbal fluency tasks must demonstrate adaptability, organizational skills, mental effort, and the ability to exercise inhibition (Olabarrieta-Landa et al., 2015). The cognitive aspect of verbal fluency requires individuals to retrieve information based on specific criteria, such as words starting with designated letters (e.g., F, A, S) and words belonging to predefined categories, including the naming of animals (Tombaugh et al., 1999).

Verbal fluency also assesses the ability of the semantic memory system to store and retrieve information, requiring individuals to access the mental lexicon and involve executive control processes (Francisco et al., 2022; Shao et al., 2014). This implies that verbal fluency can be vulnerable to the effects of neurodegeneration and is often one of the variables most affected in different kinds of neuropathology. Therefore, it is usually included in neuropsychological assessment batteries. It is an easy task to administer, as it requires individuals to produce as many words or generate verbal responses as quickly as possible based on given instructions, such as letters or providing animal names within one minute (Unsworth et al., 2011).

Additionally, as verbal fluency tasks require individuals to articulate words within a specific time frame, this suggests that individuals need to process the information as quickly as possible and produce the required information. This could imply that information retrieval is dependent on how information is received and the speed at which it is processed (Frischkorn et al., 2019). This further suggest that variations in performance on VF tasks can be linked to variations in processing speed, this might reflect cultural, educational and linguistic differences in a diverse population as such South Africa.

This study includes the theoretical and conceptual background of verbal fluency performance based on age, years of education, language experience, and socioeconomic status. Furthermore, the rationale, study aims, and research questions are presented. The methodology, including study design, sample size, instruments used, procedure, and ethics, is detailed in Chapter 2. Chapter 3 presents the results of the study, and Chapter 4 discusses the results in detail, followed by the limitations and recommendations for future studies.

In this chapter, verbal fluency will be conceptualized and the interaction with each demographic variable under consideration will be debated. The second section will continue by presenting the rationale, aims, and research questions.

2. Literature review

2.1. Verbal fluency

Verbal fluency is a cognitive function that is normally linked to the retrieval of words within a specific area, measured on the Controlled Oral Word Association test (COWAT). Verbal fluency tasks are widely used to assess cognitive function, requiring individuals to generate and articulate as many words as possible within a 60-second timeframe (Troyer et al., 2000). These tasks are typically divided into two types: phonemic and semantic fluency. Phonemic fluency, often using the letters F, A, and S, requires participants to generate words beginning with a specified letter, whereas semantic fluency involves producing words that belong to a particular category, such as naming animals (Unsworth et al., 2011).

Semantic fluency tasks rely heavily on individuals' ability to access lexical knowledge and implement memory search strategies. In contrast, phonemic fluency depends more on cognitive flexibility and shifting abilities (Unsworth et al., 2011). According to the two-stage model proposed by Troyer et al. (2000), semantic fluency engages two primary processes: clustering and switching. Clustering refers to the automatic retrieval of words within specific subcategories stored in long-term memory. This stage allows individuals to generate related words quickly. On the other hand, switching, a more effortful and strategic process, involves moving between different subcategories to produce new words (Troyer et al., 2000). These stages demonstrate the complexity of the cognitive mechanisms underlying verbal fluency tasks (Jehahi et al., 2020).

For instance, during a semantic fluency task where individuals are asked to name animals, they first engage in a broad search of subcategories such as wild and domesticated animals (Unsworth et al., 2011). In the clustering stage, individuals may begin by retrieving animals within a specific subcategory, such as wild animals, and generate examples like lions, zebras, and elephants. Exhausting one subcategory, they shift to another, continuing the process. This organized retrieval, categorized by phonemic or semantic criteria, enables participants to systematically produce words until all accessible terms from a subcategory are listed (Kavé et al., 2008). Once they complete one subcategory, they switch to another, demonstrating the use of strategic cognitive processes necessary for effective verbal fluency.

Effective management of these retrieval stages is crucial for verbal fluency performance, as the ability to switch between categories and access stored information significantly impacts the number of words produced. According to Stolwyk et al. (2015), performance on such tasks may be influenced by processing speed, with faster cognitive processing linked to greater fluency. This relationship between semantic network retrieval and processing speed highlights the complexity of cognitive mechanisms underlying verbal fluency tasks.

Verbal fluency performance is characterized by the time taken to respond to the required information because the speed of retrieval from memory is an essential indicator of cognitive processing efficiency. The ability to quickly access and articulate relevant information reflects the functioning of the brain's executive control, memory retrieval, and language processing systems (McDowd et al., 2011). Processing speed refers to the time an individual needs to interpret, process, and generate a response according to the information required (Horning & Davis, 2012).

The tasks involved in verbal fluency present individuals with a stimulus that they must rapidly process and respond to, highlighting a connection between verbal fluency and processing speed (Elgamal et al., 2011). Moreover, processing speed stands as a crucial cognitive function on which verbal fluency tasks depend to assess overall cognitive performance effectively (Hughes & Bryan, 2002). Furthermore, processing speed depends on how quickly individuals receive information transmitted in their nervous system, showing that there is a link between processing speed and the nervous system (Cavanaugh & Blanchard-Fields, 2018).

When individuals process information slowly, that may results in poor verbal fluency performance which may stem from issues in sensory processing, where information is processed slowly into the nervous system, leading to delayed responses. Additionally, a potential loss of neural transmission speed could contribute, possibly due to a slowdown in synaptic communication or the loss of information at each synaptic transmission (Louw & Louw, 2020).

A meta-analysis by Kavé et al. (2008) revealed that individuals with temporal lobe lesions exhibit deficits in semantic fluency compared to their performance on phonemic fluency. This is because the temporal brain region plays a crucial role in semantic memory and language processing. Conversely, adults with focal frontal lesions experience impairments in both semantic and phonemic fluency (Henry & Crawford, 2004). Verbal fluency performance is therefore closely associated with the functioning of the frontal and temporal lobes (Hughes & Bryan, 2002). As a result, both semantic and phonemic fluency tests are widely used as neuropsychological diagnostic tools, given their sensitivity to cognitive impairments linked to frontal lobe lesions and temporal lobe deficits (McDonnell, 2020). These tasks are also easy and quick to administer across different populations, including both healthy individuals and those with clinical disorders (Stolwyk et al., 2015).

2.2. Demographic factors and verbal fluency performance

2.2.1. Age, verbal fluency and processing speed

Demographic factors, such as age, have been shown to significantly influence verbal fluency. Other studies have shown that age-related decline is often a contributing factor affecting the performance of older healthy adults, particularly in semantic fluency tasks. Opdebeeck et al. (2016), support this by asserting that older adults are often associated with lower cognitive performance, this reinforces the trend that is found in other studies demonstrating that verbal fluency declines with age. Older adults may struggle with these tasks due to difficulties in using effective cognitive strategies, such as clustering and switching (Hughes & Bryan, 2002). As individuals age, their cognitive processing speed tends to slow down, which can impact their ability to access and retrieve information from memory efficiently.

However, other studies argue that cognitive decline is a function of normal aging, and this can further be explained by the association with various brain structures that undergo deterioration with age, with the frontal lobe experiencing a more pronounced decline in elderly individuals compared to other brain regions (Elgamal et al., 2011; Soltani et al., 2021). This can further be due to the attributed loss of neurons and synaptic connections crucial for information retrieval (Louw & Louw, 2020).

This slowing down of cognitive processes can lead to delays in responses during verbal fluency tasks and explains why older adults tend to perform lower than younger adults (Jebahi et al., 2022). This age-related decline in performance reflects the impact of neurological changes on cognitive functions necessary for effective verbal fluency. Loonstra et al. (2001), showed a progressive decline in verbal fluency performance with advancing age. Thus, it can be inferred that as individuals age, their performance in verbal fluency tends to diminish. This difficulty in word retrieval reflects broader issues with memory and executive functioning.

Age demonstrates a certain level of influence in verbal fluency as younger adults produce more words than older adults, this is supported by Shao et al. (2014) as they found discernible differences between older and younger individuals in their performance levels. Older adults frequently express challenges in recalling specific words and remembering their intended actions, presenting difficulties in their cognitive abilities for daily tasks (Louw & Louw, 2020). This then results in older individuals encountering increased difficulty in retrieving words from memory compared to their younger counterparts (Stolwyk et al., 2015).

However, while other studies have found that younger adults have better performance than older adults, the study conducted by Hughes and Bryan (2002) demonstrated different findings as they explored the difference between two age groups, 60 individuals aged 17 to 48 years old, and 60 individuals aged 65 to 88 years old, using the Controlled Oral Word Association Test (COWAT) to assess verbal fluency and they discovered that counterintuitively older participants exhibited better performance than their younger counterparts. Other studies report no significant age-related differences in verbal fluency performance, suggesting that participants across varying ages can perform similarly on verbal fluency tests (Shao et al., 2014). This challenges the notion that age inevitably leads to diminished verbal fluency.

This is further supported by the study of Stolwyk et al. (2015) they had 96 younger participants (ages 18-36) and 86 older participants (ages 65-87) and found no significant difference between the two age groups in phonemic fluency. However, they did observe a significant difference in semantic fluency, with older adults performing worse than their younger counterparts. This suggests that while phonemic fluency may remain relatively stable across ages, semantic fluency appears to be more affected by aging because it is vulnerable to the effects of age due to reliance on complex cognitive processes and memory retrieval involved in semantic tasks (Gonzalez-Burgos et al., 2019).

With other studies indicating significant differences between younger and older adults, while others indicate non-significant differences between the two groups, this suggests that the ability of how quickly an individual can access, and process information may influence verbal fluency performance. This shows the importance of processing speed in these tasks (Rodríguez-Aranda, 2003). The variation in verbal fluency performance across different age groups can often be attributed to differences in processing speed

Slower processing speed is theorized to be a significant contributor to age-related differences observed in cognitive measures. Eckert (2010) supports this notion, suggesting that declines in processing speed with age can impact various cognitive functions, including verbal fluency. As individuals age, slower processing speed can lead to delays in retrieving and articulating words, thereby affecting performance on both phonemic and semantic fluency tasks.

Elgamal et al. (2011) supported the idea that the reduced generation of words from semantic categories in older adults is closely tied to processing speed. Their study, involving 130 healthy adults aged 17 to 78 years, measured processing speed using the Trail Making Test and Digit Symbol Substitution, while verbal fluency was assessed using the COWAT test. They found that reduced word generation in semantic fluency among older adults is contingent on processing speed but noted that aging did not impact letter fluency. This indicates that processing speed plays a significant role in how effectively older adults can retrieve and generate words within semantic categories.

Processing-speed theory elucidates the relationship between processing speed and cognitive function (verbal fluency) in older adults (Baudouin et al., 2020). This theory centers on two key mechanisms; 1) The Limited Time Mechanism: Slower processing speeds impose a cap on the amount of work achievable within a given timeframe, thereby impacting performance. This implies that adults may struggle to generate more words within a set time limit, affecting their overall performance. 2) The Simultaneity Mechanism: Slower processing speeds lead to information loss over time, which subsequently influences cognitive function. The theory demonstrates that the speed of processing is a crucial constraint associated with older individuals.

2.2.2. Education, verbal fluency and processing speed

Education plays a crucial role in verbal fluency performance, but the language used in the test may introduce a confounding factor, potentially influencing outcomes for those with lower education levels, as certain words might be challenging to process and articulate (Mathuranath et al., 2003). Additionally, while the years of education (i.e., quantity) can contribute to verbal fluency performance by increasing exposure to cognitive skills development, however, the quality of education is equally important. High-quality education may offer deeper language and cognitive training, which can significantly enhance verbal fluency performance, regardless of the total years of education one could have.

However, years of education has shown to have a significant influence on verbal fluency tasks, as studies have demonstrated that individuals with lower education tend to have lower scores in verbal fluency tasks as they can generate more words compared to those with lower years of education (AlMuayqil et al., 2019; Jebahi et al., 2022; Loonstra et al., 2001; Lubrini et al., 2022; Mathuranath et al., 2003; Wu et al., 2016)

The impact of education on verbal fluency performance extends beyond exposure to language as it shapes cognitive development by creating space for critical thinking, problem-solving skills, and increased vocabulary exposure. Individuals with more years of education are likely exposed to a wider, deeper vocabulary and more complex linguistic structures, which allows them to generate words more efficiently during verbal fluency tasks (AlMuayqil et al., 2019; Jebahi et al., 2022). The positive correlation between years of education and verbal fluency performance, as demonstrated by multiple studies (Loonstra et al., 2001; Lubrini et al., 2022; Mathuranath et al., 2003; Wu et al., 2016), supports that idea that individuals with quantity of education are more exposure to a wider vocabulary as those individuals with higher levels of education can easily access and retrieve words compared to those with less levels of education (Santos Nogueira et al., 2016).

Semantic and phonemic fluency tasks are grounded in our everyday language activities, this implies that the tasks assess words that individuals use daily. However, this does not change the fact that individuals with higher levels of education tend to perform better in semantic fluency, as they produce more words than those with lower education, increasing the likelihood of good performance (AlMuayqil et al., 2019; Mathuranath et al., 2003). This further emphasizes that higher education levels are often associated with a broader mental lexicon and better access to semantic networks, enhancing both phonemic and semantic fluency.

Furthermore, this reinforces the idea that education contributes to the development of cognitive mechanisms critical for efficient word retrieval (Santos Nogueira et al., 2016). The quantity of education equips individuals with critical thinking skills that contribute to the ability to access information quicker during verbal fluency tasks leading to better performance.

However, the quantity of education in older adults tends to be different as this may be associated with the historical context in which older adults faced greater challenges in accessing higher education during the apartheid era as compared to younger generations now as a result, older adults, often with lower education levels, tend to exhibit lower performance compared to younger adults with higher education (Lubrini et al., 2021). Lower educational attainment was associated with a reduced vocabulary, although the rate of word production remained consistent in some studies (Zimmermann et al., 2014). In contrast, participants with higher education achieved higher scores, indicating superior performance compared to those with lower education levels.

It is evident that education seems to act as a protective factor against cognitive aging, as older individuals with higher levels of education demonstrate the ability to generate more words than their counterparts with lower education levels (Nejati, 2010). Adults with more years of education exhibited improved performance, aligning with the findings of (Mohammadisabet et al., 2016).

Furthermore, understanding the association between level of education (quantity) and verbal fluency is important as this can shed information on educational status that may impact the development of certain cognitive systems, and guide the stratification needed for normative studies so they can be clinically used. Therefore, it is relevant to examine the association between education status and verbal fluency to understand if this directly influences performance in healthy South African individuals.

With previous studies showing that education influences verbal fluency, does it suggest that individuals who are highly educated are fast in processing the information and providing the required information. The other studies did not explore the chance of how processing speed can be the direct influence of performance in verbal fluency.

2.2.3 Socioeconomic status, verbal fluency and processing speed

Socioeconomic status (SES) is defined as an individual's position within the socioeconomic hierarchy, encompassing factors such as education, employment, and income, which provide insight into their economic standing within the society (Berkman et al., 2014). SES can significantly impact cognitive functions, with lower SES being associated with a higher risk of inadequate nutrition, limited resources, exposure to violence and stress, and insufficient cognitive stimulation (Duncan et al., 2017; Evans, 2004; Noble et al., 2015). These factors contribute to a higher likelihood of poorer performance on cognitive tasks among individuals with lower SES, as they affect overall development and health (Ihle et al., 2018). However, the extent to which SES influences verbal fluency performance in healthy individuals, particularly within South African samples, remains unclear. This study aims to explore and clarify the relationship between SES and verbal fluency performance among healthy adults in South Africa.

Most studies have predominantly concentrated on examining the impact of low socioeconomic status on children and aging populations (Prigatano et al., 2008; Steptoe & Zaninotto, 2020). Children from lower SES have low verbal fluency scores and this could be explained better in terms of language development by looking at the child's cognitive learning mechanisms, which could be influenced by the quality of interaction between caregivers and the child, and lastly the accessibility of education and resources both at home and in the community is very low (Pace et al., 2017). Interestingly, existing literature presents conflicting perspectives on the extent of SES's impact on cognitive performance.

Prigatano et al. (2008) reported that children from low socioeconomic backgrounds exhibited higher verbal fluency scores than their counterparts in the middle class, in their study, they had 213 children majority from Hispanic and they didn't mention what they used to measure SES besides the fact that they were flagged by the school district as children from low SES family background. On the contrary, children from low socioeconomic status backgrounds perform below those with higher socioeconomic status in verbal fluency. This could be impacted by factors such as less access to educational resources (i.e., libraries, and schools being very far from home) and fewer cognitive stimulation (Pace et al., 2017).

Socioeconomic status significantly contributes to verbal fluency performance, studies have shown that individuals with higher SES tend to have a higher cognitive function which leads to better performance than those with lower SES, as they produce fewer words during the tasks (Nutakor et al., 2021; Pace et al., 2017; Schrempft et al., 2023; Wörn et al. 2017). This emphasizes the impact of SES in verbal fluency tasks and further suggests that individuals with lower SES may be affected by environmental stressors that contribute to poor performance.

There is evidence suggesting that lower socioeconomic status (SES) is associated with poorer cognitive performance, which can impact various cognitive tasks (Steptoe & Zaninotto, 2020). A study by Bialystok and Shorbagi (2021) investigated the combined effects of SES and bilingualism on verbal fluency and executive functions. Their findings revealed that in semantic fluency tasks, individuals from both lower and higher SES backgrounds performed similarly. However, in phonemic fluency tasks, children from higher SES backgrounds demonstrated better performance compared to their lower SES counterparts. This indicates that SES may exert a more significant influence on phonemic fluency than on semantic fluency. This differential impact highlights the need to consider how socioeconomic factors uniquely affect various aspects of cognitive performance and suggests that SES-related disparities might be more pronounced in tasks requiring rapid, letter-based word generation.

Understanding the association between SES and verbal fluency is important as this can shed information on how environmental factors may impact the development of certain cognitive systems. Therefore, it is relevant to examine the association between SES and verbal fluency to understand if this directly influences performance in healthy South African individuals. The effect of SES may be multifaceted and to further understand this, the effect of processing speed is investigated as a moderator of performance.

2.2.4. Language, verbal fluency and processing speed

Language serves as a foundational element in both human cognition and society, playing a crucial role in facilitating communication (Gonzalez-Burgos et al., 2019). Individuals who can speak more than two languages are commonly referred to as multilingual, while those who speak only one language are referred to as monolingual (Luo et al., 2010). The disadvantage of being multilingual is that individuals may experience language interference which may affect the ability to retrieve and produce words quickly, and also individuals may have different levels of language proficiency affecting their overall performance.

Additionally, cognitive performance in multilingual individuals can be influenced by additional factors such as the language predominantly used in education and the primary language of the community, this implies that the interplay between the language of education (academic subjects) and the primary language of the community (the language most used in the community) shapes the vocabulary of multilingual individuals (Bethlehem, 2003). For example, if an individual resides in a community where they communicate in Sepedi and attends a school that communicates in English only, this could challenge their cognitive skills as they would be more proficient in the language, they are more exposed to. The discrepancy between these two language environments can create difficulties in accessing and retrieving vocabulary in both languages, thereby influencing overall cognitive performance.

Multilingual individuals face challenges during verbal fluency tasks as they might require the need to update their immediate social context and switch to the appropriate language being assessed, the switching of languages can affect performance (Anton et al., 2019). This suggests that individuals may initially think about their responses in the language they use daily and then translate them into the language they are being assessed in, which might not be their home language but rather first or second language. This further implies that multilingual individuals might face additional hurdles in verbal fluency tasks due to the need to navigate between different linguistic systems, potentially impacting their overall performance in both semantic and phonemic fluency assessments.

However, multilingual individuals are frequently exposed to a broader and more diverse vocabulary. This exposure can enhance their ability to access and retrieve words efficiently, potentially leading to improved performance in generating words during fluency tasks (Bethlehem, 2003). The regular use and practice of multiple languages may also strengthen cognitive processes related to language production and executive function, contributing to better verbal fluency outcomes.

The correlation between verbal fluency and multilingualism has shown a positive impact on verbal fluency performance, studies have demonstrated that individuals who are multilingualism tend to exhibit better performance by having higher scores in letter and semantic fluency (Luo et al., 2010; Patra et al., 2020). This suggests that individuals who are proficient in two languages may have an advantage in generating more words. Furthermore, this observation underscores potential weak links between languages in bilingual individuals.

The research conducted by Soltani et al. (2021) consisted of 12 bilingual and 12 monolingual individuals assessed on semantic and phonetic fluency and revealed that monolingual individuals outperformed bilinguals. This outcome was attributed to the longer time required for word retrieval in bilingual individuals. Monolinguals might have high chances of word retrieval as they are not conflicted in the multilingual mind on which language to respond in. This could be attributed to the dependence of word retrieval on semantic categories, as suggested by Luo et al. (2010). Friesen et al. (2015) revealed that there is no significant difference between monolinguals and multilinguals individuals in semantic fluency, their sample had individuals who spoke English only and those who spoke English with other languages daily and they performed the same.

The comparison between bilingual or rather multilingual and monolingual individuals on verbal fluency performance (semantic and phonemic) reveals varying findings across the studies (Francisco et al., 2022; Friesen et al., 2015; Luo et al., 2010; Patra et al., 2020; Soltani et al., 2021). To date, it is unknown whether multilingualism has an advantage on performance in verbal fluency. Individuals who speak more than three languages might provide a clear understanding if the number of languages does indeed affect performance in verbal fluency or if it is influenced by the speed at which individuals are quick to process information and produce words in the language of the assessment.

Therefore, investigating various demographic factors that influence verbal fluency performance, particularly using the COWAT-FAS in non-WEIRD population, can provide valuable insights into the factors affecting cognitive assessment outcomes. This study aimed to examine the association between verbal fluency and demographic variables and further investigate the moderating effect of processing speed on the association between verbal fluency and demographic variables.

3. Theoretical Framework

Psychological assessments in South Africa are shaped by the country's diverse population, socio-cultural, and historical context, which poses challenges to their validity and applicability in clinical, educational, psychometric, and research settings. Addressing these challenges involves raising awareness of cultural considerations in assessments, ensuring that tests are validated to use in the South African context, and emphasizing fairness, cultural relevance, and inclusivity, given the country's multiethnic and multilingual population.

Historically, assessments were developed in Western contexts during the colonial and apartheid era, often reinforcing racial discrimination and overlooking the linguistic, cultural, and socio-economic diversity of South Africans (Laher & Cockcroft, 2017). Additionally, during the apartheid era, the psychological assessments were developed to support the apartheid regime's ideology of racial superiority, particularly in education and employment, the tests were normed on Western populations reinforcing racial stereotypes and inequalities as they were often used to justify segregation and economic disparity creating mistrust of testing among marginalized population (Laher & Cockcroft, 2013).

Furthermore, psychological assessments developed into different domains beyond clinical settings during the 1960s and 1980s. This development included their use in educational settings to evaluate student's learning skills and cognitive abilities, as well as in the industrial settings for employment selection. Local tests were also developed to account for cultural diversity. However, these assessments were used to marginalize black South Africans, as they continued to serve the apartheid system (Laher, 2024). In 1980, researchers addressed the biases inherent in the assessments, leading to the development of culturally sensitive tests. During this period of developing equitable assessments, the Human Science Research Council (HSRC) played a key role by considering the country's cultural diversity and ensuring that the tests were not biased against the black population (Laher, 2024).

The cultural relevance of these assessments poses concerns that they may not always be appropriate due to language barriers, educational disparities, and the underrepresentation of African knowledge systems in psychological theory (Foxcroft, 2004). The assessments are biased toward Western norms and practices and do not consider African norms and their practices. These concerns prompt efforts to develop assessments that reflect the country's multicultural landscapes, considering that South Africa has 11 official languages and cultural norms of different ethnic groups (Laher & Cockcroft, 2013).

Language diversity is a significant challenge in psychological assessments in South Africa, as these assessments are developed and administrated in English which could be a second or third language for most South Africans. For individuals who are not proficient in English, this poses difficulties in understanding the tests and may potentially impact their performance. Furthermore, translating the language assessment into the appropriate language that the individual is more proficient in is not a solution as it introduces complexities regarding the preservation of the test validity and reliability (Foxcroft & Roodt, 2013). The assessments will lose their meaning and affect the assessment's effectiveness.

The post-apartheid era saw the importance of transforming these practices, emphasizing the need to create standardized assessments that reflect the cultural relevance and the need to consider the country's diverse population. Despite the transformation, certain concerning challenges such as accessibility, cross-cultural applicability, and language barriers persist and hinder equitable testing (Foxcroft, 2004; Laher, 2024).

However, the Employment Equality Act (No. 55 of 1998) regarding ethics and legislation has assisted in ensuring that psychological assessments are scientifically valid, reliable and minimize cultural bias, and promote non-discriminating tools (Laher & Cockcroft, 2013). Therefore, they have been some initiatives to develop assessments that are more inclusive of cultural and linguistic appropriate such as the South African Personality Inventory (SAPI) and the South African Weschler Adult Intelligence Scale (SA-WAIS) (Laher & Cockcroft, 2013).

However, as South Africa reflects on three decades of democracy, it is evident that there is a need for innovation in psychological assessments to ensure that tools are relevant and address the diversity needs of the country's diverse population particularly, cultural norms and language barriers. This includes acknowledging and adapting assessments that already exist to South African culturally context and developing tools that incorporate local cultural knowledge (Laher, 2024). This suggests that continued research is needed to ensure that psychological assessments adapt to fairness, equity, and inclusivity in a diverse population such as South Africa.

4. Rationale

The proposed study seeks to delve into the intricate interplay between verbal fluency, processing speed, and demographic variables within a healthy multilingual South African sample. Previous research has examined verbal fluency regarding age, processing speed, education level, socioeconomic status (SES), and language (Abdel Aziz et al., 2017; Aki et al., 2022; Bolla et al., 1998; Elgamal et al., 2011; Francisco et al., 2022; Loonstra et al., 2001; Luo et al., 2010; Steptoe & Zaninotto, 2020).

However, many of these studies are rooted in WEIRD contexts (Western, Educated, Industrialized, Rich, and Democratic societies) and often overlook the potential moderating role of processing speed on the relationship between demographic factors and verbal fluency performance. Although some age-related studies have explored this interaction (Elgamal et al., 2011), the broader impact of processing speed as a moderator remains under-researched. Understanding whether demographic differences in verbal fluency are influenced by individual variations in processing speed could provide valuable insights.

It is evident that demographic factors such as age (Stolwyk et al., 2015), education level (Luo et al., 2010), and the number of languages spoken (Patra et al., 2020) influence verbal fluency. However, while SES has been shown to affect verbal fluency in children, this effect is less clear in adults (Steptoe & Zaninotto, 2020). South Africa's rich linguistic diversity offers a unique context to investigate how multilingual individuals perform in verbal fluency tasks. This study will provide valuable insights into the effects of language proficiency and language switching on cognitive processes in a multilingual setting, which can potentially provide insight into how the language used to assess the assessments can affect the overall performance. Moreover, it will explore whether processing speed moderates the relationship between demographic variables and verbal fluency, shedding light on whether how individuals receive, processes and response to the information is what affects their performance rather than the demographic variables.

This study will contribute to understanding the relationship between verbal fluency, processing speed, and demographic variables, which have significant clinical relevance, particularly in the context of neuropsychological assessments. The contribution of the study lies in enhancing our understanding of how demographic variables and processing speed influence verbal fluency which underscores the importance of considering these variables as potential sources of bias in cognitive testing. Furthermore, understanding these influences is crucial for managing biases in verbal fluency assessments, more specifically when working with multilingual individuals and in non-WEIRD contexts. This knowledge will enhance the accuracy and fairness of cognitive evaluations in diverse populations, ultimately improving the effectiveness of neuropsychological assessments.

Therefore, the present study aims to encompass all relevant demographic variables such as age, years of education, language experience (including the number of languages spoken and whether English is the first language), and socioeconomic status to understand their collective impact on verbal fluency performance among South Africans. The study proposes that each demographic variable might influence performance on the COWAT (FAS and animal), with processing speed potentially moderating these relationship. This approach aims to create a model that can better predict performance on verbal fluency tasks by incorporating both independent and moderating variables.

5. Research Aims

1. Examine the associations between verbal fluency measured on COWAT (F, A, S and Animals) test and demographic variables such as age, years of education, language experience (number of languages known and whether English is reported as first language) and Socioeconomic status.
2. Investigate the moderating effect of processing speed measured by Symbol Digit Modality Test on the association between demographic variables (age, years of education, language experience in terms of number of languages known and whether English is reported as first language and socioeconomic status) and verbal fluency.

6. Research Questions

The general aim of the study was to explore if processing speed (measured by the oral trial of the SDMT) moderated the relationship between demographic variables and verbal fluency (phonetic and semantic). The study will be guided by the following questions:

1 What is the association between processing speed and demographic variables age, years of education, language experience in terms of number of languages known and whether English is reported as first language and Socioeconomic status) and verbal fluency

2 Does processing speed as measured by Symbol Digit Modality Test along with demographic variables (age, years of education, language experience in terms of number of languages known and whether English is reported as first language and Socioeconomic status, act as predictors in verbal fluency performance.

Chapter 2: Methods and Materials

This chapter provides insight information on the design, sample size, instruments used, procedure, and ethics of the current study. This will assist in addressing the research questions proposed in Chapter 1. The current study was part of a larger study exploring the effects of processing speed and demographic variables on different cognitive functions such as verbal fluency and working memory.

2.1 Research design

The study was conducted as a quantitative and exploratory investigation, aligning with the principles outlined by (Roestenburg et al., 2021). The research design adopted a non-experimental approach, due to a lack of variable manipulation, and random assignment of participants to conditions (Roestenburg et al., 2021). This approach is suitable for studying naturally occurring relationships between variables, making it acceptable for exploring the complex interplay between demographic factors and verbal fluency performance.

The overarching paradigm shaping the study was post-positivist critical realism, utilizing a correlational, cross-sectional design (Roestenburg et al., 2021). This philosophical approach acknowledges the existence of an objective reality while also recognizing that our understanding of it is inevitably shaped by human cognition, experiences, and social contexts. Critical realism is particularly relevant in psychological research, as it allows for the exploration of complex and often intertwined variables, such as demographic factors and cognitive processes, without assuming a simplistic cause-and-effect relationship.

2.2 Sample and Sampling

The study utilized a non-probability snowball sampling method, a convenience sample of 97 healthy individuals across South Africa. The participants needed to be between 20 to 60 years of age, with 7 to 15 years of education, and proficient in at least three languages. The exclusion criteria: History of psychiatric or neurological illnesses, traumatic brain injuries, substance abuse, or severe language impairment, this was screened during the demographic questionnaires (Appendix C).

2.3.1 Demographic questionnaire

Demographic questionnaires were utilized to collect essential information about the participants, such as age, educational history, the number of languages spoken, and the number of caregivers in the household (Appendix C).

2.3.2 Living Standard Measure

This is a well-established tool for assessing socioeconomic status (Saaf, 2001). This measure comprised 23 series of true/false statements covering various aspects, including household appliances (e.g., telephone/microwave), entertainment devices (e.g., television/DVD player), and municipal services (e.g., flush toilets/tap water). The inclusion of the Living Standard Measure aimed to address the second research aim, which focused on understanding how age, years of education, language experience, and socioeconomic status influence the relationship under investigation. The scoring of the LSM was conducted manually, employing a weighting system.

Each weighted score contributed to determining a final LSM score, which corresponds to a socioeconomic group scale ranging from 1 (indicating the lowest) to 10 (representing the highest).

2.3.3 Language Experience and Proficiency Questionnaire

The LEAP-Q is a self-report tool that is used widely to determine the proficiency of multilingual speakers (Kaushanskaya et al., 2020; Marian et al., 2007). The tool is regarded as valuable and suitable for investigating the language proficiency of multilingual South Africans, and the moderate to high levels of Cronbach alpha support factors that influence first and second language proficiency (62 - .86; Cockcroft & Laher, 2018). For each language, data were collected on the age of acquisition, the age of attaining fluency, the age of commencement of reading, and the age of achieving reading fluency. Participants assessed their proficiency level in speaking, comprehension, and reading using a scale ranging from 0 ('None') to 10 ('Perfect') for each language (Kaushanskaya et al., 2020; Marian et al., 2007). (Appendix E).

2.3.4 Symbol Digit Modality Test (Smith, 1982)

The SDMT was employed to assess processing speed (Smith, 1982). This test serves as a measure of processing speed and involves participants substituting digits for abstract symbols using reference keys, either in written or oral form. The coding keys consist of nine different abstract symbols, each paired with a number, and participants were tasked with writing down the corresponding number for each symbol. Before the main assessment, participants underwent a practice session comprising 10 items, during which they received corrections and assistance to ensure a clear understanding of the task.

The test itself comprised 110 items, and participants were required to complete it within 1-minute. For both oral and written administrations, The test was scored using three metrics: the raw score, which represents the number of correct matches; the total completed, which is the total number of items attempted; and the accuracy score, which is the percentage of correct responses out of the total items attempted (Smith, 1982). The Symbol Digit Modality Test is known for its acceptable test-retest reliability (Smith, 1998). In South Africa, there is limited research on the psychometric properties of SDMT. However, international studies have indicated excellent test-retest reliability with r-value exceeding 0.80 (Benedict et al., 2012).

2.3.5 Controlled Oral Word Association Test (COWAT)

The Controlled Oral Word Association Test was developed by Benton, Hamshier, and Sivan in 1994 (Benton, Hamshier, & Sivan, 1994). The test was developed to assess verbal fluency, specifically; phonemic and semantic fluency and its purpose is to evaluate how spontaneously participants generate words under restricted conditions (Benton, Hamshier, & Sivan, 1994). Participants were instructed to verbally produce words that start with F and after 1 minute, they were asked to produce words that start with S then after 1 minute, they moved on to words that start with F.

Lastly, they were asked to give names of animals as many as possible within I minute. The score was captured based on the number of correct words produced, how many words were repeated, how many were incorrect, and the total errors for each category was scored. The test demonstrated excellent internal consistency of .83 for FAS. Test-retest reliability and correlation between letters 0.85 and 0.94 (Troyer, 2000)

The use of this test in South Africa presented challenges due to the country's 11 official languages, each associated with different socioeconomic statuses influencing educational histories (Katzef et al., 2019). The study addressed the fact that 78% of South African households speak an African language (Statistica, 2018), highlighting the unique linguistic and socioeconomic landscape in contrast to Western industrialized populations.

2.4 Procedure

The proposal of the study was submitted for ethics approval and the study was approved unconditionally (MASPR/23/02) by the Human Research Ethics Committee (Non-Medical). After the ethics approval, there was training on how to administer the assessment which was conducted by Saleha Mohamed-Kola who is a psychometrist registered with HPCSA (PMT0090646). The training was for all the researchers who collected data for this study (Itumeleng Legodi, Thobekile

Cele, Siphokazi Xaba, and Mayuri Lalla). After the training, there was a mock trial on how the assessments are administered with Prof Aline (the supervisor).

This was to ensure adequate administration of the assessments was correct and this was conducted twice before the go-ahead approval. Then the recruitment process started, which involved advertising on social media platforms and through word of mouth. Participants were provided with detailed information about the research and its purpose, supported by an information sheet (Appendix A). They were informed of the voluntary nature of participation and, upon expressing their willingness, proceeded to sign a consent form (Appendix B). Participants then indicated a convenient time for them to undertake the assessments. In the processing of screening the participants no individual met the exclusion criteria, therefore referrals were not necessary.

Before initiation of the assessments, a thorough explanation of the assessments was given, supplemented with practical examples to ensure participants understood the requirements while allowing for any questions. Once participants indicated that they understood what the assessments required, then the assessments commenced, with a 5-minute break between to prevent mental exhaustion. As part of a larger study, additional assessments included Digit Span forward, Digit Span backward, Digit span sequence, Letter-Number sequence, Symbol digit modality test, Semantic and Phonemic tasks, Stroop Interference, and Iowa Gambling Test. All assessments and instructions were administered in English. The average estimated time it took to complete the assessments for each participant was an hour. The data was captured in an Excel sheet with all the raw scores of the test, Saleha Mohamed-Kola and Prof Aline did the quality control before the start of data analysis.

2.5 Ethical Considerations

Ethical clearance was granted by the Human Research Ethics Committee (Non-Medical) at the University of the Witwatersrand (protocol number MASPR/23/02). Participation in the study involved low risk for the volunteers and no direct benefits. However, for participants to cover the transport, they were offered R90.00. Participants were informed of their right to withdraw from the study at any time without facing penalties. Participation was confidential and although data collection was not anonymous, all data used a research ID instead of identifying data. The anonymous data was stored in a password-protected database and managed by the researchers, research intern, and supervisor.

2.6 Data Analyses

The data was analysed using SAS version 9.4 for Windows. Both descriptive and inferential statistics techniques were used to summarize and analysed the data. Descriptive statistics were generated for the demographic variables including age, level of education, number of languages spoken, English as a first language, and lastly socioeconomic status and processing speed and verbal fluency test. Thereafter, correlation and moderation analyses were used to investigate the key variables and explore the moderating effect of processing speed. These analysis are discussed in the following chapter.

Chapter 3: Results

In this chapter, the results of the study are presented. Both descriptive and inferential statistical techniques are included, to analyse the first aim of the study which was to explore the association between demographic variables and the COWAT test. Demographic variables included age, years of education, language experience (number of languages known and English as a first language), and socioeconomic status. While the COWAT test included FAS and Animals, this was analysed by looking at model 1 in the moderation analysis.

The second aim of the study was to determine whether processing speed moderated the association between verbal fluency and demographic variables. The moderating effect of PS on the relationship between independent variables and given dependent variables was investigated using a series of nested general linear models. The models included Model 1 (IV only, for each DV), Model 2 (IV and PS, for significant IV) Model 3 (IV, PS, and their interaction for significant IV), and lastly model 4 (IVs, PS and interactions for all significant IVs). From Model 4, non-significant terms were sequentially removed to derive the most parsimonious model for interpretation. Nested models were compared using the R^2 delta F-test. At each step, the results of the statistical analyses are presented in tables and attention is drawn to the key findings of the study.

3.1 Sociodemographic of the sample

The main research questions involves a regression model for the association between the IVs, PS, and DV, serves as the basis for estimating the sample size. Regression analysis requires a minimum of 5 (ideally 10) participants for each model parameter (Hair et al., 2010). In the worst case scenario, we need 11 parameters to model all of the IVs (one for each of the following: age, years of education, 5 for Living Standard Measure, number of languages, and English as first language); 1 parameter represents PS; and an additional 11 parameters represent the interaction of the IVs with PS, if any of the interactions are significant. This comes to a total of 23 parameters.

A minimum sample size of 23*5=115 people is needed for this, ideally 23*10=230 individuals. The actual sample size of 97 (or even less in the case of some DVs) allows a final model including only 97/5=19 parameters at most. Given that not all IVs and/or moderating effects are likely to have significant associations with the DV, this should not cause insurmountable limitations. In this scenario, a minimum R^2 of 0.20 will be detected as statistically significant with 80% power, which is adequate for the purposes of the study (Hair et al., 2010) Although, G-power analysis is a valuable tool, in this study the sample size was sufficient to detect a minimum R^2 of 0.20 with 80% power, which is considered adequate for the study's objectives and model parameters were carefully considered to ensure the statistical rigor of the analysis. Furthermore, the model included maximum of 19 parameters, adhering to the guidelines of moderation analysis and alignment with the effect size which rendered additional power redundant (Field, 2009).

Descriptive statistics were used to explore the sample in terms of age, years of education, LSM, number of languages spoken and lastly if the participant spoke English as the first language or not. Table 1, of the 97 participants majority were females. The participants were between the ages of 20 and 40 years and all participants had matric but no other education above 13 years. The LSM was grouped into two, majority of the participants (75%) had a score of 8-10 while (25%) were between 5-7. Participants indicated their languages experience in such (5%) spoke one language, (33%) spoke more than two languages and (60%) spoke three languages. The majority of participants (95%) was bilingual or multilingual, and reported speaking another language, and not English, as their dominant or first language (79%). Table 1, gives in detail the sample size of the study.

Table 1

Descriptive statistics of the demographic characteristics of the sample

Variables	Mean (SD) Range
Age	32,4 (10,0) 24-40
Years of Education	12,5 (1.8) 12-13
Gender	n(%)
Female n(%)	64(66%)
Male n(%)	33(34%)
Living Standard Measure	n(%)
5-7	24(25%)
8-10	73(75%)
Number of languages spoken	n(%)
1	5(5%)
2	32(33%)
3	60(62%)
English as first language	n(%)
No	76(79%)
Yes	20(21%)

N=97, LMS included 23 series of true/false statements which covered various aspects including household appliances, entertainment devices and municipal services. This was scored on a scale of 1 (the lowest) and 10 (the highest).

3.2. Descriptive statistics of the tasks.

The descriptive statistics of all the participants performance in the tasks are presented in table 2, which shed light on the distribution of the scores between the tasks. The outliers were not excluded from the analysis as the sample size was small. To determine the distribution of the variables, Shapiro-Wilk test was analysed as it was appropriate for a sample size of the study (Mishra et al., 2019). Skewness and Kurtosis coefficient were assessed along with histogram for each variable. The skewness and kurtosis for both SMDT, Oral and Written and COWAT (FAS and Animals), according to table 2 trial A is the only one above 1, this suggests that the distribution is moderately positively skewed. Therefore, it was decided that parametric analyses (Pearson's correlation) were appropriate given that there is a normal distribution. The inferential analysis only includes the verbal fluency trials and not the errors.

Table 2

Descriptive statistics for speed of processing and verbal fluency.

Variable	N	Mean	Std Dev	Skewness	Kurtosis
Symbol Digit Written Raw score	96	41,9	11,7	-0,06*	0,37*
Symbol Digit Oral Raw Score	96	50,8	13,8	-0,29*	0,09*
COWAT F Raw Score	94	10,7	4,5	0,39*	0,25*
COWAT A Raw Score	94	10,3	6,7	1,14	0,61*
COWAT S Raw Score	94	11,0	4,1	0,27*	0,47*
Total FAS Correct	94	32,1	12,7	0,62*	0,69*
FAS Total Repeated	94	1,1	1,5	2,09	5,02
FAS Total Errors	94	2,1	2,0	1,29	1,47
COWAT Animals Raw Score	94	10,8	5,9	-0,31*	-0,52*
Animal Total Errors	94	0,6	0,8	1,49	1,52

Notes: N= number of participants, SD= Standard deviation, *significant, COWAT= Controlled Oral Written Association Test.

3.3 Inferential Statistics

The first part of inferential statistics was the correlation between demographic variables and verbal fluency which will answer the first research question and the second part is moderation analysis to investigate the potential moderating effect of speed of processing measured by SMDT on the association between verbal fluency and demographic variables such as Age, Years of education, language experience in terms of number of languages known and whether English is reported as First language and socioeconomic status which will answer the second research question of the study. This was explored using a series of nested general linear models which allows for the analysis of categorial/ordinal independent variables.

3.3.1 Correlation

Before assessing the relationships between the variables, it is essential to examine the distribution of the sample. Correlation analysis assumes that the variables are measured at the interval or ratio level, that there is linearity, and that the data approximate a normal distribution (Field, 2009). In this study, The correlation between dependent variables (DVs) was examined using Pearson's correlation coefficient to understand the relationships and potential overlap among the outcomes being measured (Table 3). Although examining the correlation between the IV and DV can be informative, moderation analysis inherently tests whether the IVs are significantly associated with the DVs in the presence of a moderating variable (PS). Therefore, running preliminary correlations was not strictly necessary, as the core relationships were explicitly tested within the moderation models.

Table 3.

Pearson's correlation between COWAT and SDMT

	Symbol_Digit_Written_Raw	Symbol_Digit_Oral_Raw	COWAT_F__Raw	COWAT_A_Raw	COWAT_S_Raw	COWAT_Aminal_Raw
Symbol_Digit_Written__Raw	1					
	96					
Symbol_Digit_Oral__Raw	*.81	1				
	<.0001					
	96	96				
COWAT_F_Raw	*.30	*.28	1			
	0.031	0				
	94	94	94			
COWAT_A_Raw	*.63	*.57	*.44	1		
	<.0001	<.0001	<.0001			
	94	94	94	94		
COWAT_S_Raw	*.42	*.42	*.74	*.44	1	
	<.0001	<.0001	<.0001	<.0001		
	94	94	94	94	94	
COWAT_Aminals_Raw	*-.38	*-.26	0.060	*-.59	0.030	1
	0.0001	0.0092	0.51	<.0001	0.74	
	94	94	94	94	94	94

*=Significant, COWAT= Controlled Oral Written Association Test, SDMT = Symbol Digit Modality Test

3.2 Moderation analysis on the association between demographic variables and COWAT

A general linear model is a model that explains the relationship between the dependent variable and independent variable which is expressed in a linear combination (Hair et al., 2013). The following models were included: Model 1 (IVs one at a time for each DV) this revealed the significant association between IV and DV. Model 2 (IVs one at a time on each DV and PS) this introduced speed of processing as the moderator, this explained the prediction of the relationship between IV and DV. Model 3 (IVs one at a time for each DV, PS and Interaction for significant IV) indicating a significant interaction effect between IV and PS which then demonstrate moderation. Finally, Model 4 (IVs, PS, and interaction for all significant IVs) this confirms the moderation role of PS on the association between the IV and DV.

3. Exploring the moderation effect of PS on the relationship between demographic variables and COWAT F

Before assessing the moderating role of processing speed (PS) on the relationship between demographic variables and the COWAT F trial, an initial model was created to explore the direct association between the independent variables (IVs) and the dependent variable (DV) specifically, the demographics and the F trial of the COWAT. The results indicated no significant associations between age ($Pr > F = 0.61$), gender ($Pr > F = 0.49$), living standards measure ($Pr > F = 0.139$), and socioeconomic status (SES) ($Pr > F = 0.09$) and the F trial. These variables were therefore excluded from the moderation analysis (details in Appendix G).

In contrast, years of education ($Pr > F = 0.003$) and English as a first language ($Pr > F = 0.017$) showed significant correlations with performance on the F trial of the COWAT. These findings suggest that participants with more years of education ($R^2 = 0.09$) and those who speak English as their first language ($R^2 = 0.06$) tend to achieve higher scores on the F trial. These results are summarized in Table 4.

Table 4

Association of independent variables and COWAT F

	COWAT F			
Independent variables	Pr>F	F value	Mean Square	R^2
YED	0.003	0.09	167. 27	0.09
EFL	0.017	0.017	112. 07	0.06

Note: YED= Years of Education, EFL= English as First Language

Two models were developed to determine whether PS had a significant moderating effect on the relationship between the demographic variables that were significantly correlated with trial F—years of education and English as a first language—and processing speed. The first model, presented in Table 4, shows no significant association between years of education ($p = 0.32$) and English as a first language ($p = 0.008$) in the F trial when PS is introduced as a moderating variable. The second model, indicates no significant moderation effect of PS on the relationship between years of education and performance in the F trial.

These findings suggest that although years of education and English as a first language independently influence performance on the COWAT F trial, introducing PS as a moderating factor does not significantly impact performance on the F trial of the COWAT.

3.3.2 Exploring the moderation effect of PS on the relationship between demographic variables and COWAT A

Before examining the moderating effect of processing speed on the relationship between demographic variables and the COWAT A trial, an initial model was developed to assess the direct association between the independent variables (IVs) and dependent variables (DVs)—specifically, the demographics and the A trial of the COWAT. The results showed that gender (Pr >F = 0.59) was not significantly associated with performance and was therefore excluded from the moderation analysis (details provided in Appendix E).

In contrast, age (Pr >F = 0.000), years of education (YED) (Pr >F = 0.000), living standards measure (LSM) (Pr >F = 0.002), number of languages spoken (NL) (Pr >F = 0.000), and English as a first language (EFL) (Pr >F = 0.000) were all significantly correlated with performance on the A trial of the COWAT.

These findings indicate that performance on trial A declines with increasing age (when an individual gets older), resulting in lower scores. However, performance improves with more years of education, leading to higher scores. Additionally, participants with higher LSM scores or those who spoke only one language performed worse on the A trial. The results are summarized in Table 5.

Table 5

The association of independent variables and COWAT A

	COWAT A			
Independent variables	Pr>F	F value	Mean Square	R^2
Age	.0001*	18.42	693.08	0.17
YED	.0001*	83.80	1980.68	0.48
LSM group	0.002*	9.96	405.87	0.10
NL	.0001*	10.24	381.60	0.18
EFL	.0001*	226.85	2957.44	0.71

Note: YED=Years of Education, LSM=Living Standard Measure, NL=Number of languages, EFL= English as First Language, *=significant

Two models were developed to examine whether processing speed (PS) had a significant moderating effect on the relationship between demographic variables that showed a significant correlation with the COWAT A trial, including age, years of education (YED), number of languages spoken (NL), and English as a first language (EFL).

In the first model (Table 6), age was no longer significantly associated with the dependent variable (DV), but PS remained significantly associated. The model's fit was significantly improved (R^2 = 0.34; $p < 0.0001$). Similarly, YED and PS were both significantly associated with the DV, leading to an improved model fit (R^2 = 0.51; $p = 0.020$).

When examining the relationship between living standards measure (LSM) category and PS, both were significantly associated with the DV, with the model fit also improving (R^2 = 0.43; p <

0.0001). However, when LSM group was introduced, it was no longer significantly associated with the DV, while PS remained significant, further improving the model fit ($R^2 = 0.36$; $p < 0.0001$).

For NL and PS, both were significantly associated with the DV, resulting in a better model fit ($R^2 = 0.44$; $p < 0.0001$). Finally, EFL and PS were also significantly associated with the DV, with the model fit showing a notable improvement ($R^2 = 0.74$; $p = 0.0017$).

Table 6

Effects of PS on COWAT A and Significant demographic variables

	p-value	F value	R-square
Age	0.37	23.82	0.34
YED	0.05	5.60	0.51
LSM	0.000*	37.33	0.36
NL	0.000*	40.49	0.44
EFL	0.002*	10.25	0.74

Note: YED=Years of Education, LSM=Living Standard Measure, NL=Number of languages, EFL= English as First Language, *Significant

The second model, presented in Table 7, examined the interactions between processing speed (PS) and various demographic variables. The interaction between age and PS was significant, leading to a significant improvement in model fit ($R^2 = 0.43$; $p = 0.0015$) and the interaction between years of education (YED) and PS was also significant, with a further improvement in model fit ($R^2 = 0.58$; $p = 0.0002$). For living standards measure (LSM) category, the interaction with PS was not significant; only the main effect of PS was significant. The model fit did not improve significantly ($p = 0.21$).

In contrast, a second model examining LSM category showed that although the interaction with PS was not significant, the main effect of PS remained significant, improving the model fit ($R^2 = 0.39$; $p = 0.038$). The interaction between number of languages spoken (NL) and PS, as well as the main effects, were not significantly associated with the dependent variable, and the model fit did not improve ($p = 0.20$). Lastly, the interaction between English as a first language (EFL) and PS was not significant, with only the main effect of PS being significant. The model fit did not improve substantially ($p = 0.062$).

Table 7

The interaction of PS and demographic variables

	p-value	F value	R^2
Age	0.002*	11.25	0.43
YED	0.000*	15.05	0.58
LSM	0.038*	3.90	0.39
NL	0.208	2.05	0.46
EFL	0.062	0.97	0.74

Note: YED=Years of Education, LSM=Living Standard Measure, NL=Number of languages, EFL= English as First Language, *Significant

In Model 4, the variables YED and EFL were excluded due to their strong association with key variables, to avoid multicollinearity. The interaction between NL and PS showed a significant contribution to performance on the A letter category, indicating that the relationship between NL and the A trial of the COWAT is moderated by PS.

Model 1 demonstrates the significant association of demographic variables with performance on the A trial of the COWAT. Model 2 shows how this association changes when PS is introduced as a moderator. Model 3 focuses on the interaction between variables that were found to be significant.

The model that best explains the moderation effect is Model 4P, which includes NL, EFL, PS, and the interaction between NL and PS. Additionally, participants who spoke English as their first language performed better in the A letter category compared to those who did not. Interestingly, as PS increased, participants who spoke only one language showed a decrease in performance, whereas those who spoke two or three languages had improved performance on the A trial of the COWAT.

3.3.3 Exploring the moderation effect of PS on the relationship between demographic variables and COWAT S

Before examining the moderating effect of processing speed (PS) on the relationship between demographic variables and the COWAT S trial, an initial model was developed to explore the associations between the independent variables (IVs) and dependent variables (DVs)—specifically, the demographic variables and the S trial of the COWAT. The results indicated that gender (Pr >F = 0.211) and living standards measure (LSM) (Pr >F = 0.109) were not significantly associated with performance and were thus excluded from the moderation analysis (details in Appendix F).

In contrast, significant correlations were found for, Age (Pr >F = 0.04), Years of education (YED) (Pr >F = 0.0004), Number of languages spoken (NL) (Pr >F = 0.0004), and English as a first language (EFL) (Pr >F = 0.02). These findings suggest that performance on the S trial decreases with increasing age, leading to lower scores among older individuals. On the other hand, performance improves with more years of education, as those with higher education tend to score better. Additionally, individuals who speak only one language performed worse on the S trial compared to those who speak three languages. Similarly, participants whose first language is English performed better on the S trial than those whose first language is not English. These results are summarized in Table 8.

Table 8

The association of independent variables and COWAT S

	COWAT S			
Independent variables	Pr>F	F value	Mean Square	R^2
Age	0.04*	4.22	69.79	0.04
YED	0.000*	13.41	202.56	0.13
NL	0.043*	3.24	52.85	0.07
EFL	0.024*	5.24	86.19	0.05

Note: YED=Years of Education, NL=Number of languages, EFL= English as First Language, *=significant

Two models were developed to assess whether processing speed (PS) had a significant moderating effect on the relationships between the demographic variables that showed significant correlations with the COWAT S trial, namely age, years of education (YED), number of languages spoken (NL), and English as a first language (EFL).

The first model, presented in Table 9, shows the follows that Age was no longer significantly associated with the dependent variable (DV), but PS was significantly associated. The model fit was significantly improved ($R^2 = 0.19$; $p = 0.0001$) and YED was also no longer significantly associated with the DV, but PS remained significantly associated. The model fit improved further ($R^2 = 0.19$; $p = 0.011$). Similarly, NL was no longer significantly associated with the DV, but PS was significantly associated, with a significant improvement in model fit ($R^2 = 0.21$; $p = 0.0001$). Lastly, EFL was no longer significantly associated with the DV, but PS maintained a significant association. The model fit improved ($R^2 = 0.18$; $p = 0.0003$).

These results suggest that when PS is introduced into the model, it becomes a dominant factor, diminishing the significance of the demographic variables (age, YED, NL, and EFL) in predicting performance on the S trial of the COWAT.

Table 9

The effects of PS on COWAT S and demographics

Independent variable	p-value	F value	R^2
Age	.0.53	15.79	0.19
YED	.0.25	7.46	0.19
NL	.0.19	16.44	0.21
EFL	0.85	14.00	0.18

Note: YED=Years of Education, NL=Number of languages, EFL= English as First Language

The second model, presented in Table 10, assessed the interactions between processing speed (PS) and the demographic variables with significant correlations to the COWAT S trial. The results indicates that the interaction between age and PS was not significant, and the model fit did not improve ($p > 0.99$) and the interaction between years of education (YED) and PS was also not significant, with no improvement in model fit ($p = 0.29$). The interaction between number of languages spoken (NL) and PS was not significant, and the model fit did not improve ($p = 0.29$). The interaction between English as a first language (EFL) and PS was not significant; only the main effect of PS was significant, but this did not result in an improved model fit ($p > 0.99$).

These findings suggest that while the main effect of PS was significant, the interactions between PS and the demographic variables did not significantly impact the performance on the S trial of the COWAT.

Table 10

The interaction of PS and demographic variables on COWAT S

Interaction *PS	p-value	F value	R^2
Age	0.99	0.52	0.18
YED	0.29	0.69	01.9
NL	0.29	1.26	0.23
EFL	0.99	0.14	0.18

Note: YED=Years of Education, NL=Number of languages, EFL= English as First Language

3.3.4 Exploring the moderation effect of PS on the relationship between demographic variables and COWAT Animal

Before assessing the moderating effect of processing speed (PS) on the association between demographic variables and the COWAT Animal trial, an initial model was developed to examine the relationship between the independent variables (IVs) and the dependent variable (DV)—specifically, the demographic variables and the Animal trial of the COWAT. The findings revealed that gender (Pr >F = 0.45) was not significantly associated with performance on the Animal trial and was therefore excluded from the moderation analysis (details available in Appendix H).

In contrast, the following variables showed significant correlations with performance on the Animal trial, age (Pr >F = 0.014), Years of Education (YED) (Pr >F = 0.0001), Living Standards Measure (LSM) category (Pr >F = 0.0006), Number of Languages (NL) (Pr >F = 0.007), English as a First Language (EFL) (Pr >F = 0.0001).

These results indicates that in terms of age performance on the Animal trial increases with age and YED performance on the Animal trial decreases with increasing years of education, LSM performance on the Animal trial is higher for individuals with a higher LSM category. NL performance on the Animal trial is lower for individuals who speak only one language compared to those who speak three languages. EFL performance on the Animal trial is lower for individuals whose first language is English. These findings are summarized in Table 11

Table 11

The association of independent variables and COWAT Animal

	COWAT Animal			
Independent variables	Pr>F	F value	Mean Square	R^2
Age	0.015*	6.18	201.99	0.06
YED	.0001*	16.93	498.94	0.16
LSM	0.001*	5.37	155.94	0.19
NL	0.008*	5.16	163.42	0.10
EFL	.0001*	156.61	1964.69	0.63

Note: YED=Years of Education, LSM=Living Standard Measure, NL=Number of languages, EFL= English as First Language, *=significant

Two models were developed to examine whether processing speed (PS) had a significant moderating effect on the relationships between demographic variables that showed significant correlations with the Animal trial of the COWAT: Age, years of education (YED), living standards measure (LSM), number of languages (NL), and English as a first language (EFL). Model 1 Results (Table 12):

Age and PS: The interaction between age and PS was not significantly associated with the dependent variable (DV). The model fit did not improve ($p = 0.19$). YED and PS: Although YED was significantly associated with the DV, PS was not. The model fit did not improve ($p > 0.99$). LSM Category and PS: LSM was significantly associated with the DV, but PS was not. The model fit did not improve ($p = 0.14$). NL and PS: Both NL and PS were significantly associated with the DV. The model fit improved significantly ($R^2 = 0.15$; $p = 0.024$). EFL and PS: Both EFL and PS were significantly associated with the DV. The model fit improved substantially ($R^2 = 0.66$; $p = 0.0056$).

These results suggest that while PS had a notable moderating effect in the relationships involving NL and EFL, it did not significantly impact the relationships involving age, YED, or LSM in the context of the Animal trial of the COWAT.

Table 12

The effect of PS on COWAT Animal and demographic variables

Independent variable	p-value	F value	R^2
Age	0.19	2.11	0.08
YED	0.99*	0.03	0.155
LSM	0.14*	1.46	0.20
NL	0.024*	5.41	0.15
EFL	0.006*	6.13	0.66

Note: YED=Years of Education, LSM=Living Standard Measure, NL=Number of languages, EFL= English as First Language, *significant

The interaction between age and PS was significant, indicating that PS moderates the relationship between age and performance on the Animal trial. The model fit improved significantly ($R^2 = 0.21$; $p = 0.0002$). YED and PS: The interaction between YED and PS was significant, with a notable improvement in model fit ($R^2 = 0.28$; $p = 0.0002$). LSM Category and PS: The interaction between LSM category and PS was significant, but the model fit did not improve ($p = 0.068$). NL and PS: The interaction between NL and PS was not significant, and the model fit did not improve ($p > 0.99$). EFL and PS: The interaction between EFL and PS was not significant, and the model fit did not improve ($p > 0.99$).

These results suggest that PS significantly moderates the relationship between age and YED with performance on the Animal trial, while it does not significantly affect the interactions involving LSM, NL, or EFL.

Chapter 4: Discussion

The primary objective of this study was to explore if processing speed measured by the oral trial of the SMDT moderated the relationship between demographic variables and verbal fluency (phonetic and semantic). Before exploring potential moderation effects, the existence of significant associations between verbal fluency and demographic variables was investigated. In this chapter the results obtained from the correlation and moderation analyses are discussed considering the literature. The methodological limitations and recommendations of the current study are also outlined at the end of this chapter.

4. The influence of demographic variables on verbal fluency and processing speed

4.1 The association between age, verbal fluency, and processing speed

The sample consisted of 97 participants with the age range of 24-40 years old and the evidence suggests that as individuals age, they tend to experience difficulties in retrieving words from memory (Stolwyk et al., 2015). However, the current study focused on a relatively younger sample, with an average age of 32.4 years and an age range of 24 to 40 years. This narrow age range may have influenced the correlations observed. Specifically, the study found no significant association between age and performance on the COWAT F (Controlled Oral Word Association Test for the letter F), suggesting that younger and older adults in this age group perform similarly and that age does not predict verbal fluency in generating words starting with F. This finding aligns with previous research, such as the study by Mathuranath et al. (2003), which also did not find a correlation between age and COWAT performance in a sample of 153 healthy adults.

However, when examining COWAT performance for the letters A and S in Model 1, the study revealed a significant association between age and verbal fluency, indicating that changes in age correspond to changes in verbal fluency scores. Specifically, younger adults outperformed their older counterparts in generating words starting with A and S, which is consistent with the findings of Elgamal et al. (2011), who reported that younger adults demonstrated superior performance in category fluency compared to older adults. This suggests differential age effects on the trials of the COWAT, making A and S more vulnerable to the effect of aging.

To investigate the association further, processing speed was introduced as a moderating variable, and it revealed that age no longer had a direct impact but rather processing speed suggesting that the impact of age on verbal fluency performance is influenced by processing speed. This further indicates that the age-related decline in verbal fluency may not be solely due to aging itself, but rather due to the decrease in processing speed that often accompanies aging. A similar finding on this was reported by Elgamal et al. (2011) who argued that older adults tend to perform lower in verbal fluency due to decline in processing speed. This is supported by (Rodríguez-Aranda, 2003) that processing speed predict performance in verbal fluency, this implies that how individuals process and access information rely on processing speed efficiency.

This raises important questions about the nature of cognitive decline such as the roles of aging and the mechanisms underlying it such as processing speed that potentially drive these decline. While aging may contribute to reduced cognitive abilities, it seems that the decline in processing speed plays a pivotal role. This challenges the notion that age alone is a sufficient predictor of verbal fluency performance (Elgamal et al., 2011).

Furthermore, this supports the processing speed hypothesis in age-related decline, as older adults tend to struggle with generating more words within a given time frame. They may find it challenging to maintain attention and are more likely to lose certain information during the task (Baudouin et al., 2019). Moreover, the current study reveals that the interaction between age and processing speed is significant, indicating that processing speed modifies performance. Interestingly, the animal naming task score was positively associated with age, showing that older individuals produced more animal names than younger individuals. The results indicated that as age increased, performance on the animal naming task also improved, suggesting a direct impact of age on this specific task.

However, when processing speed was introduced as a moderating variable, the direct association between age and animal naming performance disappeared, as did the association between processing speed and animal naming. Despite this, the interaction between age and processing speed remained significant, suggesting that performance on the animal naming task is influenced by processing speed. This implies that the speed at which individuals process information varies across age groups and affects their verbal fluency performance. Additionally, the study found that younger adults with faster processing speed had lower scores, potentially due to less reliance on retrieval strategies. This finding aligns with research by Unsworth et al. (2011), which suggests that younger and older adults may use different retrieval strategies to access information during such tasks.

4.2 The associations between years of education, verbal fluency, and processing speed

The majority of the sample had 12-13 years of education, this indicates that the quantity was acceptable. The findings indicates that years of education was strongly associated with performance across all COWAT trials (F, A, and S), demonstrating that individuals with more years of education scored higher compared to those with fewer years of education. Similarly, years of education were also linked to performance on the animal naming trial, where individuals with higher education levels exhibited lower scores than those with less education. This suggests that those with more education tend to have better semantic fluency.

The strong association between COWAT performance and education is consistent with previous research, which has shown that highly educated individuals typically perform better in verbal fluency tasks compared to those with less education (Abdel Aziz et al., 2017; Aki et al., 2022; Mathuranath et al., 2003). The findings of the current study further support this, indicating that years of education significantly influence verbal fluency, with more educated individuals generating more words. This is consistent with the work of Zimmermann et al. (2014), who found that individuals with lower levels of education tend to score lower in verbal fluency tasks. The evidence suggests that individuals with more education are exposed to a richer vocabulary and possess stronger language skills, which enhances their performance in verbal fluency tasks (Zimmermann et al., 2014).

However, the findings revealed that higher education was associated with lower scores in the animal naming task challenges this straightforward narrative of education always enhancing verbal fluency performance. Semantic fluency tasks tap into well-learned categories of knowledge, suggesting that individuals with lower education may rely more on concrete and familiar categories. This indicates that the cognitive benefits of education may be domain-specific rather than universally advantageous across all verbal fluency tasks. Therefore, educational attainment should be understood as one factor among many that influence verbal fluency performance.

The current study reveals that individuals with more years of education are more advanced, as they are equipped with greater knowledge and critical thinking skills. They are also more accustomed to academic testing environments and adept at employing strategies suited to such tasks, which may explain their superior performance in COWAT trials. Additionally, the study revealed a complex association between processing speed and years of education. When processing speed was introduced as a moderating variable, the findings indicated that years of education no longer contributed to verbal fluency performance on the COWAT F trial directly. However, years of education and processing speed were significantly associated with performance on the COWAT A and S trials. This suggests that processing speed mediates the relationship between education level and verbal fluency performance, indicating that both the level of education and the speed at which individuals process information influence their performance.

Similar findings from Shirdel et al. (2022) showed no significant difference in verbal fluency scores between individuals with primary and secondary education levels. Furthermore, the association between years of education and the animal naming trial suggests that individuals with more years of education produced fewer animal names than those with fewer years of education. When processing speed was introduced as a moderating variable, the findings revealed that years of education directly influenced performance on the COWAT animal trial, while processing speed was not significant. This indicates that processing speed does not moderate the relationship between years of education and performance on the COWAT animal trial. Instead, years of education directly affect animal naming performance, regardless of how quickly individuals process information. This is supported by findings from Jebahi et al. (2022), which showed that years of education had no effect on animal naming production.

These results suggest that individuals with lower levels of education but higher processing speeds may perform as well as or better than those with higher education. The study also found that the interaction between years of education and the COWAT animal trial was significant, indicating that individuals perform differently depending on the task provided and that both variables—education and task type—play important roles in verbal fluency performance.

4.3 The association between socioeconomic status, processing speed and verbal fluency

The majority of the participants (75%) were between 8-10 indicating that they were much above the average income while 25% were just on average income. In the current study, socioeconomic status (SES) was strongly associated with performance on the COWAT A and animal naming trials. In the COWAT A trial, individuals with higher SES produced fewer words starting with "A" compared to those from lower socioeconomic backgrounds, indicating lower scores. In the animal naming trial, individuals with higher SES outperformed those from lower SES backgrounds, suggesting that greater access to educational opportunities and resources such as libraries and reading materials may enhance language skills and vocabulary.

The study also revealed that the COWAT A and S trials were not significantly associated with SES, indicating similar performance between individuals from both lower and higher socioeconomic categories. In particular, the lack of difference in phonemic fluency tasks like the COWAT F and S trials suggests that linguistic skills may be comparable across socioeconomic groups in these specific tasks.

Previous studies have mostly focused on the impact of SES on verbal fluency in children rather than adults (Pace et al., 2017; Steptoe & Zaninotto, 2020). However, this study focused on older and younger adults, and no significant association emerged in verbal fluency performance on the COWAT F and S trials. Significant associations were only found for the COWAT A and animal naming trials. This further demonstrates that SES has a direct impact on verbal fluency but is sensitive only to specific tasks, such as those involving words starting with "A" and animal naming.

When processing speed was introduced as a moderating variable, SES was no longer significantly associated with the COWAT A trial, while processing speed was. This suggests a shift in influence, indicating that faster processing speed leads to better verbal fluency performance. It implies that even individuals with higher SES may perform poorly in verbal fluency tasks if they have slower processing speeds. Thus, performance related to SES can be better explained by processing speed. There was no interaction between SES and processing speed; both independently affected performance.

In contrast, when processing speed was introduced as a moderating variable in the animal naming trial, SES remained directly associated with performance, while processing speed was not. This suggests that processing speed does not influence performance in the animal naming task. Instead, SES directly impacts verbal fluency in this domain, implying that the ability to access and name animals is independent of processing speed. Therefore, processing speed does not mediate the relationship between SES and performance on the COWAT animal naming trial.

4.4 The association between number of languages spoken, English as first language and processing speed and verbal fluency.

Majority of the participants in this study were proficient in three languages (62%), and 33% were proficient in two languages, while 5% only spoke one language. The current study indicated that the number of languages spoken was not significantly associated with performance on the COWAT F trial. However, it was significantly associated with the COWAT A, S, and animal trials, where individuals who spoke more languages generally had lower scores compared to those who spoke only one language. This finding provides an interesting insight into the relationship between multilingualism and verbal fluency performance, highlighting the potential cognitive benefits of being multilingual. Bilingual individuals generated fewer words than multilingual individuals, suggesting that the latter group may score higher because they are exposed to and have access to diverse linguistic experiences.

This contrasts with earlier research (Anton et al., 2019), which suggested that multilingual individuals might perform poorly on verbal fluency tasks due to frequent language switching to accommodate various interlocutors. In the current study, however, monolingual individuals produced fewer words than their multilingual counterparts, demonstrating lower performance. The discrepancy between this study and previous ones could be attributed to differences in the test administration and population characteristics.

Moreover, multilingual individuals may perform differently based on their proficiency in the test language and their familiarity with language-specific lexical resources. The language in which the assessment was administered and how often does the participants use that language in their daily lives could also contribute to these discrepancies. With South Africa being a diverse population, this poses challenges in language diversity as the assessments are developed and administered in English which is one language that most South Africans are not proficient in and do not see it daily.

The positive effect of multilingualism on performance is likely subtle and may vary depending on factors such as language competency, frequency of language use, and language dominance. Moreover, the relationship between multilingualism and verbal fluency is complex but consistent with the idea of the "multilingual mind" (Hayakawa & Marian, 2019). Bi- or multilingual individuals may face a disadvantage in verbal fluency tasks because they might think of words in another language but struggle to produce them in the language required for the test, in this case, English.

To understand the impact of language experience on verbal fluency, the study also assessed whether speaking English as a first language (EFL) influenced performance. The findings revealed a strong association between EFL and COWAT (F, A, and S) as well as animal trials. In the COWAT F, A, and S trials, individuals who spoke English as their first language had higher scores, likely because they were more familiar with the language used in the assessment as this is their daily language and making it easier to generate the required words. These findings are similar to those of (Ferreira-Correia et al., 2024) which also found that EFL was significantly associated with COWAT A and S trials. However, in the animal naming trial, individuals who spoke English as their first language had lower scores, possibly because naming animals is not a common task in their daily lives.

When processing speed was introduced as a moderating variable, it was significantly associated with the COWAT A and animal trials, indicating that processing speed modifies the relationship between multilingualism and performance on these trials. This suggests that both multilingual and monolingual individuals with high processing speeds can access and retrieve information more efficiently. Interestingly, the number of languages spoken no longer contributed to performance on the COWAT S trial once processing speed was introduced, but processing speed did contribute significantly. This indicates that performance on the COWAT S trial is mediated by processing speed rather than the number of languages spoken, this suggests that individuals were able to quickly process and produce words that starts with S.

Regarding EFL, when processing speed was introduced, both EFL and processing speed were significantly associated with the COWAT A and animal trials. This suggests that the relationship between EFL and performance on these trials is mediated by processing speed. However, no association was found between processing speed and performance on the COWAT F trial, indicating that processing speed does not affect performance in this particular task. Additionally, EFL was no longer associated with performance on the COWAT S trial when processing speed was considered, further indicating that performance in the COWAT S trial is determined by processing speed rather than language background.

Although multilingual individuals may be more exposed to diverse languages, providing easier access to semantic networks, the relationship between multilingualism, EFL, and verbal fluency performance is ultimately mediated by processing speed. This highlights the importance of cognitive processing speed in verbal fluency tasks, regardless of an individual's language background.

Limitations and recommendations for future research

The generalizability of the study's findings is limited by several factors. First, the relatively small sample size may affect the robustness of the regression analysis used to explore the relationships between demographic variables, processing speed, and verbal fluency. Ideally, a sample of around 230 participants would be preferable to ensure adequate representation and enhance the validity of the regression analysis. Therefore, future research should aim to include a larger sample to improve the reliability and generalizability of the findings.

Additionally, the study assessed processing speed only through the oral trial of the SDMT and verbal fluency using the Controlled Oral Word Association Test (COWAT FAS) and an animal naming test. To provide a more comprehensive evaluation of processing speed, it is recommended to incorporate additional measures, such as the Stroop Word and Stroop Colour Tests. Including these tests could offer further insights into the speed at which individuals process information and strengthen the study's findings

Conclusion

The current study examined the association between various demographic variables—such as age, level of education, number of languages spoken, English as a first language, and socioeconomic status (SES)—and verbal fluency performance in a healthy multilingual South African sample.
The findings of the current study revealed that participants with more years of education, those with English as a first language has better performance on COWAT F trial. In COWAT A trial and animal naming, participants demonstrated an even performance across all the demographic variables. Those with younger age, more years of education, more number of languages spoken, and English as first language had better performance on COWAT S trial. SES had lower performance on COWAT S trial.

The study also investigated the role of processing speed as a moderator between demographic variables and verbal fluency. The introduction of processing speed as a moderating variable revealed that years of education and English as a first language were no longer significantly associated with COWAT F trial scores. Age and SES no longer influenced COWAT A performance when processing speed was considered, although processing speed and other demographics remained relevant. For COWAT S performance, processing speed was significantly associated, while demographic variables were not. Finally, for the COWAT animal trial, age, SES, and processing speed were not significantly associated, but other demographics showed relevance.

In conclusion, this study highlights the impact of processing speed on verbal fluency across different demographic variables as individuals with slower processing speeds tend to have poorer verbal fluency performance, while those with quicker processing speeds achieve higher scores.
This suggests that processing speed plays a crucial role in verbal fluency performance across various demographic variables. The study demonstrates that while demographic factors such as education level, language proficiency, and socioeconomic status do impact verbal fluency, processing speed significantly mediates these relationships. This underscores the importance of considering cognitive processing speed when evaluating verbal fluency, as it influences how quickly and effectively individuals process and access information.

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Appendix A: Participant Information Sheet

Psychology
School of Human and Community Development
University of the Witwatersrand
Private Bag 3, Wits, 2050
Tell: (011) 717 4500
Fax: (0110) 717 4559

Participant Information Sheet

Dear Sir/Madam

My name is Itumeleng Legodi. I am psychology research master's student at the University of the Witwatersrand. I am conducting research which forms part of a larger project entitled. *"Exploring the Relationship between Demographic Factors and the Performance in Cognitive Tests: Exploring the mediating Power of Speed of Processing".* The title of my study is: "*Investigating the relationship between Verbal Fluency, Processing Speed and Demographic Variables in a Multilingual South African Sample".* The aim of my study is to investigate the relationship between demographic variables (age, language, education, and socioeconomic status) and cognitive variables (verbal fluency, speed of processing and attention).

I would like to invite you to participate in my study which will require you to answer questions, solve problems, and complete pencil and paper activities. Prior to data collection, you will need to sign a formal consent form, agreeing to participate in this study. You will then need to complete a demographic questionnaire and a battery of cognitive tests.

Your participation will be confidential and only my supervisor and I will have access to your identifying information. Your personal information will be assigned a participant number which will ensure anonymity. The data obtained from this study will be stored on a password protected device and the results will be available on the Internet (World Wide Web) via the University's library website and potentially be published in scientific journals and presented at conferences. If you wish to have access to the results, please contact me or my supervisor using the details below.

If you decide to take part in the research study, it should be because you want to volunteer. You can withdraw from participation at any point without any penalties. You do not have to answer any questions if you do not want to. You will not get any direct benefits if you choose to join the research study. You will not lose any services, benefits, or rights you would normally have if you decided not to join. Taking part in the research study will not cost you anything. You will be compensated a total of R90,00 to cover any transport costs you may incur.

If you have any concerns or complaints about the ethical procedures of this research study, you can contact the University Human Research Ethics Committee (Non-Medical) via the details indicated below.

Human Research Ethics Committee (Non-Medical)

Telephone: 011 717 1408

Email: hrecnon-medical@wits.ac.za

If you have any questions about this research study, feel free to contact me or my supervisor using the contact details provided below.

Itumeleng Legodi
Researcher
Email: 2502213@students.wits.ac.za
Cell: 081 530 3132

Dr Aline Ferreira Correia
Research Supervisor
Email: Aline.FerreiraCorreia@wits.ac.za
011 717 952

Appendix B: Informed Consent Form

Psychology
School of Human and Community Development
University of the Witwatersrand
Private Bag 3, Wits, 2050
Tell: (011) 717 4500
Fax: (0110) 717 4559

Informed Consent Form

Name of researcher: Itumeleng Legodi

Supervisor: Dr Aline Ferreira-Correia

I, ………………………………………………………., am above the age of 21, I confirm that I have read and understood the information sheet and agree to participate in this research project entitled: "*Investigating the Relationship between Verbal Fluency, Processing Speed and Demographic Variables in a Multilingual South African Sample",* which forms part of a larger project entitled: *"Exploring the Relationship Between Demographic Factors and the Performance in Cognitive Tests: Exploring the Mediating Power of Speed of Processing".*

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about. YES/NO

I understand that participation in this study is voluntary. YES/NO

I agree that my participation will remain anonymous (my name or other identifying data will not be used by the researcher in their research report). YES/NO

I agree that other researchers may have access to the information obtained from this study, however, my name and any personal information will not be used or passed on. YES/NO

I agree that any of the information that I provide can be stored by the supervisor and used as secondary data. YES/NO

I understand that as a participant, I can withdraw from this study at any point without any prejudice/penalties. YES/NO

…………………………………… (signature)
…………………………………… (name of participant)
…………………………………… (date)

…………………………………… (signature)
…………………………………… (name of researcher)
…………………………………… (date)

Appendix C: Demographic Questionnaire

Name: ____

Surname: ____

Age: ____________________

Date of Birth:

D	D	M	M	Y	Y	Y	Y

Gender:

____

Ethnicity: _______________________________________

Home Language: _______________________________________

Highest Level of Education: _______________________________

Have you ever failed a grade in school? If so, which one?

____

Have you ever required intervention from a language specialist?

____

Have you ever been diagnosed with a neurological, metabolic or psychiatric illness?

____

Educational and occupational status of your parents or primary caregivers:

Mother: Level of Education		**Father: Level of Education**	
No schooling		No schooling	
Less than primary school completed		Less than primary school completed	
Primary school completed		Primary school completed	
Secondary school not completed		Secondary school not completed	
Secondary school completed		Secondary school completed	
Tertiary education completed		Tertiary education completed	
Other		Other	
Current occupation:		Current occupation:	

Subjective experience of financial resources (fiscal appraisal)

Income comparison

1. At present, how would this household classify its financial situation?
   5-point scale (“Much above average income” to “Much below average income”).

1	2	3	4	5
Much above average income		Average income		Much below average income

2. How would you classify your household in terms of income, compared with other households in your community?
   5-point scale ("Very comfortable" to "Extremely poor")

1	2	3	4	5
Very comfortable		Comfortable		Extremely Poor

Subjective standing

Please imagine a ten-step ladder where the poorest people in South Africa stand on the bottom (the first step) and the richest people in South Africa stand on the highest step (the tenth step). On which step are you on today?

10-point scale

Living Standards Measure:

Please answer the below questions according to your current circumstances.

Question	Answer	
1. I have the following in my household		
TV Set	True	False
Swimming pool	True	False
DVD player	True	False
M-Net/DStv subscription	True	False
Air conditioner	True	False
Computer / Laptop	True	False
Vacuum cleaner/floor polisher	True	False
Dishwashing machine	True	False
Washing machine	True	False
Tumble dryer	True	False
Home telephone (excluding a cell)	True	False

Deep freezer	True	False
Fridge/freezer (combination)	True	False
Electric stove	True	False
Microwave oven	True	False
Built-in kitchen sink	True	False
Home security service	True	False
3 or more cell phones in household	True	False
2 cell phones in household	True	False
Home theatre system	True	False
2. I have the following amenities in my home or on the plot:		
Tap water in house/on plot	True	False
Hot running water from a geyser	True	False
Flush toilet in/outside house	True	False
3. There is a motor vehicle in our household	True	False
4. I am a city dweller	True	False
5. I live in a house, cluster or town house	True	False
Question	**Answer**	
6. I live in a rural area outside Gauteng	True	False
7. There are no radios, or only one radio (excluding car radios) in my household	True	False
8. There is no domestic workers or household helpers in household (both live-in & part time)	True	False

Appendix C: Request for permission to conduct research in International Assemblies of God, Mankweng

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

International Assemblies of God
Mankweng-G
Mankweng, 0727

Dear Reverend, Moetjie

Re: Permission to conduct research at International Assemblies of God, Mankweng.

My name is Itumeleng Gracious Legodi (2502213). I am studying for a master's in social and Psychological Research at the University of the Witwatersrand. The title of my study is speed of processing and strategies in verbal fluency: Variation of demographics as predictors of performance. The study requires participants to complete cognitive assessments in a safe and secure environment, which involves answering and doing pen and paper activities. The research will entail collecting data from individuals who are between the ages of 25-65 years old. The data collection includes answering questionnaires and solving problems and completing, pencil and paper tasks.

For this, I will need a space with a desk or small table, two chairs where the privacy and safety of participants will be honored. For this reason, I am seeking permission to conduct my data collection in the church as it will offer a familiar place for the participants where they feel can feel safe. The assessments will not bring any harm to the participants and will not damage any property of the church. The duration of each assessment is approximately one hour, and the data collection will take place between July 2023 and November 2023. None of this will be tape or video recorded.

Participants will be asked to give their written consent before the data collection begins. Their responses will be treated confidentially, and identities (their names and the name of the organization) will be anonymous and confidentiality will be protected at all stages of the study and participation will be anonymous in all the reporting of the results.

The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. Participant will be given a transport fee of R90.00

I therefore request permission in writing to conduct my research at your church. If you do wish to grant me such permission, please do so by writing using your organization's letterhead, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Itumeleng Legodi
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Appendix D: Shortened Version of Language Experience and Proficiency Questionnaire (LEAP-Q-SV)

Participant No: ________________________________

The Language Experience and Proficiency Questionnaire (LEAP-Q)

1. What languages do you know?

Language A: ______________________________

Language B: ______________________________

Language C: ______________________________

2. Language A:

This is my _______________ (First, second, third) language. All questions below refer to your knowledge of language A.

2.1 Age when you...

Began acquiring this language: ____________

Became fluent in this language: ____________

Began reading in this language: ____________

Became fluent reading in this language: _________

2.2 Please circle your level of proficiency in speaking, understanding, and reading in this language:

Speaking

0	1	2	3	4	5	6	7	8	9	10

None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Understanding Spoken Language

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Reading

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

3. Language B:

This is my ______________ (First, second, third) language. All questions below refer to your knowledge of language B.

3.1 Age when you...

Began acquiring this language: ___________

Became fluent in this language: ___________

Began reading in this language: ___________

Became fluent reading in this language: ________

3.2 Please circle your level of proficiency in speaking, understanding, and reading in this language:

Speaking

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Understanding Spoken Language

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Reading

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

4. Language C:

This is my _______________ (First, second, third) language. All questions below refer to your knowledge of language C.

4.1 Age when you...

Began acquiring this language: ____________

Became fluent in this language: ____________

Began reading in this language: ____________

Became fluent reading in this language: ________

4.2 Please circle your level of proficiency in speaking, understanding, and reading in this language:

<u>Speaking</u>

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

<u>Understanding Spoken Language</u>

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

<u>Reading</u>

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Appendix F: Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE **PROTOCOL NUMBER: MASPR/23/02**

PROJECT TITLE:	Investigating the relationship between verbal fluency, processing speed and demographic variables in a multilingual South African Sample.
INVESTIGATOR	Legodi Itumeleng (2502213)
SCHOOL/DEPARTMENT OF INVESTIGATOR	SHCD/Psychology
DATE CONSIDERED	01 June 2023
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	Low Risk
EXPIRY DATE	31 December 2025

ISSUE DATE OF CERTIFICATE 03 June 2023 **CHAIRPERSON** ____________________
(Dr Aline Ferreira Correia)

cc: Dr Aline Ferreira Correia (Supervisor)

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure be contemplated from the research procedure as approved, I/we undertake to submit an amendment of the protocol to the Committee.

____________________ 07 / 17 / 2023
Signature **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix G; Results for COWAT F and demographics on the moderating effect of processing speed.

Model 1: YED

Dependent Variable: COWAT___F__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	167.275917	167.275917	9.09	0.0033
Error	92	1692.596423	18.397787		
Corrected Total	93	1859.872340			

R-Square	Coeff Var	Root MSE	COWAT___F__Raw_Score_ Mean
0.089939	39.91988	4.289264	10.74468

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	167.2759171	167.2759171	9.09	0.0033

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	1.613899352	3.06027322	0.53	0.5992
Years_of_Education	0.730462520	0.24225013	3.02	0.0033

Model 1: EF

Dependent Variable: COWAT___F__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	112.076896	112.076896	5.84	0.0177
Error	91	1747.234932	19.200384		
Corrected Total	92	1859.311828			

R-Square	Coeff Var	Root MSE	COWAT___F__Raw_Score_ Mean
0.060279	40.75097	4.381824	10.75269

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	112.0768965	112.0768965	5.84	0.0177

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	10.17808219	B	0.51285374	19.85	<.0001
English_as_a_first_l Y	2.67191781	B	1.10591055	2.42	0.0177
English_as_a_first_l N	0.00000000	B	.	.	.

Model 2: YED and PS

Dependent Variable: COWAT___F__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	194.278452	97.139226	5.31	0.0066
Error	91	1665.593888	18.303230		
Corrected Total	93	1859.872340			

R-Square	Coeff Var	Root MSE	COWAT___F__Raw_Score_ Mean
0.104458	39.81717	4.278227	10.74468

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	42.92237994	42.92237994	2.35	0.1291
Symbol_Digit_Oral__R	1	27.00253542	27.00253542	1.48	0.2277

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	2.040259104	3.07251633	0.66	0.5083
Years_of_Education	0.483551252	0.31576535	1.53	0.1291
Symbol_Digit_Oral__R	0.052266497	0.04303135	1.21	0.2277

Model 2: EF and PS

Dependent Variable: COWAT___F__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	176.611674	88.305837	4.72	0.0112
Error	90	1682.700154	18.696668		
Corrected Total	92	1859.311828			

R-Square	Coeff Var	Root MSE	COWAT___F__Raw_Score_ Mean
0.094988	40.21287	4.323964	10.75269

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	24.72472733	24.72472733	1.32	0.2532
Symbol_Digit_Oral__R	1	64.53477770	64.53477770	3.45	0.0665

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	6.774916966	B	1.90038372	3.57	0.0006
English_as_a_first_l Y	1.461569120	B	1.27097122	1.15	0.2532
English_as_a_first_l N	0.000000000	B	.	.	.
Symbol_Digit_Oral__R	0.072029882		0.03877019	1.86	0.0665

Model 3: YED, PS and their interaction

Dependent Variable: COWAT___F__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	194.614672	64.871557	3.51	0.0185
Error	90	1665.257668	18.502863		
Corrected Total	93	1859.872340			

R-Square	Coeff Var	Root MSE	COWAT___F__Raw_Score_ Mean
0.104639	40.03372	4.301495	10.74468

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	5.47506057	5.47506057	0.30	0.5878
Symbol_Digit_Oral__R	1	0.73865683	0.73865683	0.04	0.8421
Years_of_*Symbol_Dig	1	0.33621983	0.33621983	0.02	0.8931

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	3.066989113	8.21928805	0.37	0.7099
Years_of_Education	0.395406275	0.72688977	0.54	0.5878
Symbol_Digit_Oral__R	0.031694175	0.15862716	0.20	0.8421
Years_of_*Symbol_Dig	0.001721181	0.01276834	0.13	0.8931

Model 3: EFL, PS and their interaction

Dependent Variable: COWAT___F__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	190.894778	63.631593	3.39	0.0213
Error	89	1668.417050	18.746259		
Corrected Total	92	1859.311828			

R-Square	Coeff Var	Root MSE	COWAT___F__Raw_Score_ Mean
0.102670	40.26616	4.329695	10.75269

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	8.15693012	8.15693012	0.44	0.5112
Symbol_Digit_Oral__R	1	66.86133034	66.86133034	3.57	0.0622
Symbol_Di*English_as	1	14.28310343	14.28310343	0.76	0.3851

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	7.387614928	B	2.02823566	3.64	0.0005
English_as_a_first_l Y	-4.822619176	B	7.31100203	-0.66	0.5112
English_as_a_first_l N	0.000000000	B	.	.	.
Symbol_Digit_Oral__R	0.059061789	B	0.04156724	1.42	0.1588
Symbol_Di*English_as Y	0.101515951	B	0.11630016	0.87	0.3851
Symbol_Di*English_as N	0.000000000	B	.	.	.

Appendix H: Results for COWAT A and demographics on the moderating effect of processing speed.

Model 1; Age

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	693.084072	693.084072	18.42	<.0001
Error	92	3462.022311	37.630677		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.166803	59.32430	6.134385	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	693.0840718	693.0840718	18.42	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	19.17240874	2.15302422	8.90	<.0001
Age	-0.27309422	0.06363420	-4.29	<.0001

Model 1; YED

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1980.682616	1980.682616	83.80	<.0001
Error	92	2174.423767	23.635041		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.476686	47.01536	4.861588	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	1980.682616	1980.682616	83.80	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-21.07903220	3.46861091	-6.08	<.0001
Years_of_Education	2.51355662	0.27457400	9.15	<.0001

Model 1; LSM Group

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	405.876621	405.876621	9.96	0.0022
Error	92	3749.229762	40.752497		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.097681	61.73603	6.383768	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SES_groups	1	405.8766211	405.8766211	9.96	0.0022

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	11.55714286	B	0.76300625	15.15	<.0001
SES_groups 2	-4.76547619	B	1.51003287	-3.16	0.0022
SES_groups 3	0.00000000	B	.	.	.

Model 1; Number of languages

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	763.202045	381.601022	10.24	<.0001
Error	91	3391.904338	37.273674		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.183678	59.04222	6.105217	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	763.2020448	381.6010224	10.24	<.0001

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	10.20689655	B	0.80165426	12.73	<.0001
LEAP__Number_of_Lang 1	11.79310345	B	2.84559034	4.14	<.0001
LEAP__Number_of_Lang 2	-1.49721913	B	1.35831739	-1.10	0.2733
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.

Model 1; English as a First Yes and No.

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2957.442341	2957.442341	226.85	<.0001
Error	91	1186.385616	13.037205		
Corrected Total	92	4143.827957			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.713698	34.79749	3.610707	10.37634

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	2957.442341	2957.442341	226.85	<.0001

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	7.42465753	B	0.42260128	17.57	<.0001
English_as_a_first_l Y	13.72534247	B	0.91129143	15.06	<.0001
English_as_a_first_l N	0.00000000	B	.	.	.

Model 2; Age and PS

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1411.247875	705.623938	23.40	<.0001
Error	91	2743.858508	30.152291		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.339642	53.10333	5.491110	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	24.4672191	24.4672191	0.81	0.3701
Symbol_Digit_Oral__R	1	718.1638035	718.1638035	23.82	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-.7148284616	4.50772160	-0.16	0.8744
Age	-.0641850172	0.07125273	-0.90	0.3701
Symbol_Digit_Oral__R	0.2580092658	0.05286688	4.88	<.0001

Model 2; YED and PS

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	2106.643559	1053.321779	46.79	<.0001
Error	91	2048.462824	22.510580		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.507001	45.88333	4.744532	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	719.8629027	719.8629027	31.98	<.0001
Symbol_Digit_Oral__R	1	125.9609431	125.9609431	5.60	0.0201

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-20.15817587	3.40740444	-5.92	<.0001
Years_of_Education	1.98027503	0.35018212	5.65	<.0001
Symbol_Digit_Oral__R	0.11288574	0.04772154	2.37	0.0201

Model 2; LSM group and PS

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1793.974997	358.794999	13.37	<.0001
Error	88	2361.131386	26.831038		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.431752	50.09338	5.179869	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SES_LSM_category	4	407.1943405	101.7985851	3.79	0.0068
Symbol_Digit_Oral__R	1	722.9088234	722.9088234	26.94	<.0001

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	1.491199283	B	2.69370199	0.55	0.5813
SES_LSM_category 7	-4.646142633	B	1.84054510	-2.52	0.0134
SES_LSM_category 8	-5.936804299	B	1.84062112	-3.23	0.0018
SES_LSM_category 9	-2.776995797	B	1.42723494	-1.95	0.0549
SES_LSM_category 5-6	-5.043898791	B	1.84170019	-2.74	0.0075
SES_LSM_category 10	0.000000000	B	.	.	.
Symbol_Digit_Oral__R	0.226926108		0.04371812	5.19	<.0001

Model 2; NL and PS

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1815.625331	605.208444	23.28	<.0001
Error	90	2339.481052	25.994234		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.436962	49.30604	5.098454	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	428.844675	214.422337	8.25	0.0005
Symbol_Digit_Oral__R	1	1052.423286	1052.423286	40.49	<.0001

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	-3.327744987	B	2.22997206	-1.49	0.1391
LEAP__Number_of_Lang 1	9.653426015	B	2.40002136	4.02	0.0001
LEAP__Number_of_Lang 2	-0.027447834	B	1.15760808	-0.02	0.9811
LEAP__Number_of_Lang 3	0.000000000	B	.	.	.
Symbol_Digit_Oral__R	0.258652128		0.04064989	6.36	<.0001

Model 2; EFL and PS

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	3078.718135	1539.359068	130.07	<.0001
Error	90	1065.109822	11.834554		
Corrected Total	92	4143.827957			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.742965	33.15367	3.440139	10.37634

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	1685.113519	1685.113519	142.39	<.0001
Symbol_Digit_Oral__R	1	121.275795	121.275795	10.25	0.0019

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	2.75942613	B	1.51194199	1.83	0.0713
English_as_a_first_l Y	12.06613513	B	1.01118250	11.93	<.0001
English_as_a_first_l N	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.09874221		0.03084549	3.20	0.0019

Model 3; Interaction Age and PS

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1716.238518	572.079506	21.11	<.0001
Error	90	2438.867865	27.098532		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.413043	50.34246	5.205625	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	200.0435316	200.0435316	7.38	0.0079
Symbol_Digit_Oral__R	1	685.3065846	685.3065846	25.29	<.0001
Age*Symbol_Digit_Ora	1	304.9906424	304.9906424	11.25	0.0012

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-20.34864946	7.24653639	-2.81	0.0061
Age	0.46977561	0.17290243	2.72	0.0079
Symbol_Digit_Oral__R	0.67764559	0.13475133	5.03	<.0001
Age*Symbol_Digit_Ora	-0.01212839	0.00361520	-3.35	0.0012

Model 3, Interaction YED and PS

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2400.158486	800.052829	41.03	<.0001
Error	90	1754.947897	19.499421		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.577641	42.70438	4.415815	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	13.6392085	13.6392085	0.70	0.4052
Symbol_Digit_Oral__R	1	180.1389962	180.1389962	9.24	0.0031
Years_of_*Symbol_Dig	1	293.5149270	293.5149270	15.05	0.0002

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	10.17792014	8.43772940	1.21	0.2309
Years_of_Education	-0.62408490	0.74620809	-0.84	0.4052
Symbol_Digit_Oral__R	-0.49495073	0.16284295	-3.04	0.0031
Years_of_*Symbol_Dig	0.05085458	0.01310768	3.88	0.0002

Model 3; LSM, PS and interaction.

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1953.535331	217.059481	8.28	<.0001
Error	84	2201.571052	26.209179		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.470153	49.50947	5.119490	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SES_LSM_category	4	65.7782897	16.4445724	0.63	0.6442
Symbol_Digit_Oral__R	1	302.1288839	302.1288839	11.53	0.0010
Symbol_Di*SES_LSM_ca	4	159.5603347	39.8900837	1.52	0.2032

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	-5.88743299	B	4.94023224	-1.19	0.2367
SES_LSM_category 7	10.58233145	B	7.82630558	1.35	0.1800
SES_LSM_category 8	8.64917192	B	8.16605552	1.06	0.2926
SES_LSM_category 9	3.28265402	B	5.97922856	0.55	0.5845
SES_LSM_category 5-6	6.94698098	B	8.15015985	0.85	0.3964
SES_LSM_category 10	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.35401111	B	0.08369160	4.23	<.0001
Symbol_Di*SES_LSM_ca 7	-0.30250046	B	0.15592511	-1.94	0.0557
Symbol_Di*SES_LSM_ca 8	-0.27228790	B	0.15230669	-1.79	0.0774
Symbol_Di*SES_LSM_ca 9	-0.09962820	B	0.10716225	-0.93	0.3552
Symbol_Di*SES_LSM_ca 5-6	-0.23034427	B	0.16422742	-1.40	0.1644
Symbol_Di*SES_LSM_ca 10	0.00000000	B	.	.	.

Model 3: NL and PS interaction

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1919.717122	383.943424	15.11	<.0001
Error	88	2235.389261	25.402151		
Corrected Total	93	4155.106383			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.462014	48.74127	5.040055	10.34043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	142.3234080	71.1617040	2.80	0.0661
Symbol_Digit_Oral__R	1	0.8362078	0.8362078	0.03	0.8564
Symbol_Di*LEAP__Numb	2	104.0917911	52.0458955	2.05	0.1350

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	-3.03387889	B	2.83093393	-1.07	0.2868
LEAP__Number_of_Lang 1	62.55709870	B	27.11311968	2.31	0.0234
LEAP__Number_of_Lang 2	-1.51975982	B	4.17624956	-0.36	0.7168
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.25303624	B	0.05260119	4.81	<.0001
Symbol_Di*LEAP__Numb 1	-0.87223128	B	0.44651759	-1.95	0.0539
Symbol_Di*LEAP__Numb 2	0.03130872	B	0.08199348	0.38	0.7035
Symbol_Di*LEAP__Numb 3	0.00000000	B	.	.	.

Model 3, EFL, PS an their interaction.

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3090.164482	1030.054827	87.01	<.0001
Error	89	1053.663475	11.838915		
Corrected Total	92	4143.827957			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.745727	33.15978	3.440773	10.37634

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	14.54790141	14.54790141	1.23	0.2706
Symbol_Digit_Oral__R	1	97.43540989	97.43540989	8.23	0.0051
Symbol_Di*English_as	1	11.44634665	11.44634665	0.97	0.3281

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	3.307915982	B	1.61182196	2.05	0.0431
English_as_a_first_l Y	6.440502785	B	5.80999231	1.11	0.2706
English_as_a_first_l N	0.000000000	B	.	.	.
Symbol_Digit_Oral__R	0.087133121	B	0.03303314	2.64	0.0098
Symbol_Di*English_as Y	0.090877515	B	0.09242276	0.98	0.3281
Symbol_Di*English_as N	0.000000000	B	.	.	.

Model 4;

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	3249.522006	295.411091	26.76	<.0001
Error	81	894.305951	11.040814		
Corrected Total	92	4143.827957			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.784184	32.02257	3.322772	10.37634

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	6.4631237	6.4631237	0.59	0.4464
SES_groups	1	5.6386304	5.6386304	0.51	0.4769
LEAP__Number_of_Lang	2	143.1803750	71.5901875	6.48	0.0024
English_as_a_first_l	1	0.0745654	0.0745654	0.01	0.9347
Symbol_Digit_Oral__R	1	1.4697702	1.4697702	0.13	0.7162
Age*Symbol_Digit_Ora	1	2.8343896	2.8343896	0.26	0.6138
Symbol_Di*SES_groups	1	2.5009056	2.5009056	0.23	0.6354
Symbol_Di*LEAP__Numb	2	134.0213841	67.0106921	6.07	0.0035
Symbol_Di*English_as	1	30.6596811	30.6596811	2.78	0.0995

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	2.42979946	B	5.65019122	0.43	0.6683
Age	0.10165945		0.13287004	0.77	0.4464
SES_groups 2	-2.55538576	B	3.57577520	-0.71	0.4769
SES_groups 3	0.00000000	B	.	.	.
LEAP__Number_of_Lang 1	54.29594736	B	18.77710880	2.89	0.0049
LEAP__Number_of_Lang 2	-5.91130936	B	3.03011212	-1.95	0.0545
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
English_as_a_first_l Y	0.53926163	B	6.56192628	0.08	0.9347
English_as_a_first_l N	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.09232165	B	0.10966948	0.84	0.4024
Age*Symbol_Digit_Ora	-0.00138918		0.00274176	-0.51	0.6138
Symbol_Di*SES_groups 2	0.03586255	B	0.07535170	0.48	0.6354
Symbol_Di*SES_groups 3	0.00000000	B	.	.	.
Symbol_Di*LEAP__Numb 1	-0.85419652	B	0.30662450	-2.79	0.0066
Symbol_Di*LEAP__Numb 2	0.11037347	B	0.05847497	1.89	0.0627
Symbol_Di*LEAP__Numb 3	0.00000000	B	.	.	.
Symbol_Di*English_as Y	0.17320368	B	0.10393788	1.67	0.0995
Symbol_Di*English_as N	0.00000000	B	.	.	.

Model 4P: most parsimonious model

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	3181.808674	530.301446	47.41	<.0001
Error	86	962.019283	11.186271		
Corrected Total	92	4143.827957			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.767843	32.23282	3.344588	10.37634

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	97.753573	48.876786	4.37	0.0156
English_as_a_first_l	1	1259.957171	1259.957171	112.63	<.0001
Symbol_Digit_Oral__R	1	19.282781	19.282781	1.72	0.1927
Symbol_Di*LEAP__Numb	2	92.383990	46.191995	4.13	0.0194

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	4.28303747	B	2.00037164	2.14	0.0351
LEAP__Number_of_Lang 1	43.59671946	B	18.08054208	2.41	0.0180
LEAP__Number_of_Lang 2	-4.21366210	B	2.78284401	-1.51	0.1337
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
English_as_a_first_l Y	11.64346288	B	1.09710182	10.61	<.0001
English_as_a_first_l N	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.07138167	B	0.03890973	1.83	0.0700
Symbol_Di*LEAP__Numb 1	-0.69057672	B	0.29680804	-2.33	0.0223
Symbol_Di*LEAP__Numb 2	0.08164427	B	0.05462632	1.49	0.1387
Symbol_Di*LEAP__Numb 3	0.00000000	B	.	.	.

Appendix I: Results for COWAT S and demographics on the moderating effect of processing speed.

Model 1; Age

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	69.794474	69.794474	4.22	0.0428
Error	92	1522.035313	16.543862		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.043845	36.83401	4.067415	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	69.79447394	69.79447394	4.22	0.0428

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	13.84524791	1.42756650	9.70	<.0001
Age	-0.08666227	0.04219277	-2.05	0.0428

Model 1; YED

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	202.564593	202.564593	13.41	0.0004
Error	92	1389.265194	15.100709		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.127253	35.19080	3.885963	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	202.5645933	202.5645933	13.41	0.0004

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.9947063015	2.77252883	0.36	0.7206
Years_of_Education	0.8038277512	0.21947239	3.66	0.0004

Model 1: NL

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	105.714993	52.857497	3.24	0.0439
Error	91	1486.114794	16.330932		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.066411	36.59620	4.041155	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	105.7149930	52.8574965	3.24	0.0439

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	11.10344828	B	0.53062962	20.93	<.0001
LEAP__Number_of_Lang 1	4.09655172	B	1.88354829	2.17	0.0322
LEAP__Number_of_Lang 2	-0.84538376	B	0.89909512	-0.94	0.3496
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.

Model 1: EFL

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	86.192672	86.192672	5.24	0.0244
Error	91	1496.796575	16.448314		
Corrected Total	92	1582.989247			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.054449	36.83356	4.055652	11.01075

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	86.19267197	86.19267197	5.24	0.0244

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	10.50684932	B	0.47467818	22.13	<.0001
English_as_a_first_l Y	2.34315068	B	1.02358931	2.29	0.0244
English_as_a_first_l N	0.00000000	B	.	.	.

Model 2: Age and PS

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	294.888657	147.444329	10.35	<.0001
Error	91	1296.941130	14.252100		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.185251	34.18770	3.775195	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	5.4508568	5.4508568	0.38	0.5378
Symbol_Digit_Oral__R	1	225.0941831	225.0941831	15.79	0.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	2.711411554	3.09910550	0.87	0.3839
Age	0.030295194	0.04898699	0.62	0.5378
Symbol_Digit_Oral__R	0.144446054	0.03634653	3.97	0.0001

Model 2: YED and PS

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	307.810608	153.905304	10.91	<.0001
Error	91	1284.019179	14.110101		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.193369	34.01696	3.756341	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	18.3728078	18.3728078	1.30	0.2568
Symbol_Digit_Oral__R	1	105.2460148	105.2460148	7.46	0.0076

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	1.836443963	2.69771084	0.68	0.4978
Years_of_Education	0.316364964	0.27724625	1.14	0.2568
Symbol_Digit_Oral__R	0.103186755	0.03778211	2.73	0.0076

Model 2: NL and PS

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	105.714993	52.857497	3.24	0.0439
Error	91	1486.114794	16.330932		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.066411	36.59620	4.041155	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	105.7149930	52.8574965	3.24	0.0439

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	11.10344828	B	0.53062962	20.93	<.0001
LEAP__Number_of_Lang 1	4.09655172	B	1.88354829	2.17	0.0322
LEAP__Number_of_Lang 2	-0.84538376	B	0.89909512	-0.94	0.3496
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.

Model 2: EFL and PS

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	86.192672	86.192672	5.24	0.0244
Error	91	1496.796575	16.448314		
Corrected Total	92	1582.989247			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.054449	36.83356	4.055652	11.01075

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	86.19267197	86.19267197	5.24	0.0244

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	10.50684932	B	0.47467818	22.13	<.0001
English_as_a_first_l Y	2.34315068	B	1.02358931	2.29	0.0244
English_as_a_first_l N	0.00000000	B	.	.	.

Model 3: Age, PS and their interaction

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	302.271417	100.757139	7.03	0.0003
Error	90	1289.558371	14.328426		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.189889	34.27913	3.785291	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	2.52519473	2.52519473	0.18	0.6756
Symbol_Digit_Oral__R	1	9.35104831	9.35104831	0.65	0.4213
Age*Symbol_Digit_Ora	1	7.38275963	7.38275963	0.52	0.4747

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	5.766128221	5.26934755	1.09	0.2768
Age	-0.052780761	0.12572668	-0.42	0.6756
Symbol_Digit_Oral__R	0.079157180	0.09798496	0.81	0.4213
Age*Symbol_Digit_Ora	0.001886988	0.00262881	0.72	0.4747

Model 3; YED, PS and their interaction

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	317.619195	105.873065	7.48	0.0002
Error	90	1274.210592	14.157895		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.199531	34.07453	3.762698	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	21.99130884	21.99130884	1.55	0.2159
Symbol_Digit_Oral__R	1	33.77050261	33.77050261	2.39	0.1260
Years_of_*Symbol_Dig	1	9.80858675	9.80858675	0.69	0.4074

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-3.709146735	7.18975490	-0.52	0.6072
Years_of_Education	0.792455039	0.63584088	1.25	0.2159
Symbol_Digit_Oral__R	0.214302313	0.13875781	1.54	0.1260
Years_of_*Symbol_Dig	-0.009296473	0.01116900	-0.83	0.4074

Model 3: NL, PS and their interaction

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	370.134361	74.026872	5.33	0.0003
Error	88	1221.695426	13.882903		
Corrected Total	93	1591.829787			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.232521	33.74199	3.725977	11.04255

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	41.53491922	20.76745961	1.50	0.2297
Symbol_Digit_Oral__R	1	2.58700372	2.58700372	0.19	0.6670
Symbol_Di*LEAP__Numb	2	34.87124488	17.43562244	1.26	0.2899

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	4.27502183	B	2.09283325	2.04	0.0441
LEAP__Number_of_Lang 1	34.65841470	B	20.04399958	1.73	0.0873
LEAP__Number_of_Lang 2	0.51415096	B	3.08738889	0.17	0.8681
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.13049382	B	0.03888664	3.36	0.0012
Symbol_Di*LEAP__Numb 1	-0.52213468	B	0.33009844	-1.58	0.1173
Symbol_Di*LEAP__Numb 2	-0.01324925	B	0.06061557	-0.22	0.8275
Symbol_Di*LEAP__Numb 3	0.00000000	B	.	.	.

Model 3: EFL, PS and their interaction

Dependent Variable: COWAT___S__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	289.682774	96.560925	6.64	0.0004
Error	89	1293.306473	14.531533		
Corrected Total	92	1582.989247			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.182997	34.62093	3.812025	11.01075

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	1.6353358	1.6353358	0.11	0.7381
Symbol_Digit_Oral__R	1	110.9756089	110.9756089	7.64	0.0069
Symbol_Di*English_as	1	2.0211768	2.0211768	0.14	0.7101

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	4.724345911	B	1.78573426	2.65	0.0096
English_as_a_first_l Y	-2.159350159	B	6.43687863	-0.34	0.7381
English_as_a_first_l N	0.000000000	B	.	.	.
Symbol_Digit_Oral__R	0.122389895	B	0.03659735	3.34	0.0012
Symbol_Di*English_as Y	0.038187845	B	0.10239499	0.37	0.7101
Symbol_Di*English_as N	0.000000000	B	.	.	.

Model 4: all significant IVs, MV, and interactions with all significant IVs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	418.432295	46.492477	3.31	0.0017
Error	83	1164.556952	14.030807		
Corrected Total	92	1582.989247			

R-Square	Coeff Var	Root MSE	COWAT___S__Raw_Score_ Mean
0.264330	34.01922	3.745772	11.01075

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	1.76819615	1.76819615	0.13	0.7235
Years_of_Education	1	21.97552940	21.97552940	1.57	0.2143
LEAP__Number_of_Lang	2	49.52299754	24.76149877	1.76	0.1776
Symbol_Digit_Oral__R	1	2.37495413	2.37495413	0.17	0.6818
Age*Symbol_Digit_Ora	1	0.01128098	0.01128098	0.00	0.9774
Years_of_*Symbol_Dig	1	13.24713085	13.24713085	0.94	0.3340
Symbol_Di*LEAP__Numb	2	42.97396912	21.48698456	1.53	0.2223

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	-12.37292566	B	16.02614686	-0.77	0.4423
Age	0.06061984		0.17076187	0.35	0.7235
Years_of_Education	1.16214953		0.92861065	1.25	0.2143
LEAP__Number_of_Lang 1	35.76444546	B	20.41765676	1.75	0.0835
LEAP__Number_of_Lang 2	2.70840908	B	3.61668921	0.75	0.4561
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.32866055	B	0.29281836	1.12	0.2649
Age*Symbol_Digit_Ora	0.00009807		0.00345862	0.03	0.9774
Years_of_*Symbol_Dig	-0.01561166		0.01606681	-0.97	0.3340
Symbol_Di*LEAP__Numb 1	-0.54201018	B	0.33751115	-1.61	0.1121
Symbol_Di*LEAP__Numb 2	-0.05503650	B	0.06958471	-0.79	0.4312
Symbol_Di*LEAP__Numb 3	0.00000000	B	.	.	.

Model 4P: most parsimonious model

Dependent Variable: COWAT___A__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	3181.808674	530.301446	47.41	<.0001
Error	86	962.019283	11.186271		
Corrected Total	92	4143.827957			

R-Square	Coeff Var	Root MSE	COWAT___A__Raw_Score_ Mean
0.767843	32.23282	3.344588	10.37634

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	97.753573	48.876786	4.37	0.0156
English_as_a_first_l	1	1259.957171	1259.957171	112.63	<.0001
Symbol_Digit_Oral__R	1	19.282781	19.282781	1.72	0.1927
Symbol_Di*LEAP__Numb	2	92.383990	46.191995	4.13	0.0194

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	4.28303747	B	2.00037164	2.14	0.0351
LEAP__Number_of_Lang 1	43.59671946	B	18.08054208	2.41	0.0180
LEAP__Number_of_Lang 2	-4.21366210	B	2.78284401	-1.51	0.1337
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
English_as_a_first_l Y	11.64346288	B	1.09710182	10.61	<.0001
English_as_a_first_l N	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.07138167	B	0.03890973	1.83	0.0700
Symbol_Di*LEAP__Numb 1	-0.69057672	B	0.29680804	-2.33	0.0223
Symbol_Di*LEAP__Numb 2	0.08164427	B	0.05462632	1.49	0.1387
Symbol_Di*LEAP__Numb 3	0.00000000	B	.	.	.

Appendix J: Results for COWAT Animal and demographics on the moderating effect of processing speed.

Model 1: Age

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	201.998280	201.998280	6.18	0.0147
Error	92	3008.608103	32.702262		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.062916	52.75244	5.718589	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	201.9982795	201.9982795	6.18	0.0147

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	6.072394088	2.00708976	3.03	0.0032
Age	0.147432551	0.05932100	2.49	0.0147

Model 3: YED

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	498.948166	498.948166	16.93	<.0001
Error	92	2711.658217	29.474546		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.155406	50.08149	5.429046	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	498.9481659	498.9481659	16.93	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	26.60996301	3.87347687	6.87	<.0001
Years_of_Education	-1.26156300	0.30662304	-4.11	<.0001

Model 1: LSM

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	623.772467	155.943117	5.37	0.0006
Error	89	2586.833916	29.065550		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.194285	49.73280	5.391248	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SES_LSM_category	4	623.7724669	155.9431167	5.37	0.0006

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	7.393939394	B	0.93849573	7.88	<.0001
SES_LSM_category 7	4.356060606	B	1.81738916	2.40	0.0186
SES_LSM_category 8	5.606060606	B	1.87699146	2.99	0.0036
SES_LSM_category 9	5.798368298	B	1.41374679	4.10	<.0001
SES_LSM_category 5-6	4.939393939	B	1.81738916	2.72	0.0079
SES_LSM_category 10	0.000000000	B	.	.	.

Model 1: NL

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	326.856105	163.428052	5.16	0.0076
Error	91	2883.750278	31.689563		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.101805	51.92922	5.629348	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	326.8561049	163.4280524	5.16	0.0076

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	11.39655172	B	0.73916966	15.42	<.0001
LEAP__Number_of_Lang 1	-8.39655172	B	2.62379200	-3.20	0.0019
LEAP__Number_of_Lang 2	-0.33203560	B	1.25244392	-0.27	0.7915
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.

Model 1; EFL

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1964.699433	1964.699433	156.61	<.0001
Error	91	1141.580137	12.544837		
Corrected Total	92	3106.279570			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.632493	33.00539	3.541869	10.73118

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	1964.699433	1964.699433	156.61	<.0001

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	13.13698630	B	0.41454442	31.69	<.0001
English_as_a_first_l Y	-11.18698630	B	0.89391773	-12.51	<.0001
English_as_a_first_l N	0.00000000	B	.	.	.

Model 2: Age and PS

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	270.271410	135.135705	4.18	0.0183
Error	91	2940.334973	32.311373		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.084181	52.43622	5.684309	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	40.93383229	40.93383229	1.27	0.2633
Symbol_Digit_Oral__R	1	68.27313071	68.27313071	2.11	0.1495

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	12.20418880	4.66632125	2.62	0.0104
Age	0.08301997	0.07375969	1.13	0.2633
Symbol_Digit_Oral__R	-0.07955152	0.05472695	-1.45	0.1495

Model 2: YED and PS

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	499.944142	249.972071	8.39	0.0005
Error	91	2710.662241	29.787497		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.155716	50.34666	5.457792	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	270.6065641	270.6065641	9.08	0.0033
Symbol_Digit_Oral__R	1	0.9959762	0.9959762	0.03	0.8553

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	26.52807913	3.91965050	6.77	<.0001
Years_of_Education	-1.21414283	0.40282612	-3.01	0.0033
Symbol_Digit_Oral__R	-0.01003796	0.05489568	-0.18	0.8553

Model 2: NL and PS

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	490.370321	163.456774	5.41	0.0018
Error	90	2720.236062	30.224845		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.152734	50.71492	5.497713	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	261.0327428	130.5163714	4.32	0.0162
Symbol_Digit_Oral__R	1	163.5142158	163.5142158	5.41	0.0223

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	16.73148868	B	2.40460061	6.96	<.0001
LEAP__Number_of_Lang 1	-7.55315708	B	2.58796643	-2.92	0.0044
LEAP__Number_of_Lang 2	-0.91137397	B	1.24826008	-0.73	0.4672
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	-0.10195267		0.04383317	-2.33	0.0223

Model 2; EFL and PS

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	2037.498543	1018.749271	85.79	<.0001
Error	90	1068.781027	11.875345		
Corrected Total	92	3106.279570			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.655929	32.11260	3.446062	10.73118

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	1800.527680	1800.527680	151.62	<.0001
Symbol_Digit_Oral__R	1	72.799110	72.799110	6.13	0.0152

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	9.52247855	B	1.51454542	6.29	<.0001
English_as_a_first_l Y	-12.47249977	B	1.01292366	-12.31	<.0001
English_as_a_first_l N	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.07650306		0.03089861	2.48	0.0152

Model 3; Age, PS and their interaction

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	689.058460	229.686153	8.20	<.0001
Error	90	2521.547923	28.017199		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.214619	48.82767	5.293128	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	266.9457847	266.9457847	9.53	0.0027
Symbol_Digit_Oral__R	1	487.0567390	487.0567390	17.38	<.0001
Age*Symbol_Digit_Ora	1	418.7870500	418.7870500	14.95	0.0002

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	35.21109340	7.36834505	4.78	<.0001
Age	-0.54267491	0.17580878	-3.09	0.0027
Symbol_Digit_Oral__R	-0.57128121	0.13701639	-4.17	<.0001
Age*Symbol_Digit_Ora	0.01421204	0.00367597	3.87	0.0002

Model 3: YED, PS and their interaction

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	914.135558	304.711853	11.94	<.0001
Error	90	2296.470825	25.516343		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.284724	46.59753	5.051370	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Years_of_Education	1	123.7200491	123.7200491	4.85	0.0302
Symbol_Digit_Oral__R	1	372.7936217	372.7936217	14.61	0.0002
Years_of_*Symbol_Dig	1	414.1914159	414.1914159	16.23	0.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-9.508631349	9.65214741	-0.99	0.3272
Years_of_Education	1.879616006	0.85360766	2.20	0.0302
Symbol_Digit_Oral__R	0.712020229	0.18628046	3.82	0.0002
Years_of_*Symbol_Dig	-0.060410931	0.01499423	-4.03	0.0001

Model 3: NL PS and their interaction

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	494.706739	98.941348	3.21	0.0105
Error	88	2715.899644	30.862496		
Corrected Total	93	3210.606383			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.154085	51.24709	5.555402	10.84043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LEAP__Number_of_Lang	2	7.38673275	3.69336638	0.12	0.8874
Symbol_Digit_Oral__R	1	20.61885510	20.61885510	0.67	0.4159
Symbol_Di*LEAP__Numb	2	4.33641806	2.16820903	0.07	0.9322

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	17.27597961	B	3.12039815	5.54	<.0001
LEAP__Number_of_Lang 1	-1.61189292	B	29.88544797	-0.05	0.9571
LEAP__Number_of_Lang 2	-2.25027804	B	4.60327289	-0.49	0.6262
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	-0.11235809	B	0.05797968	-1.94	0.0558
Symbol_Di*LEAP__Numb 1	-0.09662023	B	0.49217421	-0.20	0.8448
Symbol_Di*LEAP__Numb 2	0.02743642	B	0.09037735	0.30	0.7622
Symbol_Di*LEAP__Numb 3	0.00000000	B	.	.	.

Model 3; EFL, PS and their interaction

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2039.642377	679.880792	56.73	<.0001
Error	89	1066.637193	11.984688		
Corrected Total	92	3106.279570			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.656619	32.26010	3.461891	10.73118

Source	DF	Type III SS	Mean Square	F Value	Pr > F
English_as_a_first_l	1	35.33814038	35.33814038	2.95	0.0894
Symbol_Digit_Oral__R	1	21.21621876	21.21621876	1.77	0.1867
Symbol_Di*English_as	1	2.14383360	2.14383360	0.18	0.6734

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	9.28510589	B	1.62171475	5.73	<.0001
English_as_a_first_l Y	-10.03786715	B	5.84565198	-1.72	0.0894
English_as_a_first_l N	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.08152719	B	0.03323589	2.45	0.0161
Symbol_Di*English_as Y	-0.03932951	B	0.09299002	-0.42	0.6734
Symbol_Di*English_as N	0.00000000	B	.	.	.

Model 4: all significant IVs, MV, and interactions with all significant IVs

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	1484.302258	87.311898	4.04	<.0001
Error	75	1621.977312	21.626364		
Corrected Total	92	3106.279570			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.477839	43.33554	4.650415	10.73118

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	23.7414460	23.7414460	1.10	0.2981
Years_of_Education	1	12.0184658	12.0184658	0.56	0.4583
SES_LSM_category	4	279.9749819	69.9937455	3.24	0.0166
LEAP__Number_of_Lang	2	11.1492077	5.5746038	0.26	0.7735
Symbol_Digit_Oral__R	1	8.2813996	8.2813996	0.38	0.5379
Age*Symbol_Digit_Ora	1	60.2667045	60.2667045	2.79	0.0992
Years_of_*Symbol_Dig	1	41.4597287	41.4597287	1.92	0.1703
Symbol_Di*SES_LSM_ca	4	242.1223996	60.5305999	2.80	0.0318
Symbol_Di*LEAP__Numb	2	6.9582059	3.4791029	0.16	0.8517

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	8.91259893	B	24.59375134	0.36	0.7181
Age	-0.24339208		0.23229754	-1.05	0.2981
Years_of_Education	1.00761449		1.35164189	0.75	0.4583
SES_LSM_category 7	-10.38725170	B	8.70125179	-1.19	0.2363
SES_LSM_category 8	-5.01416652	B	8.54324982	-0.59	0.5590
SES_LSM_category 9	8.86106674	B	6.75256061	1.31	0.1934
SES_LSM_category 5-6	-7.63259301	B	8.60513016	-0.89	0.3779
SES_LSM_category 10	0.00000000	B	.	.	.
LEAP__Number_of_Lang 1	-11.60276932	B	25.70454517	-0.45	0.6530
LEAP__Number_of_Lang 2	-3.04377002	B	5.09508503	-0.60	0.5520
LEAP__Number_of_Lang 3	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	0.10827100	B	0.45162617	0.24	0.8112
Age*Symbol_Digit_Ora	0.00788270		0.00472202	1.67	0.0992
Years_of_*Symbol_Dig	-0.03327687		0.02403372	-1.38	0.1703
Symbol_Di*SES_LSM_ca 7	0.24791907	B	0.17314107	1.43	0.1563
Symbol_Di*SES_LSM_ca 8	0.15667543	B	0.16098594	0.97	0.3336
Symbol_Di*SES_LSM_ca 9	-0.11885310	B	0.12374591	-0.96	0.3399
Symbol_Di*SES_LSM_ca 5-6	0.18777094	B	0.17132258	1.10	0.2766
Symbol_Di*SES_LSM_ca 10	0.00000000	B	.	.	.
Symbol_Di*LEAP__Numb 1	0.14639078	B	0.42455233	0.34	0.7312
Symbol_Di*LEAP__Numb 2	0.04683502	B	0.09674181	0.48	0.6297
Symbol_Di*LEAP__Numb 3	0.00000000	B	.	.	.

Model 4P: most parsimonious model

Dependent Variable: COWAT___Aminals__Raw_Score_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	1325.984764	120.544069	5.48	<.0001
Error	81	1780.294806	21.978948		
Corrected Total	92	3106.279570			

R-Square	Coeff Var	Root MSE	COWAT___Aminals__Raw_Score_ Mean
0.426872	43.68737	4.688171	10.73118

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	1	121.6587033	121.6587033	5.54	0.0211
SES_LSM_category	4	276.0077079	69.0019270	3.14	0.0188
Symbol_Digit_Oral__R	1	113.8732273	113.8732273	5.18	0.0255
Age*Symbol_Digit_Ora	1	195.7182380	195.7182380	8.90	0.0038
Symbol_Di*SES_LSM_ca	4	281.1307437	70.2826859	3.20	0.0172

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	30.43728560	B	7.09228825	4.29	<.0001
Age	-0.41638813		0.17698245	-2.35	0.0211
SES_LSM_category 7	-11.93809190	B	7.81664579	-1.53	0.1306
SES_LSM_category 8	-9.86506796	B	7.61124169	-1.30	0.1986
SES_LSM_category 9	4.71887849	B	5.93398284	0.80	0.4288
SES_LSM_category 5-6	-11.96193562	B	7.67515847	-1.56	0.1230
SES_LSM_category 10	0.00000000	B	.	.	.
Symbol_Digit_Oral__R	-0.50751206	B	0.13103130	-3.87	0.0002
Age*Symbol_Digit_Ora	0.01112877		0.00372936	2.98	0.0038
Symbol_Di*SES_LSM_ca 7	0.31168116	B	0.15581334	2.00	0.0488
Symbol_Di*SES_LSM_ca 8	0.28438769	B	0.14150641	2.01	0.0478
Symbol_Di*SES_LSM_ca 9	-0.01025777	B	0.10690527	-0.10	0.9238
Symbol_Di*SES_LSM_ca 5-6	0.30896625	B	0.15450911	2.00	0.0489
Symbol_Di*SES_LSM_ca 10	0.00000000	B	.	.	.