Working Memory and Multiple Language Proficiency

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Chapter 1: Introduction and Literature Review

Populations are becoming progressively older, both globally and in a South African context (Lee et al., 2012). This leads to a rise in cases of age-related memory loss, Alzheimer's disease, and dementia, problems for which there exists no medical "cure". Additionally, due to the high prevalence rates of HIV/AIDS in South Africa, HIV-associated dementia (HAD) is also becoming more prevalent (Vally, 2011). Individuals suffering from age-related memory loss, Alzheimer's disease, dementia, and HAD all present with various deficits of working memory (Vally, 2011). Research indicates that the acquisition of a second or several languages affect working memory in positive ways which may be particularly relevant in a South African context, and as such may be a possible mitigating factor in the presentation of these problems (Fratiglioni, Paillard-Borg, & Winblad, 2004; Mechelli et al., 2004).

Bilingualism in today's society has become the norm rather than the exception, with research indicating that globally, approximately 80 percent of individuals are bilingual or multilingual (Erard, 2012). According to Edwards (1998), the interest in the maintenance of indigenous languages has created situations in which two or more languages co-exist and are necessary in everyday communication. Bilingualism was initially thought to have negative effects on cognitive functioning, although it may have positive outcomes for communicative purposes (Bialystok, 2009). However, many of these misconceptions have been scientifically disproven and bilingualism has been seen in an increasingly positive light (Bialystok, 2009). Learning a second or third language increases communication for various purposes whether work, research, travel or studying and helps in attempting to understand the cultures attached to each language. Research also indicates that bilingualism and multilingualism may improve academic and cognitive functioning in a variety of areas (Alloway, Elliot, & Place, 2010; Bialystok, 2009). Most notable are the positive effects of bilingualism on the executive control system, a system which is crucial for all higher thought processes and forms part of working memory (Miyake & Shah, 1999).

The Concept of Working Memory

Working memory is a theoretical concept used to refer to the limited capacity storage system which temporarily and simultaneously stores and maintains information. It is also assumed to support human thought processes by providing an interface between perception, long-term memory and action (Andrade, 2001; Baddeley, 2003; Conway, Jarrold, Kane, Miyake, & Towse, 2007; Miyake & Shah, 1999).

The concept of working memory has much history attached to it. The term first appeared in a book entitled, "Plans and the structure of behaviour" by Miller, Galanter and Pribam in 1960 and was subsequently used in a paper by Atkinson and Shiffrin in 1968, in which they proposed a dichotomous view of memory, namely short term memory and long term memory (Baddeley, 2003). However, by the early 1970's it was becoming apparent that the dichotomous view proposed by Atkinson and Shiffrin (1968, cited in Baddeley, 2003) could not account for all aspects of memory. One such problem appeared in the neuropsychological evidence that was initially used to support the model (Baddeley, 2003). Atkinson and Shiffrin initially proposed that the short-term store within their model qualified as a working memory and was necessary for learning, retrieving learnt material and performing various other cognitive tasks (Baddeley, 2003). However, some patients with grossly defective short term memory stores, nonetheless, showed normal long-term learning capacity and few cognitive handicaps, which would not have been the case had the proposed model been accurate (Baddeley, 2012). Consequently, Baddeley and Hitch (1974) revised Atkinson and Shiffrin's model and adopted the term "working memory" for their multicomponent model. Several viable, alternative models of working memory exist such as the Embedded-Processes Model proposed by Cowan (2001) and the model by Ericsson and Kintsch (1995) in which they propose that the concept of a Long-Term Working Memory be used as an alternative to a capacity model of working memory in everyday skilled performance. O'Reilly, Braver, and Cohen (1999) proposed a biologically based computational model of working memory while, Engle, Kane and Tuholski (1999) focused on the "controlled attention" framework of working memory. As science becomes more sophisticated various ways of understanding the working memory are found, such as the modelling of working memory models into a unified architecture (Lovett, Reder, & Lebiere, 1999). However, many other ways of understanding working memory exist. It is beyond the scope of this project to give an exhaustive account of the models of working memory. Baddeley and Hitch's (1974) model will serve as the theoretical framework on which the proposed study is based as the measurement used to assess working memory (Automated Working Memory Assessment, Alloway, 2007) is based on this model and this is the most widely researched model.

This model purports that there exists a system of limited attentional capacity (the central executive) which is supplemented by two peripherally-based storage systems, commonly referred to as slave systems (namely, the visuo-spatial sketch pad and the phonological loop), the structure of which is depicted in Figure 1 (Baddeley, 2003; Miyake & Shah, 1999). The fourth component of working memory, namely the episodic buffer, was recently proposed (Baddeley, 2003).

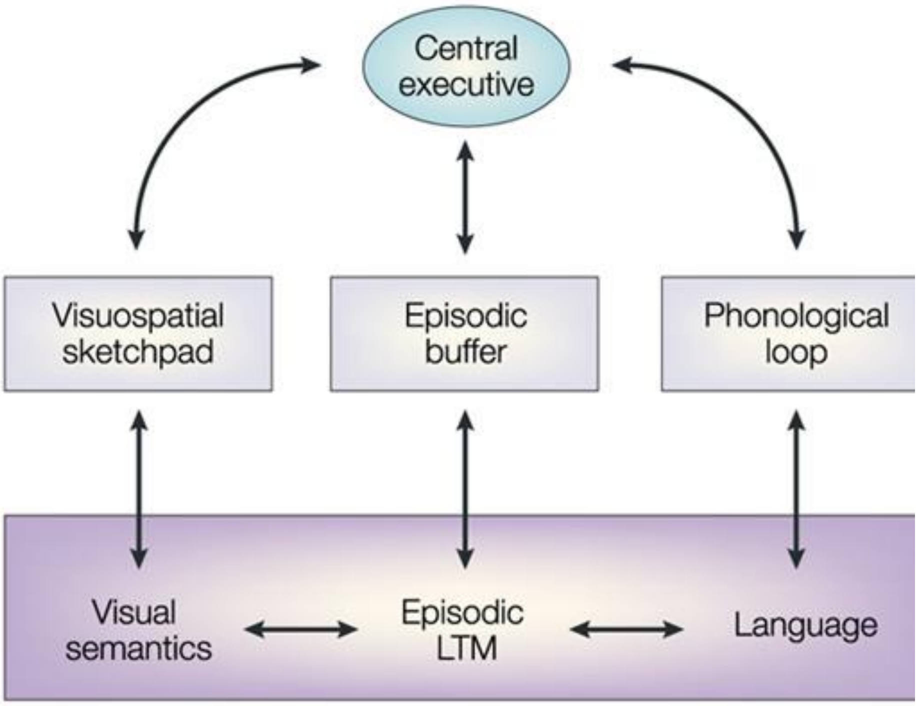

Figure 1: Baddeley's modified model of Working Memory adapted from "Working Memory: looking back and looking forward" by A. D. Baddeley, 2003, *Nature Reviews Neuroscience,* 4, 829-839.

The Role of Working Memory

Baddeley (2012) states that his model is "a relatively loose theoretical framework rather than a precise model that allows specific prediction" (p. 7). The peripheral slave systems, are more tractable than the central executive and consequently, have received more attention in research (Baddeley, 2003). Of these two systems, the phonological loop is the most tractable and thus the most researched.

The phonological loop consists of a phonological store, in which memory traces can be held for a few seconds before fading, as well as an articulatory rehearsal process which, according to Baddeley (2003), is comparable to subvocal speech. The evidence for the existence of the phonological loop is drawn from research on the phonological similarity effect (when words are phonologically similar and verbally presented, serial recall is worse than for words that are phonologically dissimilar), and the word length effect (the recall of short, sequential words is superior to the recall of long, sequential words) (Henson, 2001). Additional evidence is drawn from research on articulatory suppression (when simple sounds are repeated during encoding, the articulatory control process of the phonological loop is utilized) and irrelevant sound effects (serial recall is hampered when external stimuli are presented), the latter which occurs despite the visual presentation of the listed items (Baddeley, 2003; Logie, 2011). Research indicates that the phonological loop's primary function is to facilitate language acquisition. However, there is still much controversy regarding the exact role and structure of the phonological loop (Baddeley, 1968; Baddeley, 2003; Brown, Preece, & Hulme, 2000; Henson, 2001; Henson, Norris, Page & Baddeley, 1996).The phonological loop is limited in capacity and can only maintain information for a brief duration of a few seconds, with a capacity of either seven or nine (+- 2) items (Miller, 1956; Brown et al., 2000; Henson, 2001).

The other working memory slave system, the visuo-spatial sketchpad, holds and manipulates visuo-spatial representations and is typically limited to three or four objects in its capacity (Logie, 2011). According to O'Regan (1992), detailed visual retention would be redundant as the visual world provides a continuing memory record, persisting over time. Visuo-spatial working memory is often used as a measure of non-verbal intelligence predicting success in fields such as architecture and engineering (Baddeley, 2003).

The visuo-spatial sketchpad is comprised of a visual and a spatial component, which incorporate an inner cache and inner scribe (Logie, 2011). The distinction between visual and spatial coding was determined through neuroimaging, specifically Positron Emission Tomography (PET), which has indicated that visual and spatial information are processed in different parts of the brain (Smith, 1992; Wheeler & Treisman, 2002).

The third, and most important component of working memory, is the central executive which focuses, evaluates, divides, switches and monitors attention and is a part of executive functioning (Baddeley, 2003). This component is important in a variety of higher order skills for example, chess playing and research has indicated that this component is particularly susceptible to the effects of Alzheimer's disease and age-related memory loss (Baddeley, 2003).

The most recently proposed component of working memory, the episodic buffer, is a limited capacity store that binds information from long term memory together in order to form integrated episodes, and is attentionally controlled by the central executive. This component serves as a temporary link between working memory and long term memory and is accessible to conscious awareness (Baddeley, 2003).

Evidence suggests that the various components of working memory may be positively affected in multilingual individuals (Gollan, Montoya, & Werner, 2002). These mechanisms are discussed in the section that follows.

Multilingualism

Multilingualism is particularly relevant in a South African context and is a much contested topic still in today's society, especially with regards to education (Hill, 2009).

According to a recent article published in the New York Times (Erard, 2012), linguist Mikael Parkvall from the Stockholm University, attempted to reconcile data on global multilingualism and found that reliable data is sparse. However, his study (not yet published) concluded that an estimated 80 percent of people worldwide are multilingual. Research indicates that there may be a more compelling reason than simple communication to learn a second language as one of the known effects is on working memory (Costa, Hernández, & Sebastián-Gallés, 2008).

Bilingualism, Multilingualism and Working Memory: A Review of the Literature

The term “bilingual” is used here to refer to individuals who are proficient in two languages, while the term “monolingual” refers to individuals who are proficient in only one language. According to Blumenfeld and Marian (2011) bilingual language processing leads to the simultaneous activation of two (or more in the case of multilingual individuals) language systems and the bilingual or multilingual individual is required to have the ability to control all the activated languages and switch between them in a task or situation appropriate way (Blumenfeld, & Marian, 2007; Blumenfeld, & Marian, 2011; Green, 1998; Roderiguez-Fornells, Balaguer, & Munte, 2006).

Several studies have investigated the effects of bilingualism on specific aspects of working memory. These studies have largely been conducted with French or Spanish speaking children and have found both positive and negative effects of bilingualism on working memory (Bialystok, 2009; Dijkstra, 2005; Gollan, Fennema-Notestine, Montoya & Jernigan, 2007; Gollan et al., 2002).

The negative effects include the finding that bilingual individuals tend to access smaller vocabularies of each language and have more lexical access and retrieval difficulties when compared to their monolingual counterparts (Bialystok, 2009). A study of 29 Spanish-English Bilinguals (mean age of 74 years), found that the bilinguals exhibited slower picture naming (Gollan et al., 2007), while research conducted with Spanish-English (mean age of 20.4), Tagalog-English (mean age of 37.6) and two monolingual English groups (matched for age with each bilingual group) indicated more tip of the tongue experiences for bilingual individuals relative to monolinguals (Gollan & Acenas, 2004). Rogers, Lister, Febo, Besing, and Abrams (2006) conducted a study with 15 monolingual English speakers (mean age of 25.3) and 12 Spanish-English bilingual speakers (mean age of 24.7) which found that the bilingual individuals exhibited poorer word identification through noise, while Gollan et al.

(2002) found that their English-Spanish participants obtained lower verbal fluency task scores when compared to the monolingual English participants. Additionally, Ransdell and Fischler (1987) found that the bilingual (comprising of English-Spanish, English-French and English-German) participants had more lexical decision interference than the monolingual English participants.

The reasons for these differences in performance remain unclear, however, various proposals exist. One view, based on connectionist models and bilingual speech production modelling, attributes the lower performance by bilingual individuals to "weaker links" among the connections required for rapid and fluent speech, due to the fact that bilinguals generally use each of their languages less often than monolinguals use their one language (Bialystok, 2009; Michael & Gollan, 2005). This would account for the tip of the tongue difficulties, lexical access deficits and lexical retrieval deficits.

Hernandez and Li (2007) propose a sensorimotor account involving the age of second language acquisition which states that the later a second language is learnt, the less sensorimotor processing is involved in the learning process. On the other hand, Green (1998) attributes lexical deficits to the competition from corresponding items in the non-target language, creating conflict between them. An attentional controlling mechanism is required to address this conflict, with the possibility that it may inhibit the interfering option. This type of conflict would generally be resolved by the executive processes for attention, control and switching and as such Bialystok (2008) proposes that the constant use of these processes in bilinguals will transform these processes and consequently make them more efficient and available. The processes described here are the very processes used by working memory's central executive.

Thus, there is a possibility that the executive control system in bilinguals is enhanced through more frequent use, thereby making it more robust for other functions, including working memory. Due to the constant involvement, bilingual individuals should have enhanced processes such as inhibition, increased cognitive flexibility, as well as increased efficiency in the updating of information in the working memory (Bialystok, 2009; Miyake et al., 2000). Various studies have indicated that bilingual children acquire the ability to switch criteria for sorting decisions and attend to new features, while ignoring misleading distraction from meaning, earlier than their monolingual peers (Ben-Zeev, 1977, Bialystok, 1999; Bialystok, 2010; Bialystok & Martin, 2004). Additionally, bilingual children have been shown to perform significantly better than monolingual children on metalinguistic tasks that require controlled attention and inhibition (Bialystok, 2009; Bonifacci, Giombini, Bellocchi, and Contento, 2011; Carlson & Meltzoff, 2008; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009; Kovács & Mehler, 2009). However, Bialystok (2006) and Bialystok, Craik, and Ruocco (2006) found that these differences were not as statistically significant in undergraduate university students. This may indicate that these functions may only be significantly different during childhood where the bilingual child may learn these functions earlier than the monolingual child. As the children age and reach early adulthood the monolingual child may have developmentally caught up to the bilingual child and the difference in these functions between the two groups may not be as noticeable.

Lu and Proctor (1995) have shown that the conflict inherent in the Simon task is more easily resolved by bilingual than monolingual individuals, and that this resolution is coupled with faster reaction times in bilinguals. The Simon task is a visuo-spatial task in which individuals are presented with arrows to the right or left of their visual field which are pointing either to the left or the right. Participants are then instructed to respond to this by pressing a button indicating the direction that the arrows are pointing in. In incongruent stimuli, the left-pointing arrows are shown on the right side and the right-pointing arrows on the left side. This task measures attentional switching through reaction time without the subjects having to be familiar with the content. Few studies have explored verbal working memory in bilinguals. The current study includes assessments of both verbal and visuospatial working memory.

Costa, Hernández and Sebastián-Gallés (2008) found that early (individuals who have learned a second language before age five and have practised it regularly since) and high proficiency bilinguals (Catalan-Spanish) between the ages of 19 and 32 years (mean age 22 years), experienced reduced switching costs between the different trial types in the Attentional Network Task (ANT), were aided more by the presentation of alerting cues and were better at resolving conflicting information as compared to monolingual Spanish speakers of similar ages.

Costa et al. (2008), theorize that the bilingual advantage may be due to the bilingual individual having to control their attention to a target system (the language selected), while simultaneously inhibiting the competing language system. The mechanisms for the control and inhibition of attention may thus be better developed in bilingual than in monolingual individuals. While bilinguals exhibit lower performance in vocabulary acquisition and lexical retrieval, they show significant advantages in executive control abilities relative to monolinguals throughout their lifespan, indicating both positive and negative effects for cognitive performance (Bialystok, 2009; Costa et al., 2008).

Bonifacci et al. (2011) studied 68 participants divided into two age groups and further divided into bilingual and monolingual groups. The two groups were children (bilinguals mean age 9.28 years and monolinguals mean age 9.61 years) and youths (bilinguals mean age 18.06 years and monolinguals mean age 19.06). The monolingual language was Italian while the bilingual sample groups spoke Italian and another language such as English and German. This study found that bilingualism did not enhance basic processing speed on simple cognitive tasks and that it did not increase working memory abilities as determined on tasks requiring minimal executive control. This study did not find any difference between groups on inhibition but did find that bilingual individuals were more adept at anticipation, namely anticipating incoming stimuli at different levels of complexity (Bonifacci et al., 2011).

A study by Ben-Zeev (1977) had 96 participants who were divided into four groups. One Hebrew-English group was assessed in the United States of America (USA) and another monolingual English group was also assessed in the USA. A second Hebrew-English and a monolingual Hebrew group assessed in Israel. The mean age of these groups was 7 years and the sex distribution was equal. The results from this study indicate that the bilingual groups were superior to the monolingual groups in their ability to recognize patterns and analyse non-verbal material (Peal & Lambert, 1962). They were also more adept at visual scanning, problem solving and increasing attention to visual material. While the bilingual group seemed to exhibit a smaller vocabulary they were able to process verbal material superiorly. Additionally, the bilingual group seemed to have increased cognitive flexibility as indicated by their ability to readily reorganize their perceptions and displayed an increased ability to understand the rules governing syntactic structures and change or disregard these rules to benefit information processing and meaning-making. The results indicated that the bilingual group took a more analytical approach to syntax which enabled them to process verbal information at a greater speed. While they were able to aptly reorganize verbal material they were not able to do the same with visual material but displayed higher levels of attention in relation to non-verbal information.

Related to these findings Ianco-Warral (1972) found that Afrikaans-English bilinguals were better able to conceive of words as arbitrary symbols compared to English and Afrikaans monolinguals. This may relate to Ben-Zeev’s finding that bilinguals were better able to analyse the rules of syntax. Additionally, Ianco-Warral (1972) found that Afrikaans-English bilinguals were more focused on attaching meaning to stimuli or interpreting stimuli in an attempt to attribute meaning but performed similarly to monolinguals on tasks measuring operational thinking and assessing the ability to deal flexibly with structures. Ianco-Warral's (1972) participants ranged in age from 4 to 9 years but she did not describe her procedures in detail and as such it is difficult to determine whether her participants were fully bilingual. It is stated that the parents of the bilingual group were all monolingual and as such only spoke either English or Afrikaans at home which may indicate that the children were not highly proficient in both languages, or did not acquire both from an early age.

There may be evidence that the experience of bilingualism also has physical effects on the brain, with research indicating that neural connections maintain their plasticity and can be modified through experiences, such as the acquisition of a second language when at an advanced age (Bialystok, 2009). Bilingual individuals have been found to possess an increased density of grey matter in their left inferior parietal cortex, relative to monolinguals, and this change is more pronounced in early bilinguals and individuals with higher levels of proficiency in their second language (Mechelli et al., 2004). Green, Crinion and Price (2007) found that this brain region is responsive to vocabulary acquisition in both monolinguals and bilinguals, and that different areas are enlarged depending on the bilingual individual's two languages. Additional research indicates that stimulating experiences across the lifespan have a cumulative effect which lead to increased cognitive reserves thereby protecting against age related cognitive decline (Bialystok, 2009; Fratiglioni, Paillard-Borg, & Winblad, 2004; Kramer et al., 2004; Staff, Murray, Deary, & Whalley, 2004; Valenzuela & Sachdev, 2006).

In support of this view, a study by Bialystok, Craik and Freedman (2007) and another by Craik, Bialystok and Freedman (2010) found that bilingual individuals exhibited signs of dementia four to five years later than monolinguals, with various other studies indicating that bilingualism appears to have positive effects in terms of delaying age-related memory loss (Bialystok et al., 2007; Gollan, Montoya, Cera, and Sandoval, 2008). The first study by

Bialystok et al. (2007) consisted of 91 monolingual and 93 bilingual participants, all of whom were patients with dementia and two thirds of whom had been diagnosed with Alzheimer's disease. The average age at which the symptoms were detected for the monolingual group was 71.4 years while the average age for symptom detection in the bilingual group was 75.5 years. The second study (Craik et al., 2010) consisted of 109 monolingual and 102 bilingual participants, all of whom had been diagnosed with Alzheimer's disease. The average age of symptom detection in the monolingual group was 72.6 years and 77.7 years in the bilingual group. Bilingual individuals also appear to maintain better, more efficient executive control systems throughout their adulthood which decline less severely with ageing when compared to their monolingual counterparts (Gollan et al., 2008).

Research has indicated both the positive and negative effects of bilingualism on the subcomponents of working memory. However, as previously stated, these have largely been conducted with Spanish or French speaking children and have focused on the visuo-spatial aspects of working memory (Bialystok, 2009; Dijkstra, 2005; Gollan et al., 2007; Gollan et al., 2002). African languages differ from European languages in aspects such as lexical processing, orthography and morphology (Phillipson, 1996). Few studies exist which explore bilingualism in a European and African language or context. South Africa has 11 official languages, while the schooling system requires learners to study a second language from Grade 3 all the way through to matric (grade 12). Consequently, the effects of multiple language proficiency on working memory in South Africa may be different to their European counterparts, in part due to the unique language structure of African languages and also due to the degree of bilingual proficiency that is often evident in the majority of South Africans. This study is also novel in investigating the potential effects if multiple language proficiency on both the verbal and visuo-spatial working memory.

Socioeconomic Status and Working Memory

There is evidence that socioeconomic status may affect the development of working memthe executive control system in children (Evans & Schamberg, 2008). As socioeconomic statuses vary considerably in South Africa, it is acknowledged that this may affect working memory performance. However, a study by Engel, Santos, and Gathercole, (2008) indicate that while low socioeconomic status negatively affects both expressive and receptive vocabularies, no significant differences were found in working memory, in a group of Brazilian children.

Relevance/ Contribution

A relationship between working memory and the delay of symptoms related to age-related memory loss, HIV-associated dementia (HAD) and Alzheimer's disease would be particularly relevant in a community setting, whether in a South African or globally. It is acknowledged that age-related memory loss is a natural process, while dementia, HAD and Alzheimer's disease are classified as pathological memory loss and differ neurologically, they are all mentioned here as these are problems that community psychologists encounter during their work. In the United States alone, life expectancy has increased dramatically over the past century (Shrestha, 2006). Data from 2003 indicates life expectancy at birth for the American population to be at 77.5 years (in comparison to 49.2 years at the turn of the 20th century). Shrestha (2006) states that a decrease in fertility coupled with an increase in life expectancy have led to a "rapid aging of the American population, as reflected by an increasing proportion of persons aged 65 and older" (Shrestha, 2006, p. 1). In South Africa, a recent study indicates that the average life expectancy has increased from 54 years (2009) to 60 years (Lee et al., 2012). As such, we are faced with communities that are getting increasingly older.

In addition to an ageing population, South Africa also has a high prevalence of HIV/AIDS. South Africa has one of the highest HIV/AIDS infection rates with an estimated

10.5% of the population living with HIV/AIDS in 2010 (Statistics South Africa, 2011). HIV/AIDS has various presenting symptoms including HIV-associated dementia (HAD) and is associated with deficits in basic attentional, visual working memory and verbal working memory (Vally, 2011).

As such, the relationship between bilingualism and working memory may prove to be a crucial one. If bilingualism has a positive effect on the subcomponents of working memory then it may be that proficiency in multiple languages can be used to actively counteract the onset of various symptoms related to HAD, as well as age related memory loss, leading to a better quality of life for affected individuals.

Bilingualism and multilingualism have both positive and negative effects on working memory (Ben-Zeev, 1977; Bialystok, 2009; Blumenfeld, & Marian, 2007; Carlson, & Meltzoff, 2008; Costa et al., 2009; Gollan et al., 2002; Gollan et al., 2007). Bilingual and multilingual individuals appear to have access to smaller vocabularies, more lexical retrieval and access deficits, poorer word identification through noise and more tip of the tongue experiences. However, the positive effects seem to outweigh the negative. These include increased inhibition and cognitive flexibility, as well as better attentional control, conflict resolution and anticipation. Additionally, bilingual and multilingual individuals may be more adept at ignoring irrelevant information, have enhanced problem-solving and visual scanning abilities, may be more meaning orientated with regards to stimuli and may be more efficient at updating information in their working memory. Physically, they may also have more dense grey matter and increased cognitive reserves which may protect them against age-related cognitive decline. Research is divided regarding the effects of socio-economic status on working memory.

Consequently, the aim of the proposed study was to investigate the relationship between proficiency in multiple languages and working memory. The research was guided by the following questions: (1.) Is proficiency in multiple languages positively related to working memory?, and (2.) Is there a significant difference between monolingual and multilingual participants in terms of their working memory functioning? As such, this research made use of both correlational and comparative statistics.

Chapter 2: Method

Aim

The aim of the proposed study was to investigate the relationship between proficiency in multiple languages and working memory. The research was guided by the following questions: (1.) Is the degree of proficiency in multiple languages positively and significantly related to working memory? (2.) Is there a significant difference between monolingual and multilingual participants in terms of their working memory functioning?

Research Design

This study is a comparison between two groups, one monolingual English-speaking, and one multilingual group, on tasks measuring working memory, non-verbal intelligence and language proficiency. Each group consisted of 20 participants who were matched, as closely as possible, for age (monolingual: M= 19.84, S.D.= 0.85; multilingual: M=19.73, S.D.=0.98) and gender (8 male and 16 female), following the collection of the data. The multilingual group had been collected prior to this project, allowing for the matching to occur after collection of the monolingual data. The research design was ex post facto, and non-experimental (Terre Blanche, Durrheim, & Painter, 2006). This was chosen as the variables could not be manipulated during the course of the research procedure, making it non-experimental and, as both language proficiency and working memory are determined by the individual and various other factors, the design is ex post facto. The independent variable for this study is the group (monolingual or multilingual), while the dependent variables are the scores on the various subtests assessing working memory. The measure of non-verbal intelligence was included in order to determine whether the groups were equivalent in this regard, and to statistically control for it if necessary.

Research Paradigm: Post Positivist

This design is located within the post positivist paradigm. The post positivist tradition arose from the positivist paradigm, contending that reality could never be fully apprehended but merely approximated (Denzin & Lincoln, 2005). Post positivism, advocates for a more realist perspective of science than its predecessor, introducing the notion that unobservable phenomena could exist and be capable of explaining the functioning of observable phenomena (Clark, 1998). Unlike positivism, the post positivist tradition relies on a triangulation of multiple methods in an attempt to capture as much of "reality" as is possible while simultaneously emphasizing both the discovery and verification of theories. However, the traditional evaluation criteria, such as internal and external validity still apply and qualitative procedures are often included, while the focus tends to be on quantitative analysis, which lend themselves to structured, and sometimes statistical, analysis (Denzin & Lincoln, 2005). Researcher biases are acknowledged in this paradigm as well as the complications accompanied by over generalisation and claims to universal knowledge. However, as results are viewed as contextually related, the probability of similar findings elsewhere could be induced (Clark, 1998). Additionally, it can be argued that post-positivism, while attempting to overcome the limitations of the positivist paradigm, still holds some of the weaknesses of that paradigm. This can be seen in the fact that the post positivist tradition, like its positivist predecessor, still attempts to render complex aspects of the human existence, researchable by seeking patterns for prediction, causation and explanation (Clark, 1998).

It is thus acknowledged that the concept of Working Memory is a theoretical construct and thus an unobservable one which could be used to explain observable phenomena such as complex reasoning ability and short term memory. The differences in language proficiency between the two groups could also explain the difference in scores on the assessments. Triangulation methods were used by including aspects of a cognitive assessment, namely the

Weschler Adult Intelligence Scale (WAIS-III), as well as the Automated Working Memory Assessment (AWMA). While qualitative procedures were included (LEAP-Q and demographic questionnaire) the interpretation was statistical and thus quantitative in nature.

Participants

Convenience sampling methods were used to obtain the sample for this study (Kelly, 2006). This was done by placing advertisements on the University Campus (Appendix A) and by utilizing the first year research participation program at the University. A blurb was also placed on the Psychology First Year SAKAI website as an invitation to participate (Appendix B). First year psychology classes were approached and asked to take part in the research, those who did were given 1% credit towards their psychology course mark. A list was circulated on which interested individuals could note their contact details for the researcher to contact them. Additionally, the contact details of the researcher were supplied to the class should anyone wish to contact the researcher expressing interest.

The inclusion criteria for this study were that the participants were between the ages of 18 and 22 years and were, at the time of the study, University students due to the fact that they are easily accessible, and test wise In addition, they needed to speak only English with high levels of proficiency as determined by the Language Experience and Proficiency Questionnaire (LEAP-Q) (described on page 66). The assumption is that university students would be proficient in English and developmental language issues would thus not be a concern. This would not be the case had the study focused on children. Older adults were not included in the sample as there are too many extraneous variables to control for, such as increased crystallized intelligence and age related cognitive decline which may exacerbate the differences between the monolingual and multilingual groups' performance (Gollan et al., 2008).

Due to the diversity of languages, and exposure to at least two languages in South African schools, it was assumed that there were no purely monolingual (proficient in only one language with no exposure to other languages) individuals residing in South Africa. As such, for the purposes of this study, monolingual participants were defined as individuals who reported themselves to be monolingual English speakers and who rated themselves as proficient (6 or above) in English only on the Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian, Blumenfeld, & Kaushanskaya, 2007).

As stated earlier, the data set for the multilingual participants had already been collected. These participants were also undergraduate students from the same University. They were similar in all respects to the monolingual sample, except that they were highly proficient in two or more languages. Since research suggests that bilingualism may exert a possible effect on working memory, it is possible that these effects may increase with the degree of proficiency in the second language (Bialystok, 2009). These participants completed the Automated Working Memory Assessment (AWMA), Wechsler Adult Intelligence Scale Third Edition (WAIS-III), the complete LEAP-Q (Marian et al., 2007) (Refer to Appendix C), as well as a demographic questionnaire (Refer to Appendix D). It is important to note that the participants from this group did not have English as their first language which may have implications for testing purposes as the testing procedures and instruments were administered in English. However, the university requires that students receive a minimum of 70% in their Matric level English, should English be their second language. As such, it was assumed that the students were proficient in English. Participant characteristics are described Table 1.

Table 1. *Participant Characteristics for the respective Monolingual and Multilingual groups.*

		Multilingual N=20	Monolingual N=20
Gender M:F		4:16	4:16
Age (in years)	Range	18.11 -21.5	18.5 - 21.6
	Mean	20.18	19.84
	S.D.	1.01	0.85
Home Language	English	0	20
	Pedi	1	0
	Sotho	2	0
	Tsonga	2	0
	Tswana	3	0
	Venda	4	0
	Xhosa	4	0
	Zulu	4	0
School Language	English	16	20
	Tsonga	1	0
	Tswana	1	0
	Zulu	2	0
Number of Languages Spoken	1	0	10
	2	2	6
	3	7	4
	4	7	0
	5	4	0
Number of Languages Proficient in	1	0	20
	2	8	0
	3	6	0
	4	5	0
	5	1	0

Note. M= male; F= female

Each group consisted of 20 participants with an age range of 18.11-21.6 for the multilingual group and 18.11-21.5 for the monolingual group. There were 4 males and 16 females for each group with the majority of the monolingual group being Caucasian and the majority of the multilingual group being African. The monolingual participants reportedly spoke between 1 and 3 languages, but were only highly proficient in English, while the multilingual participants spoke between 1 and 5 languages, with a reported proficiency in up to 5 languages. None of the participants reported any grade failures. The Living Standard Measure (LSM) for the respective groups differed with the mean LSM for the multilingual group calculated at 7.5 while the monolingual LSM measure was calculated at 10.3. An independent-samples t-test was conducted to determine the significance of LSM in relation to group membership. A significant difference was found in favour of the monolingual group; $t(19.93)=8.12$, $p = 0.00$.

The participants were all undergraduate students from all Faculties in the University. None of the participants had failed a grade at school and the majority attended preschool. The levels of maternal education ranged considerably and included not having completed primary school, with the majority of participants stating that their mothers had completed tertiary education (N=9 for each group). With regards to paternal educational levels, many of the multilingual participants stated that they did not know their father’s level of education (N=6), while 8 reported that their fathers had completed secondary school only. The monolingual group only reported one father’s educational level as unknown, while the majority reported that their father had either completed secondary school (N=10) or tertiary education (N=9). The multilingual group reported a range of answers regarding the marital status of their caregivers, with most stating that they had one caregiver (N=10) while the monolingual group largely stated that their caregivers were married (N=14) and that they had two care givers (N=14). Thus, while careful attempts were made to match participants from the two groups, it is apparent that there were significant differences in their home backgrounds, which may have influenced their final results.

Measures

The following measures were used in order to determine language proficiency and assess working memory.

The Automated Working Memory Assessment (AWMA) (Alloway, 2007). The AWMA is a standardized, computer based battery, providing multiple assessments of verbal and visuospatial short-term memory (STM), as well as an assessment of verbal and visuospatial working memory (Alloway, Elliot, & Place, 2010). According to Alloway, Gathercole and Pickering (2006) the AWMA was assessed for reliability with 128 randomly selected individuals, ranging in age (mean=10.4 years, S.D= 5 years). Administration of testing was separated by a four week period and there was little change between the first and second scores obtained (r=.69 to .90). The test-retest reliability is as follows: digit recall r=.89, word recall r=.88, nonword recall r=.69, listening recall r=.88, counting recall r=.83, backwards digit recall r=.86, dot matrix r=.85, mazes memory r=.86, block recall r=.90, odd-one-out r=.88, Mister X=.84 and spatial recall=.74 (Alloway et al., 2010). Alloway, Gathercole, Kirkwood, & Elliot (2008) found the AWMA to have high convergent validity with the WISC-IV Working Memory Index as well as high divergent validity. This was established through the classification accuracy of children into group of low and average working memory (Alloway et al., 2008). The digit span subtest of the WISC-IV correctly assigned group membership to 91 of the children (see Alloway et al., 2008, for further measures of test validity). Although it is computerized it requires individual face-to-face administration. The subtests are computer scored, each subtest is described below.

Visuo-Spatial Complex Working Memory. These included three subtests, the first being the Odd-One-Out subtest in which the participant was instructed to view three shapes in a row and identify the shape that did not fit the pattern. Following each trial, the participant recalled the location of these shapes by indicating the correct box on the screen. This subtest also included a score on Odd One Out Processing which was indicative of the participant's ability to simultaneously processes and recall visual information.

The second subtest was the Mister X subtest in which the participant viewed two cartoon figures, referred to as Mister X (one with a blue hat and one with a yellow hat). The participant was then instructed to whether the Mister X with the yellow hat was holding the ball in the same hand as the Mister X with the blue hat. The orientation of the cartoon depicting the Mister X with the blue hat could also be changed. This subtest also provided a processing score namely Mister X Processing. This score was a measure of the participant's ability to process, maintain and recall visual information

The final subtest was the Spatial Recall subtest in which the participant had to determine whether the two presented shapes were identical or opposites. The participant was presented with a shape on the left of the screen and then a shape on the right of the screen. The instruction was to determine whether the shape on the right side of the screen was identical or opposite to the shape on the left side of the screen. This subtest included a score for the participant's ability to process, maintain and recall visuo-spatial information, namely Spatial Recall Processing.

Visuo-Spatial Simple Working Memory. These tasks included the Dot Matrix subtest (the participant was instructed to recall the positioning of a red dot within a four by four matrix by tapping the appropriate square on the screen), the Mazes Memory subtest (the participant was presented with a maze that had a red path drawn through it for a period of three seconds and then had to trace the same path through a blank maze), and the Block Recall subtest (the participant was instructed to reproduce a sequence of blocks consisting from one to nine blocks).

Verbal Complex Working Memory. These tasks consisted of the Listening Recall subtest (the participant listened to a series of spoken sentences and was instructed to verify the sentence by stating ‘true’ or ‘false’ and then recall the final word for each sentence in sequence), the Counting Recall subtest (the participant was presented with red circles and blue triangles and was instructed to count the number of circles in each array. After three arrays had been shown, the participant recalled the final amount from each array sequence), and the Backwards Digit Recall task (the participant recalled a sequence of spoken digits in reverse order, beginning with two digits and then increasing in digit span). The Listening Recall subtest also a provided a processing score namely Listening Recall Processing which was indicative of the participants ability to process and recall verbal information. The Counting Recall subtest also provided a measure of the participant’s ability to simultaneously process and maintain visuo-spatial and verbal information, as reflected in the Counting Recall Processing score.

Verbal Simple Working Memory. These consisted of the Digit Recall task, the Word Recall task and the Non-Word Recall task. In the Digit Recall task a series of numbers were verbally presented. The participant was expected to remember and recite the numbers in the sequence in which they were presented. The sequence ranged from 2 to a maximum of 9 numbers. The sequence had to be recited in the correct order for a correct score to be received. The Word Recall task required the participant to remember and recite a series of words in sequence. The sequence was presented verbally and ranged from 1 to a maximum of 7 words. The sequence had to be recited in the correct order for a correct score to be received. The Non-Word recall was a verbal subtest in which a series of nonsensical words were presented. The participant was instructed to recall these words in the correct serial order. The sequence started with one word and continued to increase with difficulty with a maximum of seven words possible in the sequence.

Wechsler Adult Intelligence Scale Third Edition (WAIS III) Selected Subtests (Weschler, 2002). Two verbal and two non-verbal subtests of the WAIS-III were used as controls to ensure that intelligence did not influence the results. The two verbal comprehension subtests were Vocabulary and Similarities, and the two non-verbal subtests, indicating perceptual organization, were Block Design and Matrix Reasoning. These subtests were administered and scored according to the standardized procedures outlined in the manual and followed the same as that used for the larger study for comparative purposes.

According to The Psychological Corporation (2002), the WAIS-III has been extensively researched for both validity and reliability. According to the Psychological Corporation (2002) the mean reliability coefficients for each subtest were calculated using a Fishers's z transformation and are .93, .86, and .86, for Vocabulary, Similarities, and Block Design respectively. With regards to the validity of the instrument, correlational studies were done between the WAIS-III, WAIS-R, WISC-III, the WIAT, the Stanford-Binet Intelligence Scale-Fourth Edition (SB-IV), and the Standard Progressive Matrices, and it was found that the WAIS-III exhibited high levels of concurrent validity. The correlation coefficients between the WAIS-III and WAIS-R were r=.94 for the VIQ, r=.86 for the PIQ, and r=.93 for the FSIQ scores while the correlation coefficients for the comparison of the WAIS-III and WISC-III were r=.88, r=.78, and r=.88 for the VIQ, PIQ and FSIQ respectively (The Psychological Corporation, 2002). The correlation between the WAIS-III and the Ravens Standard Progressive Matrices was lower, ranging from r=.49 to r=.79 for the VIQ, PIQ and FSIQ scores. With regards to the SB-IV the WAIS-III FSIQ score correlated positively with a correlation coefficient of r=.88 while the PIQ scores and the SB-IV Standard Area Scores exhibited the highest correlations ranging in the .80s. However, the data indicated that the Short Term Memory Area of the SB-IV and the WMI of the WAIS-III do not share a large amount of variance (The Psychological Corporation, 2002).

Construct validity was determined through the administration of the test to individuals with neuropsychological deficits such as Alzheimer's dementia and traumatic brain injury. It is important to note that the Human Sciences Research Council (HSRC) (Claassen, Krynauw, & Wagamathe, 2001) standardized the scores of the WAIS-III for a South African population, however, clinical data was found to be problematic for use with black African first language speakers as the HSRC did not stratify strictly for quality of education, namely disadvantaged backgrounds as in comparison to standardized education (Shuttleworth-Edwards, 2012). According to Shuttleworth-Edwards (2012) it was found that predominantly Xhosa speaking individuals (age range of 19-30 years) with disadvantaged education backgrounds performed significantly lower than the US standardization by 20 to 30 IQ points. As such, the test has not been completely normalized for a South African population. However, participants were not compared to the WAIS-III norms in this study. Rather, scores were compared between monolingual and multilingual groups to ensure that there were no significant differences between them. Each WAIS-III subtest used in this study is described below.

Vocabulary. This subtest is a measure of learning, comprehension and expression of English vocabulary, namely crystallized intelligence. The researcher presented the participant with a vocabulary card and read the word out simultaneously. The participant was then asked to supply a definition for the word. The participant's response was recorded verbatim on the response sheet. This subtest was scored according to the guidelines in the scoring manual with a score of 0, 1, or 2 being awarded for the answer. A maximum score of 66 points could be awarded.

Similarities. Fluid intelligence is assessed in this subtest as the individual's verbal abstract reasoning is assessed. This subtest consisted of 19 items. The researcher verbally presented the participant with two words that were representative of common concepts or objects. The participant was then instructed to indicate how these two words were related or alike. This was scored according to the manual; 1 point was awarded for the correct answer while 0 was awarded for an incorrect or incomplete answer. A maximum of 33 points was possible.

Block Design. This subtest was used in order to measure the participant's spatial perception, visual abstract processing, and problem solving (fluid intelligence). The researcher gave the participant a set of blocks and instructed the participant to replicate models or pictures of two-colour designs with these blocks. Each block had two white sides, two red sides, and two half red and half white sides. The designs that the participant was asked to replicate progressed in difficulty and range from two-block designs to nine-block designs. This subtest was scored according to the time it required for the participant to complete the block design. The scoring ranges from 4 to 7 points with 0 points being rewarded should the participant exceed the time limit or replicate the design incorrectly. A maximum of 68 points could be awarded.

Matrix Reasoning. Fluid intelligence was measured in this subtest by assessing the participant's inductive reasoning ability, spatial reasoning ability, as well as their ability to solve nonverbal, abstract problems. This subtest tested four types of nonverbal reasoning namely pattern completion, classification, analogy, and serial reasoning and consisted of 26 items. The participant was presented with a matrix and was instructed to identify one of five response options in order to complete the matrix. One point was awarded for the correct answer while 0 was awarded for the incorrect answer with a maximum of 26 points possible.

The Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian, Blumenfeld, & Kaushanskaya, 2007). The Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian, Blumenfeld, & Kaushanskaya, 2007) is a self-report questionnaire which assesses the degree of proficiency in multiple languages. This was used to determine whether or not the monolingual English participants were indeed monolingual as in comparison to the multilingual data set collected, as well as to determine how many languages the multilingual group were proficient in.

The questionnaire included questions relating to the age of language acquisition, dominance of languages and self-reported levels of proficiency in various languages. This questionnaire was completed in a computerized format. According to Marian et al. (2007) it was determined that the LEAP-Q has high internal consistency. This was indicated by high Cronbach's alphas for the majority of the factors. The highest Cronbach's alphas were found in the Relative language 2 to language 1 competence, late language 2 learning, language 2 immersion and media-based language 1 learning (Marian et al., 2007), the values of which are not provided in the study. These results were established by analysing responses from a diverse bilingual group consisting of 52 individuals (M = 27.29 years, SD = 5.92; 29 women, 23 men), through factor analysis and multiple regression analyses. The participants were American, recruited from Chicago and an American University. Further details pertaining to race and nationality were not supplied, however, the participants ranged in their educational levels from 2 years at university to a doctoral degree (M = 18.04 years of education, SE =2.62; range=15–27years) (Marian et al., 2007).

Criterion-based validity was established through a group of fifty bilingual speakers of English and Spanish participants (M = 26.7, SD = 10.4; 31 women, 19 men) utilizing multiple regression analyses and factor analysis with Marian et al. (2007) stating that according to these studies the LEAP-Q is found to be a reliable and valid tool for the assessment of bilingual language status. The participants ranged in their educational level with a mean of 16 years of education and a range of 11-22 years of education. Pearson's R correlation analysis was utilized in order to establish criterion-based validity (Marian et al., 2007). With regards to Language 1, it was found that self-reported measure and behavioural measures of oral comprehension were the strongest correlates (speaking= .541, comprehension= .481, and reading= .661). The self-reported proficiency in Language 2 was found to correlate stronger with the standardized behavioural measures in comparison to language 1. The strongest correlates were found to be in relation to the passage and oral comprehension (speaking= .741, comprehension= .621, and reading= .634) (Marian et al., 2007).

The data for the LEAP-Q was coded according to percentile rankings, as displayed on the questionnaire. The scale varied from 0 to 100 and was based on standardized measures as this was the case for all the other measures used (Marian et al., 2007). Participants were classified as monolingual if their self-reported degree of language proficiency was 6 (out of a possible score of 10) or above in only one language, namely English, in the categories of understanding, and speaking.

Demographic Questionnaire. This questionnaire was developed for the larger study and includes questions relating to the participant's age, gender, home language, and tertiary education as well as socio-economic status (SES) (Refer to Appendix D). Types of questions included whether or not the participant owned a television, dishwasher, or cellphone as well as whether or not there was a domestic working in the house. The scores were calculated using the LSM calculator at the following website: http://www.eighty20.co.za/databases/show_db.cgi?db=fulllsmcalculator. Values of 'low' were coded with a .0 while values of 'high' were coded as .5, for example 10 high was coded as 10.5 while 10 low was coded as 10.0. Further information about caregivers and individuals with whom the participant spends most of their time was also requested.

Procedure

Participants in the monolingual English group were required to set aside an hour and a half of their time in order to complete the Automated Working Memory Assessment (AWMA) (Alloway, 2007), four subtests from the WAIS III (Wechsler Adult Intelligence Scale), as well as the demographic questionnaire (Appendix D) and the LEAP-Q (Marian et al., 2007) (Refer to Appendix C), in a quiet room in the Emthonjeni Center at the University. All scoring and testing (excluding the WAIS-III testing), was administered on the computer. The demographic questionnaire and the LEAP-Q were also filled in on the computer but were scored manually.

The research procedure was communicated verbally to participants. They were also verbally informed that participation was voluntary and that they could choose to withdraw from the study at any time, should they wish to do so, without prejudice. Furthermore, they were informed as to the purposes of the research, the possibility that the research may be published in the future and that by taking part in the study they were consenting to these terms. They were also informed that the raw data set may be kept for additional research in future. This information was also given to participants in a written format (Refer to Appendix E). In order to maintain confidentiality and anonymity, no names or identifying data was requested from participants, and feedback was given in terms of group trends, published in a blog, no individual feedback was given.

First year Psychology students took part in the research and obtained 1 percent credit towards their course for their participation. This required that the participants provide their student numbers for the purpose of obtaining credit. As such, students who participated were given a credit slip (Refer to Appendix F) on which they wrote their student numbers and course codes. In order to maintain confidentiality only student numbers were collected with the consent of the participant and the relevant proof of participation slip was given to the student upon the completion of their testing. A final list of student numbers were given to the relevant course administrator in order to cross-verify the students who participated, however, the course administrator does not have access to the data collected. Participation in the research for credit purposes does not allow for full confidentiality. However, the student numbers were not used in the data collection or analysis in any way and were only given to the course administrator for credit purposes. Additionally, as the data was collected according to participant numbers it was not possible to identify which student provided which results.

Of the data collected, three participant's results were excluded from the study due to psychopathology, this was determined through self-report. Additionally, one participant did not complete the AWMA assessment and as such the incomplete data set from the participant was also excluded.

Ethical Considerations

All participants were above the age of 18 years. Consent was voluntary and participants were able to withdraw from the study at any time without prejudice. Data was collected through face-to-face administration of the testing instruments and as such anonymity was not possible. However, no personal or identifying information were collected and confidentiality was assured. Student numbers were only collected for students who consented to giving their student numbers and who wanted to receive extra credit for the participation in this study. In order to maintain confidentiality the participant number and student number were not the same, additionally, students received their proof of participation slip upon the completion of the data collection, so they did not have to collect these at a later point. As a list of student numbers were required for cross-validation purposes, the course administrator was provided with a list of students who had participated in the research, however, the administration did not have access to the data collected. The researcher did not retain the student numbers. This was explained to participants in the information and credit slip (Refer to Appendix F).

As the data gathered was not of an emotional, invasive, sensitive or psychologically damaging nature, no additional psychological support needed to be provided to participants. Data was captured on a spreadsheet and kept in a password protected file on the researcher's computer, accessible by the researcher and supervisor. As this data may be used for possible further research, there is no limit set with regards to the period of time that the data will be stored. Feedback was published on a blog in group trends, the address of which was given to participants upon the completion of the research. No individual results were published. Additionally, participants were informed prior to participation, that individual feedback was not possible as identifying information was not collected. There were no foreseeable risks or benefits to participants.

In conclusion, the assessment battery has proven to be both valid and reliable. While the qualitative measures have not been standardized, these have provided valuable background information. The next chapter will expand on the results provided from these assessments.

Chapter 3: Results

For the purposes of statistical analysis the IBM SPSS Statistics (version 21) (IBM Corporation and other(s), 1989, 2012) program was used. The cumulative sample (N=40) is small for comparative purposes and as such a Kolmogorov-Smirnov statistical tests for normality were conducted in order to determine the distribution of data. The histograms (Refer to Appendix G) and the statistical results of the Kolmogorov-Smirnov indicated that the data was normally distributed and as such could be analysed using parametric procedures. The independent variables used were group membership (either monolingual or multilingual), gender, years of study, and socio-economic status. The independent variables are classified as nominal data. The dependent variables were the performance scores on the relevant WAIS-III and AWMA subtests, the results of which are described below. The dependent variables are classified as ratio data. Standard scores were used in the analyses for both tests. With regards to the Leap-Q, raw scores were used for analyses.

WAIS-III Subtests

The WAIS-III subtests included the Vocabulary, Similarities, Block Design, and Matrix Reasoning Subtests. The descriptive data for the scores on the WAIS-III subtests are listed in the table below:

Table 1. *Descriptive statistics for scores on the WAIS III and AWMA subtests*

	Monolingual (n=20)				Multilingual (n=20)			
	Mean	Min	Max	SD	Mean	Min	Max	SD
Vocabulary	11.8	8	15	2.19	10.8	8	16	1.99
Similarities	10.4	7	15	2.21	9.6	7	12	1.67
Block Design	9.15	6	16	2.28	9.7	6	15	2.47
Matrix Reasoning	11.15	8	18	2.23	12.45	9	16	2.04
Digit Recall	85.00	69.00	116.00	12.76	98.4	73.00	136.00	14.95
Word Recall	91.10	66.00	116.00	16.05	89.44	73.00	129.00	14.8
Nonword Recall	98.85	68.00	131.00	16.33	92.64	6.00	108.00	12.92
Verbal Short Term Memory	89.90	69.00	121.00	14.31	91.75	69.00	127.00	15.07
Listening Recall	93.00	70.00	115.00	12.39	98.5	73.00	128.00	14.26
Listening Recall Processing	87.95	73.00	113.00	11.29	98.7	75.00	131.00	15.31
Counting Recall	89.75	57.00	109.00	12.84	102.6	57.00	132.00	17.55
Counting Recall Processing	87.35	77.00	120.00	12.14	103.8	77.00	121.00	14.55
Backwards Digit Recall	84.45	70.00	126.00	23.97	93.94	70.00	126.00	15.23
Verbal Working Memory	88.8	72.00	106.00	11.24	98.25	72.00	125.00	12.76
Dot Matrix	90.85	63.00	122.00	13.74	98.25	77.00	118.00	13.77
Mazes Memory	87.65	66.00	126.00	14.84	100.45	70.00	134.00	14.22
Block Recall	82.75	6.00	98.00	11.87	90.55	60.00	117.00	14.42
Visuo-spatial Short Term Memory	84	62.00	96.00	9.96	95.3	74.00	123.00	13.45
Odd One Out	91.75	77.00	108.00	9.79	102.85	74.00	131.00	14.49
Odd One Out Processing	89.25	70.00	113.00	11.41	101.5	76.00	122.00	12.08
Mister X	94.1	68.00	128.00	14.45	101.4	64.00	121.00	17.2
Mister X Processing	93.15	92.00	124.00	14.37	101.4	77.00	118.00	13.33
Spatial Recall	89.35	72.00	107.00	9.28	99.99	81.00	135.00	14.01
Spatial Recall Processing	87.30	72.00	108.00	9.93	100.00	84.00	132.00	13.57
Visuo-spatial Working Memory	89.00	66.00	112.00	11.60	102.30	86.00	123.00	12.98

The results for the Levene's Test for Equality of Variances indicates that the significant values for the respective subtests are greater than 0.05, using $p<0.05$ (see Table 3). As such, the variability of the two groups is not significantly different and equality of variances could be assumed.

In order to ascertain whether intelligence had an effect on the results obtained from the two groups with regards to working memory, a series of independent t-tests were conducted comparing the groups' scaled scores on the WAIS subtests, namely Vocabulary, Similarities, Block Design and Matrix Reasoning, prior to the comparison of working memory scores.

As seen in Table 1, the mean scores for the multilingual and monolingual groups are similar. An independent t-test showed no significant differences between the groups on any WAIS-III subtests (Refer to Table 2).

Table 2. *Independent t-tests and Tests for Equality of Variances, comparing monolingual and multilingual groups on the Vocabulary, Similarities, Block Design and Matrix Reasoning subtests.*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Vocabulary	Equal variances assumed	.499	.484	1.511	38	.139	1.0000	.6617	-.3396	2.3396
	Equal variances not assumed			1.511	37.652	.139	1.0000	.6617	-.3400	2.3400
Similarities	Equal variances assumed	.785	.381	1.292	38	.204	.8000	.6190	-.4531	2.0531
	Equal variances not assumed			1.292	35.333	.205	.8000	.6190	-.4562	2.0562
Block Design	Equal variances assumed	1.221	.276	-.732	38	.469	-.5500	.7518	-2.0718	.9718
	Equal variances not assumed			-.732	37.745	.469	-.5500	.7518	-2.0722	.9722
Matrix Reasoning	Equal variances assumed	.039	.844	-1.924	38	.062	-1.3000	.6757	-2.6679	.0679
	Equal variances not assumed			-1.924	37.695	.062	-1.3000	.6757	-2.6683	.0683

Note. $p < 0.05$

Although a Multivariate Analysis of Variance (MANOVA) reconfirmed that there were no statistically significant differences between the mean scores of the groups on the WAIS-III subtests, the effects sizes (Cohen's *d)* ranged from small to moderate. Matrix Reasoning showed a practically significant difference between the groups, in favour of the multilingual group.

Table 3. *MANOVA between groups on the WAIS-III subtests*

	Post-hoc (*F*)	Cohen's *d*
Vocabulary	2.284	0.49
Similarities	1.67	0.42
Block Design	0.535	0.24
Matrix Reasoning	3.701	0.62

Comparisons between the groups on the working memory tests

The groups' performance on the subtests of the AWMA were statistically analysed using a MANOVA in order to determine whether group membership (either monolingual or multilingual) and consequently multiple language fluency had any effect on performance in these subtests. Effect sizes (Cohen's *d*) were calculated for all subtests as the effect sizes could be significant even though the p value is not. For the purposes of this research, Cohen's *d* was calculated according a formula, as set out in Thalheimer & Cook (2002). The effect sizes were interpreted according to the values as set out in Cohen (1988), negligible effect (<0.15), small effect (>=0.15 and <0.40), medium effect (>=0.40 and <0.75), large effect (>=0.75 and <1,10), and very large effect (>=1.10 and <1.45). The results of the MANOVA are indicated in Table 4 below.

Table 4. *MANOVA results and effect sizes between groups on the AWMA subtests (scaled scores used)*

	Multilingual		Monolingual		Post-hoc (F)	Cohens *d*
	M	SD	M	SD		
Digit Recall	98.40	14.95	85.00	12.76	9.32**	0.99
Word Recall	89.44	14.80	91.10	16.05	0.12	0.11
Nonword Recall	92.64	12.92	98.85	16.33	1.84	0.43
Verbal Short Term Memory	91.75	15.07	89.90	14.31	0.16	0.13
Listening Recall	98.50	14.26	93.00	12.39	1.70	0.42
Listening Recall Processing	98.70	15.31	87.95	11.29	6.39*	0.82
Counting Recall	102.60	17.55	89.75	12.84	6.99*	0.86
Counting Recall Processing	103.80	14.55	87.35	12.14	15.07***	1.26
Backwards Digit Recall	93.94	15.23	84.45	23.97	2.23	0.48
Verbal Working Memory	98.25	12.76	88.80	11.24	6.18*	0.81
Dot Matrix	98.25	13.77	90.85	13.74	2.90	0.55
Mazes Memory	100.45	14.22	87.65	14.84	7.75**	0.90
Block Recall	90.55	14.42	82.75	11.87	3.49	0.61
Visuo-spatial Short Term Memory	95.30	13.45	84.00	9.96	9.11**	0.98
Odd One Out	102.85	14.49	91.75	9.79	8.06**	0.92
Odd One Out Processing	101.50	12.08	89.25	11.41	10.88**	1.07
Mister X	101.40	17.20	94.10	14.45	2.12	0.47
Mister X Processing	101.40	13.33	93.15	14.37	3.54	0.61
Spatial Recall	99.99	14.01	89.35	9.28	8.02**	0.92
Spatial Recall Processing	100.00	13.57	87.30	9.93	11.41**	1.10
Visuo-spatial Working Memory	102.30	12.98	89.00	11.60	10.64**	1.06

Note. *p<0.05, **p<0.01, ***p<0.001

A series of MANOVAs were conducted on the AWMA scores in order to determine whether there is a significant difference in working memory between the monolingual and multilingual groups (Refer to Table 4). The first MANOVA was conducted on the scaled scores of the Verbal Short Term Memory (VSTM) subtests which included the Digit Recall, Word Recall, and Non-word Recall subtests. The results indicate that while no significant differences were found in the overall VSTM scores, there was a significant difference on the Digit Recall subtest ($F=9.32$, $p<0.05$), with the multilingual group performing significantly higher in this subtest. The effect size (*d*) was large. While the p-value was not significant, the effect size (*d*) on the Nonword Recall subtest was Medium, with the monolingual group performing slightly better in this subtest.

The second MANOVA was conducted on the scaled scores of the Verbal Working Memory (VWM) and the relevant subtests namely, Listening Recall, Listening Recall Processing, Counting Recall, Counting Recall Processing, and Backwards Digit Recall. Significant differences were found between the groups on the VWM total score (F=6.18, p<0.05, d=0.81) with the Multilingual group scoring significantly higher. Among the subtests, significant differences were found on the Listening Recall Processing, Counting Recall, and Counting Recall Processing subtests with the multilingual group outperforming the monolingual group in all of these subtests. The effect sizes ranged from large to very large on these subtests. While the p-value did not indicate a significant difference on the Listening Recall and Backwards Digit Recall subtests, the *d* values indicated a medium effect size in favour of the multilingual group.

The third MANOVA was performed on the scaled scores of the Visuo-spatial Short Term Memory (VSSTM) subtests namely, Dot Matrix, Mazes Memory, and Block Recall. The results indicated that overall, the multilingual group scored significantly higher in the VSSTM than their monolingual counterparts (F=9.11, p<0.05, d=0.98). A significant difference was found on the Mazes Memory subtest with the Multilingual group outperforming the monolingual group in this regard (F=7.75, p<0.05, d=0.90). The effect sizes for VSSTM and Mazes Memory were indicated as large while the effect sizes for the Dot Matrix (d=0.55) Block Recall (d=0.61) subtests were indicated as medium in favour of the multilingual group.

The final MANOVA was conducted on the Visuo-spatial Working Memory (VSWM) total and the relevant subtests (Odd One Out, Odd One Out Processing, Mister X, Mister X Processing, Spatial Recall, and Spatial Recall Processing). The results indicate that there were significant differences between the groups on the VSWM (F=10.64, p<0.05, d=1.06) with the multilingual group outperforming their monolingual counterparts and a large effect size. The multilingual group scored significantly higher than their monolingual counterparts on the Odd One Out (F=8.06, p<0.05), Odd One Out Processing (F= 10.88, p<0.05), Spatial Recall (F= 8.02, p<0.05), and Spatial Recall Processing (F= 11.41, p<0.05) subtests. The effect sizes for these subtests ranged from large to very large. Although the p-value did not indicate a significant difference, the effect sizes for the Mister X and Mister X Processing subtests indicated a medium effect with the multilingual group scoring higher in these subtests.

Summary of Results

Statistical analyses compared the data between the monolingual and multilingual groups. A Kolmogorov-Smirnov Test of normality determined that the data was normally distributed and that parametric tests could thus be used. A series of MANOVA’s were performed on the scaled scores obtained in the WAIS-III subtests following which it was determined that these scores had no statistically significant effect on the scores of the working memory subtests (AWMA). The results indicate that the multilingual group scored significantly higher than the monolingual group on all working memory measures, except on the Nonword Recall subtest of the VSTM where the moderate effect size indicates practical significance in favour of the monolingual group.

Chapter 4: Discussion

The aim of this research was to investigate the relationship between proficiency in multiple languages and working memory. Results indicate that firstly, the degree of proficiency in multiple languages is positively related to working memory and secondly that there is a significant difference between monolingual and multilingual participants in terms of their working memory functioning. Findings suggest that the multilingual group performed superiorly to the monolingual group in all subtests except the Nonword recall subtest of the AWMA.

The results from the study indicate that the multilingual group were able to discriminate perceptual distinctions, scan and categorize verbal and nonverbal information, recognize patterns and analyse non-verbal information better than their monolingual peers. The multilingual participants demonstrated increased cognitive flexibility and pattern recognition through the Odd one Out, Odd One Out Processing, Mister X, Mister X Processing, Listening Recall and Listening Recall Processing subtests, results which were also found by Ben-Zeev (1977), however, the mean age of her groups was 7 years. The above mentioned subtests were also a measure of attentional control and efficiency in updating information in the working memory. Better performance on these aspects was found by Bialystok (2009) (mean age of 48 years) and Miyake et al. (2000) (mean age unknown but they were undergraduate university students). Ben-Zeev's study (1977) found that the bilingual group had access to a smaller vocabulary, however, the scores between the monolingual and multilingual groups on the Similarities and Vocabulary subtests of the WAIS-III were not significantly different and as such there was no evidence for this in the current study. However, this could indicate developmental differences which disappear in early adulthood. Additionally, no evidence was found in support of a difference in the groups' expressive and receptive vocabulary abilities which Bialystok (2001) (age range of participants 4,5 to 5,5 years) found there to be. It may be that the multilingual participants in the current study are also highly proficient in English as they study in an English medium school, which may account for the lack of differences in expressive and receptive vocabulary abilities. Additionally, this may indicate developmental differences which are no longer present in young adulthood.

The better overall performance of the multilingual group may be an indication of increased cognitive efficiency, as proposed by Bialystock (2008). The multilingual groups' superior performance on the processing or complex working memory subtests (Listening Recall Processing, Counting Recall Processing, Odd One Out Processing, Serial Recall Processing, ad Mister X Processing) are consistent with Bialystock's (2009) findings that processing abilities are enhanced in bilingual individuals, which seems to be consistent irrespective of age. According to Bialystock (2001) and Bialystok and Martin (2004) as well as Bonifacci, Giombini, Bellocchi and Contento (2011) multilingual individuals should demonstrate enhanced abilities in the realms of selective attention, inhibition of attention in relation to irrelevant information as well as enhanced ability to switch between languages and competing information. Additionally, multilingual individuals exhibit more advanced encoding skills, the ability to assess and select relevant information and to make inferences about information in a logical manner. The superior performance of the multilingual group on the processing subtests may be attributed to these processes.

The multilingual group's performance on the Verbal Short Term Memory and Verbal Working Memory subscales could be attributed to their increased ability to scan verbal information and reorganize their strategies regarding the coding and processing of this information as found by Ben-Zeev (1977). Additionally, these scales are heavily influenced by the multilingual group's superior processing ability. The monolingual group's performance on the Nonword recall, while not statistically significant, was practically significant and could be explained by increased lexical decision interference, as found by Ransdell and Fischler (1987), in the multilingual group. This would mean that the multilingual group would have more possible lexical analogies to choose from when pronouncing the nonsense word. However, as research indicates that multilingual individuals have a more analytical approach to syntax (Ben-Zeev, 1977; Berko, 1958) it may be that the multilingual group struggled to make meaning from non-meaningful information. Research indicates that multilingual individuals are more meaning-orientated (Ben-Zeev, 1977; Bialystock, 2001; Bonifacci, Giombini, Bellocchi, & Contento, 2011; Ianco-Warral, 1972) and as such the strategies for processing may be more complex as there is no meaning to be attributed to the word. This would account for the monolingual group's superior performance on this subtest.

The participants from the multilingual group were all from a significantly lower socioeconomic status in comparison to the monolingual group, except for one participant who was from the same socioeconomic group as the monolinguals. Socioeconomic statuses were indicated through a calculation of living standards. The SES yielded a mean of 7.5 for the multilingual group on the Living Standards Measure and a mean of 10.3 for the monolingual group (a higher number indicates a higher socioeconomic status), a t-test was conducted which indicated that this difference was statistically significant. While research indicates that working memory could be negatively affected by a low socioeconomic status (Evans & Schamberg, 2008), this does not seem to have affected this sample as the multilingual group performed superiorly to the monolingual group. It is possible that their multiple language proficiency provided an advantage that could have superseded the effects of their SES, however, this is highly tentative.

Limitations

It is acknowledged that no research is without its limits. As such, it is important to acknowledge the limits of this research. Extraneous variables could not be completely controlled for, these may have influenced the results in some way. These variables include the race of the participants, the choice of degree, as well as socioeconomic status. Additionally, it is unclear what the effect of degree choice may have on working memory. Different degrees may develop different aspects of working memory, for example studying towards obtaining a degree in architecture or engineering may develop the visuo-spatial working memory while studying a degree in languages may develop verbal working memory. The majority of the monolingual group were students from the Faculty of Humanities while the multilingual group was more diverse in terms of degrees including degrees in the Science and Commerce Faculties. It is acknowledged that there was a difference in socio-economic status between the two groups, however, as found by Engel, Santos, and Gathercole, (2008) this appeared not to affect working memory in the bilingual group.

As the multilingual dataset had been collected prior to the collection of the monolingual dataset researcher bias may also be a factor to consider. As the data was collected by two different researchers over different time periods, it may be that researcher administration affected results.

Finally, it is acknowledged that the sample size was small and that the results can consequently not be generalized to the general population. However, this is also reflective of the difficulties the researcher had in obtaining participants for the monolingual sample. It was found that the majority of individuals in the university context had been exposed to at least two languages and it is thus questioned whether a truly monolingual participant exists in a South African context.

Suggestions for Future Research

While studies have been done on the relationship between working memory and the onset of HAD and Alzheimer’s, these studies have not been in an African context. This study could also be duplicated with a larger sample in order to determine whether the results could be generalized. Additionally, it would be useful to compare the working memory of a multilingual group who are proficient in African languages to a multilingual group proficient in other orthographies such as European languages. This would aid in determining the specific influences of different types of orthographies on working memory.

Conclusion

Working memory is an important part of our daily functioning. While a theoretical construct, it can account for various cognitive activities we take part in on a daily basis, such as decision making. Research has indicated that an increase in working memory function could delay the onset of HIV-Associated Dementia and Alzheimer’s (Bialystok, Craik, & Freedman, 2007; Craik & Bialystok, 2006; Gollan, Montoya, Cera, & Sandoval, 2008). As such, finding a way to improve working memory function could be an invaluable way of delaying the onset of these disorders which are becoming more prevalent in South Africa due to the high HIV prevalence and increasingly older population (Lee et al., 2012; Shrestha, 2006). While studies have indicated positive effects of bilingualism on working memory (Ben-Zeev, 1977; Bialystok, 1999; Bialystock, 2001; Bialystock, 2006; Carlson, & Meltzoff, 2008; Costa, Hernandez, & Sebastian-Galles, 2008; Ianco-Worrall, 1972), few exist that explore the effects of multiple language proficiency, specifically of African languages, on working memory and its functions. As such, this research aimed at investigating the effects that multiple language proficiency has on working memory functioning.

The results indicate that proficiency in multiple African languages may have positive effects on working memory. In general, the multilingual group significantly outperformed the monolingual group on the subtests that evaluated all aspects of short term and working memory, with the exception of one test of verbal short term memory.

As such, the hypotheses of this research were confirmed, in that the multilingual students showed generally superior working memory to their monolingual peers. However, causality cannot be determined. Consequently, learning a second language in adulthood may be a buffer against the onset of cognitive disorders, such as HAD and Alzheimer's, and this should be explored in future research.

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Appendix A: Advertisement

School of Human and Community Development

CALL FOR PARTICIPANTS

Is your home language **English**??? Are you between 18 and 22 years old?? If you are monolingual (only speak fluent English) and would like to participate in a **study about Working Memory and Language**, please contact me.

The study will involve you filling out a demographic questionnaire, as well as completing some tests and will take approximately 1 hour and 30 minutes of your time.

If you are interested, please contact Luzanne Liversage on 084 652 9772 or email me at luzanne.liversage@gmail.com

Luzanne Liversage 084 652 9772

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Luzanne Liversage 084 652 9772

Luzanne Liversage 084 652 9772

Appendix B: Blurb for SAKAI

School of Human and Community Development

CALL FOR PARTICIPANTS

Is your home language **English**??? If you are monolingual (only speak fluent English), between the ages of 18 and 22 years and would like to participate in a **study about Working Memory and Language**, please contact me.

The study will involve you filling out a demographic questionnaire, as well as completing some tests and will take approximately 1 hour and 30 minutes of your time.

If you are interested, please contact Luzanne Liversage on 084 652 9772 or email me at luzanne.liversage@gmail.com

First year Psychology Students can obtain 1% towards their class mark for participation in this study.

Appendix C: Language Experience and Proficiency Questionnaire (LEAP-Q)

Language Experience and Proficiency Questionnaire (LEAP-Q)

Last Name	N/A	First Name	N/A	Today's Date	
Age		Date of Birth		Male ☐	Female ☐

(1) Please list all the languages you know **in order of dominance**:

1	2	3	4	5

(2) Please list all the languages you know **in order of acquisition** (your native language first):

1	2	3	4	5

(3) Please list what percentage of the time you are *currently* and *on average* exposed to each language.
(*Your percentages should add up to 100%*):

List language here:					
List percentage here:					

(4) When choosing to read a text available in all your languages, in what percentage of cases would you choose to read it in each of your languages? Assume that the original was written in another language, which is unknown to you.
(*Your percentages should add up to 100%*):

List language here					
List percentage here:					

(5) When choosing a language to speak with a person who is equally fluent in all your languages, what percentage of time would you choose to speak each language? Please report percent of total time.
(*Your percentages should add up to 100%*):

List language here					
List percentage here:					

(6) Please name the cultures with which you identify. On a scale from zero to ten, please rate the extent to which you identify with each culture. (Examples of possible cultures include US-American, Chinese, Jewish-Orthodox, etc):

List cultures here					
	(click here for scale)	(click here for scale)	(click here for scale)	(click here for scale)	(click here for scale)

(7) How many years of formal education do you have? ______________________________

Please check your highest education level (or the approximate US equivalent to a degree obtained in another country):

☐ Less than High School	☐ Some College	☐ Masters
☐ High School	☐ College	☐ Ph.D./M.D./J.D.
☐ Professional Training	☐ Some Graduate School	☐ Other:

(8) Date of immigration to the USA, if applicable ______________________________

If you have ever immigrated to another country, please provide name of country and date of immigration here. ______________________________

(9) Have you ever had a vision problem ☐, hearing impairment ☐, language disability ☐, or learning disability ☐ ? (Check all applicable). If yes, please explain (including any corrections):

____

Language:

This is my (please select from pull-down menu) language.

All questions below refer to your knowledge of .

(1) Age when you…:

began acquiring :	*became fluent* in :	*began reading* in :	*became fluent reading* in :

(2) Please list the number of years and months you spent in each language environment:

	Years	Months
A country where is spoken		
A family where is spoken		
A school and/or working environment where is spoken		

(3) On a scale from zero to ten, please select your *level of* ***proficiency*** in speaking, understanding, and reading from the scroll-down menus:

Speaking	(click here for scale)	Understanding spoken language	(click here for scale)	Reading	(click here for scale)

(4) On a scale from zero to ten, please select how much the following factors contributed to you learning :

Interacting with friends	(click here for pull-down scale)	Language tapes/self instruction	(click here for pull-down scale)
Interacting with family	(click here for pull-down scale)	Watching TV	(click here for pull-down scale)
Reading	(click here for pull-down scale)	Listening to the radio	(click here for pull-down scale)

(5) Please rate to what extent you are currently exposed to in the following contexts:

Interacting with friends	(click here for pull-down scale)	Listening to radio/music	(click here for pull-down scale)
Interacting with family	(click here for pull-down scale)	Reading	(click here for pull-down scale)
Watching TV	(click here for pull-down scale)	Language-lab/self-instruction	(click here for pull-down scale)

(6) In your perception, how much of a foreign accent do you have in ?

(click here for pull-down scale)

(7) Please rate how frequently others identify you as a non-native speaker based on your accent in :

(click here for pull-down scale)

Appendix D: Demographic Questionnaire

CODE | | | | |

Demographic Questionnaire

Gender: M F Date of Birth: D D M M Y Y Y Y

Home Language(s): ____________________________

School Language(s): _____________________________________

Current Degree &

Faculty:____

____

Previous degrees or qualifications:

____

Current year of study (1st, 2nd, 3rd):

____

How many years have you been at university?

____

Did you ever fail a grade at school? If so, which one?

____

Did you ever require an intervention from a language specialist?

____

Did you attend pre-primary school?

____

Living Amenities & Caregiving

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:	

Marital status of primary caregivers:

Married	
Living together as husband and wife	
Widow/widower	
Divorced/separated	
Other	

Number of caregivers in the household in which you spend the most time (please tick):

0	
1	
2	
>2	

Living Standards Measure:

Please answer the following questions according to your circumstances while growing up, and not in your current student accommodation if these are different.

Question	**Answer**	
1. I have the following in my household:		
TV set	TRUE	FALSE
VCR	TRUE	FALSE
DVD player	TRUE	FALSE
M-Net/DStv subscription	TRUE	FALSE
Hi-fi/music centre	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
6. I live in a rural area outside Gauteng and the Western Cape	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 E: Research Information

School of Human and Community Development

Private Bag 3, Wits

2050

Johannesburg, South Africa

Tel: 27 (0)11 717 4524/5 Fax: 27 (0)11 717 4556

Dear Student,

My name is Luzanne Liversage and I am a student completing a Master’s degree in Community-Based Counselling Psychology at the University of Witwatersrand.

My research aims to identify the relationship between working memory and language. In order to participate, you will be tested on a few measures of cognitive performance, and will be required to complete a demographic questionnaire that will take 5-10 minutes to fill in. Testing will happen individually and at a time that is convenient for you, with the entire procedure taking between 60 and 90 minutes. I would thus like to invite you to please consider taking part in this study

Participation in this study is voluntary and as such you are free to withdraw from the study at any time for any reason, no questions asked, and will experience no penalty for leaving. There are no foreseeable benefits or harms in participating in this study and confidentiality is guaranteed as all results will be published in terms of group trends. As soon as the data is collected, it will be assigned an anonymous code. No findings that could identify any individual participant will be published and the raw data will only be accessed by myself and my supervisor, Professor Kate Cockcroft.

Results from this study will be published in terms of group trends on an online blog. The address for this blog will be given to you upon the completion of the data collection process. As no identifying information will be collected individual feedback is not possible and will not be given. However, should you wish to receive credit for participation in this study, your student number will be required but no further identifying information.

By taking part in this study, you as a participant, agree to allow the data collected from this study to be published and used in further studies and consent to the above information.

Should you have any further questions please do not hesitate to contact me. My contact details appear below my signature.

Thank you for considering taking part in the research project.

Kind Regards,

Luzanne Liversage

MA Community-Based Counselling
084 652 9772
Luzanne.liversage@gmail.com

Supervisor:
Professor Kate Cockcroft
011 717 4511
Kate.cockcroft@wits.ac.za

Appendix F: Information and Credit Slip

SCHOOL OF HUMAN & COMMUNITY DEVELOPMENT

FACULTY OF HUMANITIES

UNIVERSITY OF THE WITWATERSRAND

Private Bag 3, WITS, 2050

Tel: (011) 717 4500 Fax: (011) 717 4559

Dear potential first year Psychology participant,

As you may be aware, as a Psychology first year student you are eligible to obtain credit towards your final course mark for participating in research projects. This project is one of the projects for which you are able to obtain credit for participating however it is not the only project which will allow you to do so and you are reminded that you will be given many opportunities to obtain this credit if you wish. However, should you choose to participate in this study, you will be able to obtain 1**%** credit towards your final first year Psychology mark. Additionally, the current study does not require any emotional information or information of any personal nature.

In order to credit you for participating in this research, it will be necessary for you to obtain a proof of participation slip. In addition, I, as the researcher, am required to obtain a list of participants for cross-verification purposes. In order to allow you to remain anonymous but still meet these requirements, you will be asked to provide the course code/s in Psychology for which you are registered and your student number in the space below but not your name.

Your student number and participant number will not be the same and as such there will be no way to link your student number to any of the data you have provided and your responses will therefore be completely anonymous.

As the researcher I will then compile a list of participants by student number only. Thus I will have no access to your name or individual identity. This list will then be given to the relevant course coordinator/s and administrator/s to allow them to credit you. The course coordinator/s and administrator/s will thus be aware that you participated in research but not what your responses were – they will have no access to any of your data.

In addition, I will complete the relevant participation slips by student number only and give this to you directly following the completion of the data collection procedure.

If you agree to provide your student number and the course code/s for Psychology for which you are currently registered below strictly for the purposes of obtaining credit as per the conditions outlined above, please fill in the slip on the next page. Please detach and keep this sheet.

Thank you for considering taking part in the research project.

Luzanne Liversage

MA Community-Based Counselling

084 652 9772

Luzanne.liversage@gmail.com

Supervisor:

Professor Kate Cockcroft

011 717 4511

Kate.cockcroft@wits.ac.za

Student Number and Psychology Codes

(for Obtaining Course Credit Only)

Student Number:

Course codes:

PSYCHOLOGY ________

THANK YOU!

PROOF OF PARTICIPATION SLIP (RESEARCHER)

This slip hereby serves to confirm that student:

Student Number:

participated in a Masters-level study conducted by a student in the Department of Psychology at the University of the Witwatersrand and is thus eligible to receive course credit for this participation.

Signed by researcher: ___________________________

Date: _____________________________

Appendix G: Distribution of Monolingual Data

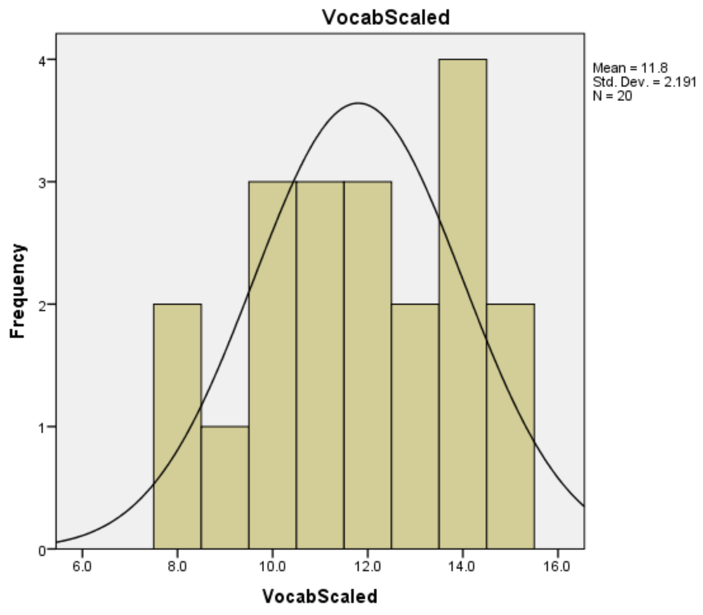

Figure 1A. Histogram of the distribution of data from the WAIS-III Vocabulary subtest.

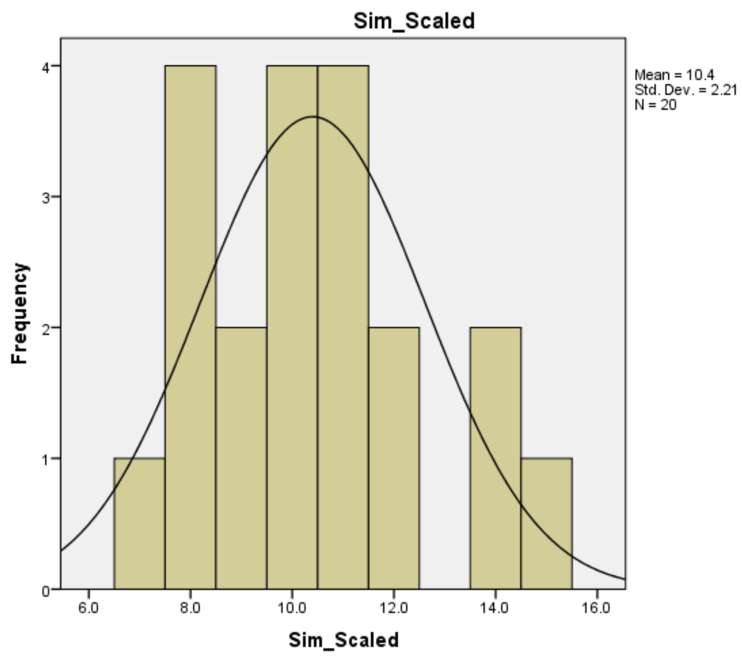

Figure 2A. Histogram of the distribution of data from the WAIS-III Similarities subtest

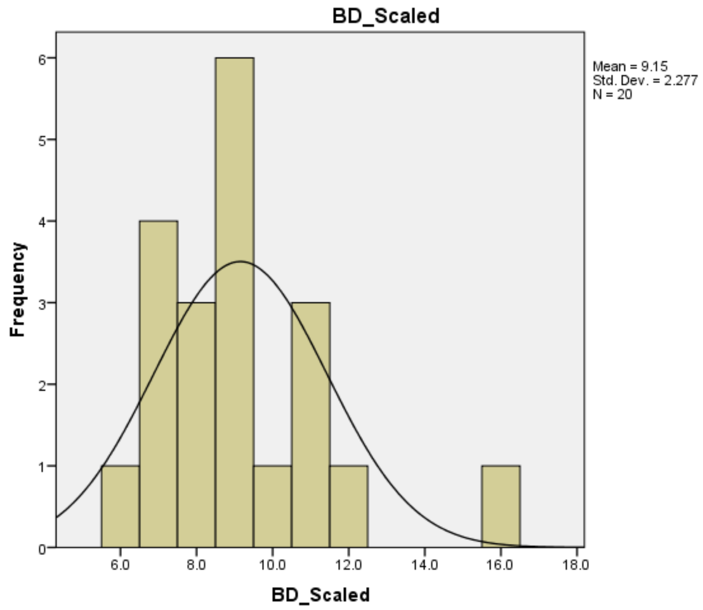

Figure 3A. Histogram of the distribution of data from the WAIS-III Block Design subtest.

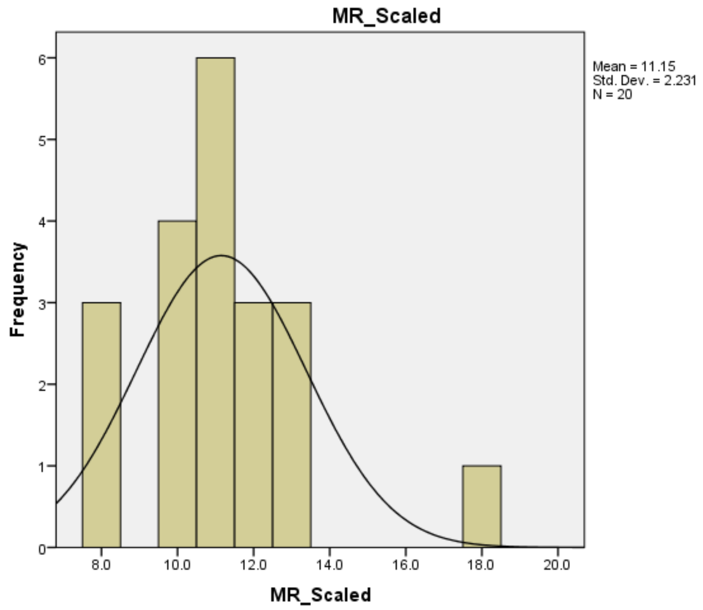

Figure 4A. Histogram of the distribution of data from the WAIS-III Matrix Reasoning subtest.

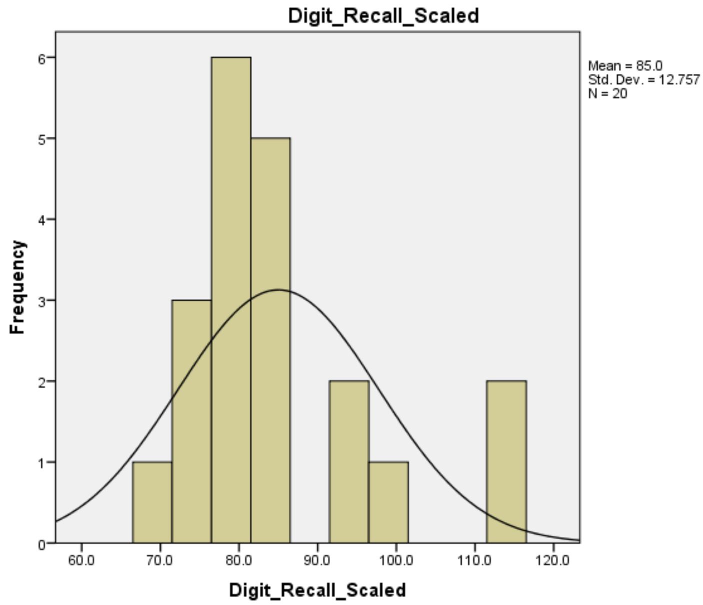

Figure 5A. Histogram of the distribution of data from the AWMA Digit Recall subtest.

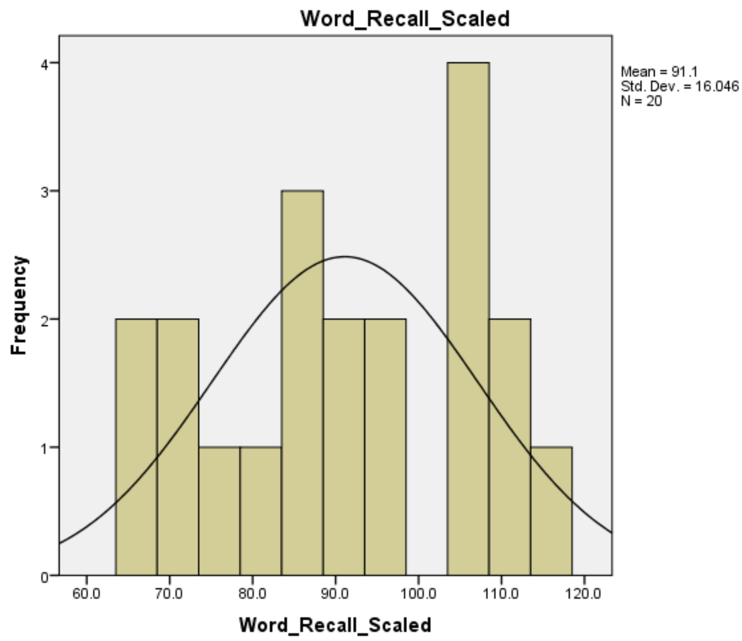

Figure 6A. Histogram of the distribution of data from the AWMA Word Recall subtest.

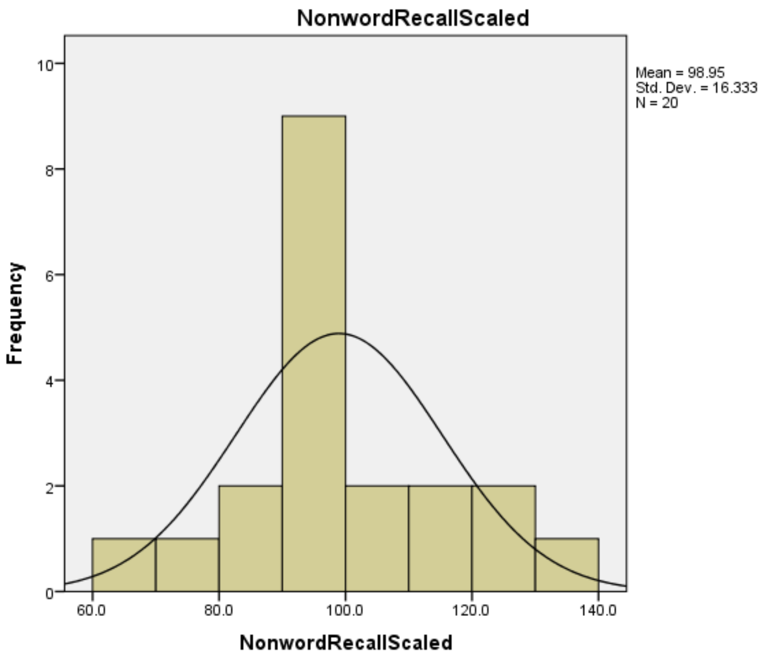

Figure 7A. Histogram of the distribution of data from the AWMA Non-Word Recall subtest.

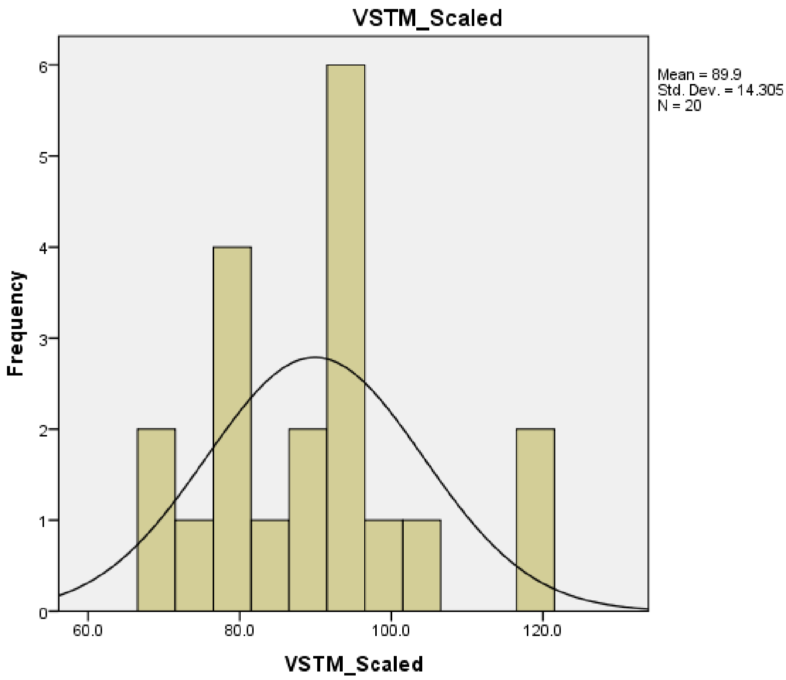

Figure 8A. Histogram of the distribution of data from the AWMA Verbal Short Term Memory scores.

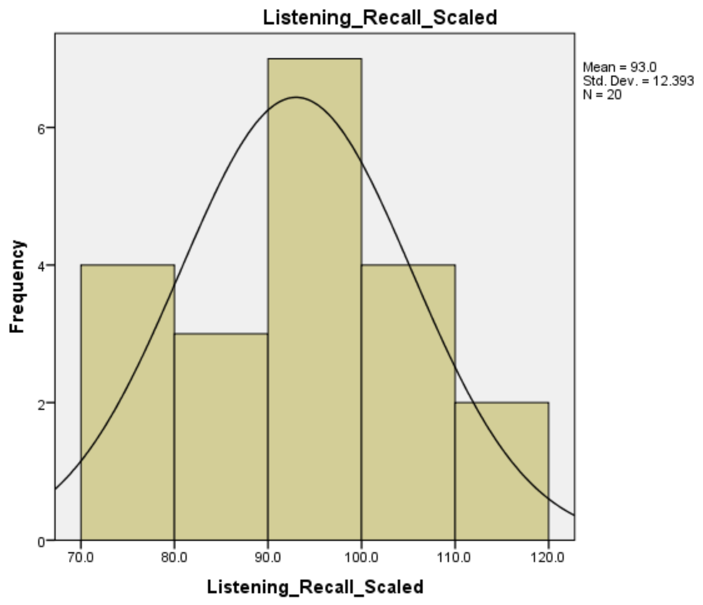

Figure 9A. Histogram of the distribution of data from the AWMA Listening Recall subtest

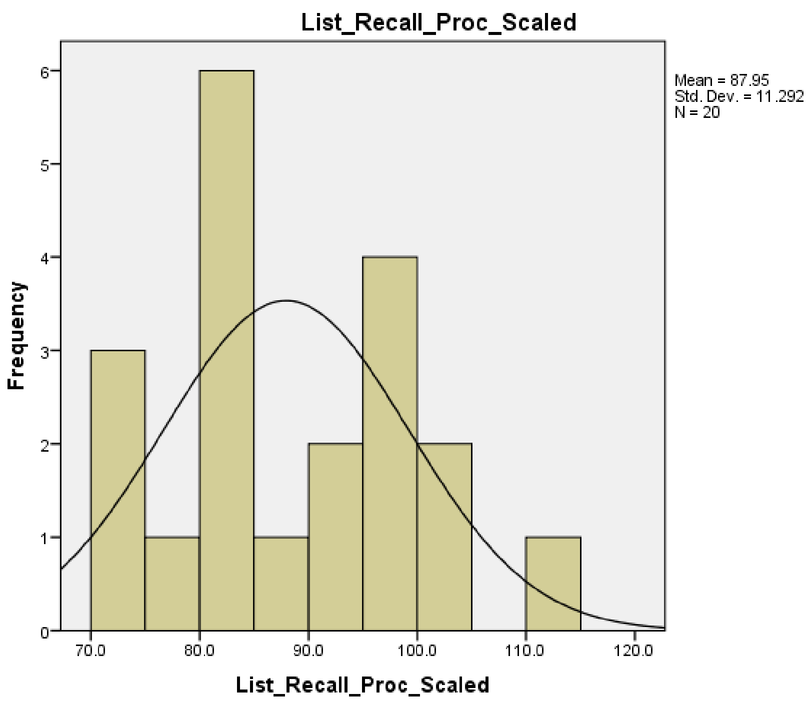

Figure 10 A. Histogram of the distribution of data from the AWMA Listening Recall Processing scores

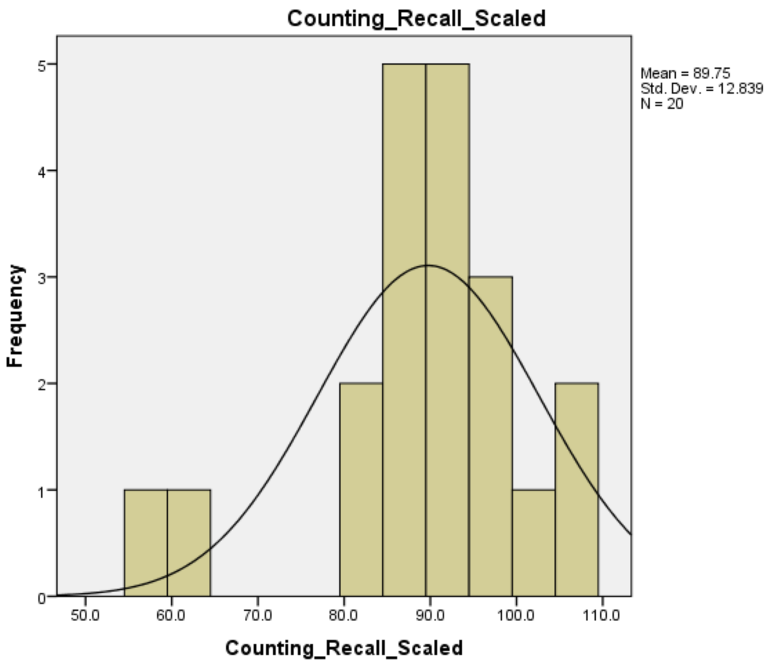

Figure 11A. Histogram of the distribution of data from the AWMA Counting Recall subtest.

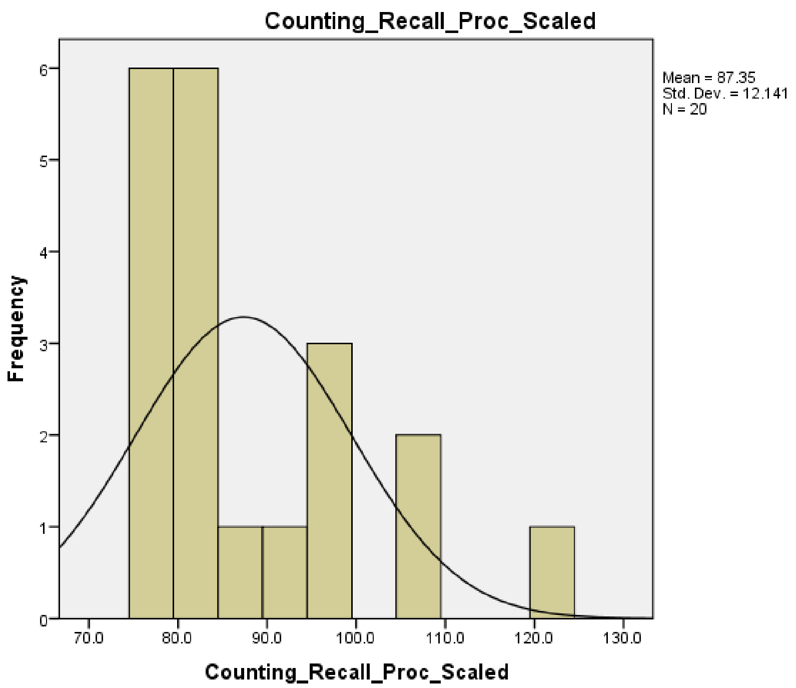

Figure 12A. Histogram of the distribution of data from the AWMA Counting Recall Processing scores.

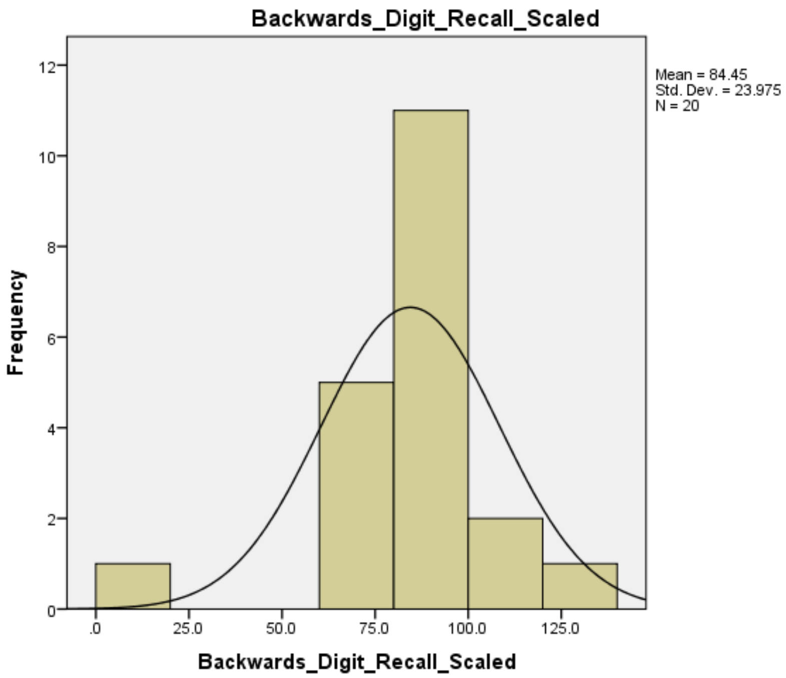

Figure 13A. Histogram of the distribution of data from the AWMA Backwards Digit Recall subtest.

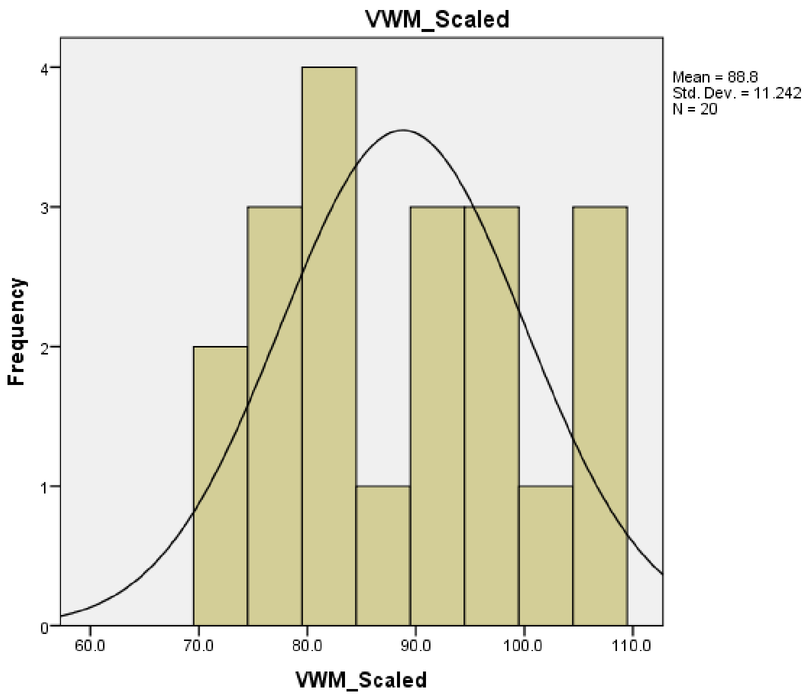

Figure 14A. Histogram of the distribution of data from the AWMA Verbal Working Memory (VWM) scores.

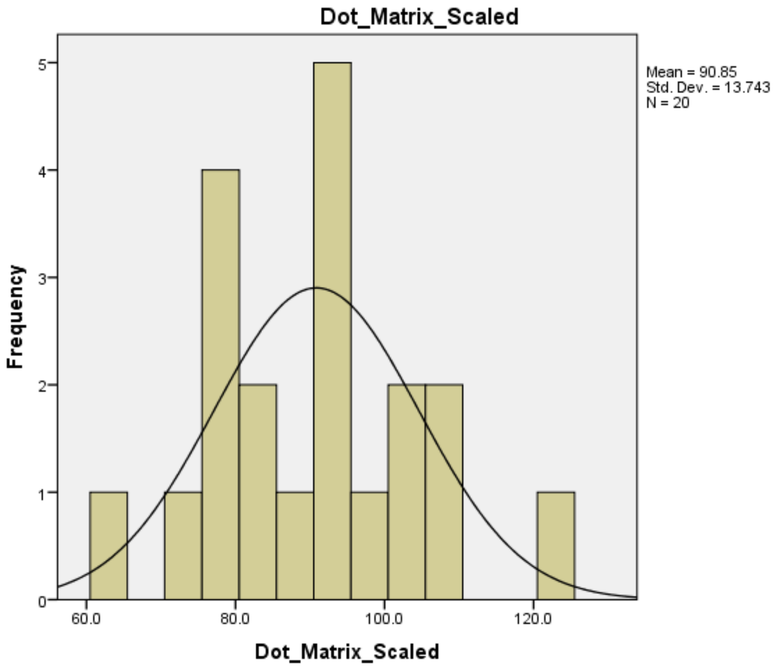

Figure 15A. Histogram of the distribution of data from the AWMA Dot Matrix subtest.

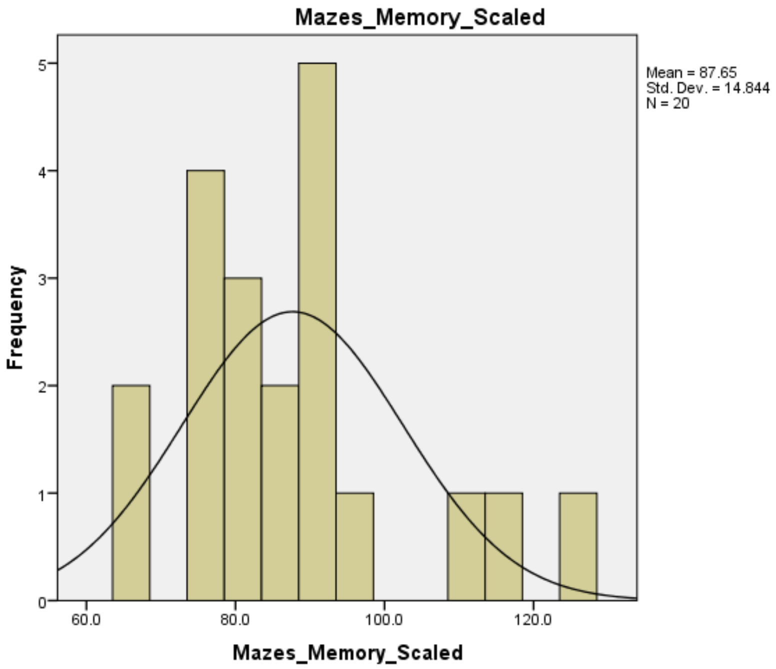

Figure 16A. Histogram of the distribution of data from the AWMA Mazes Memory subtest.

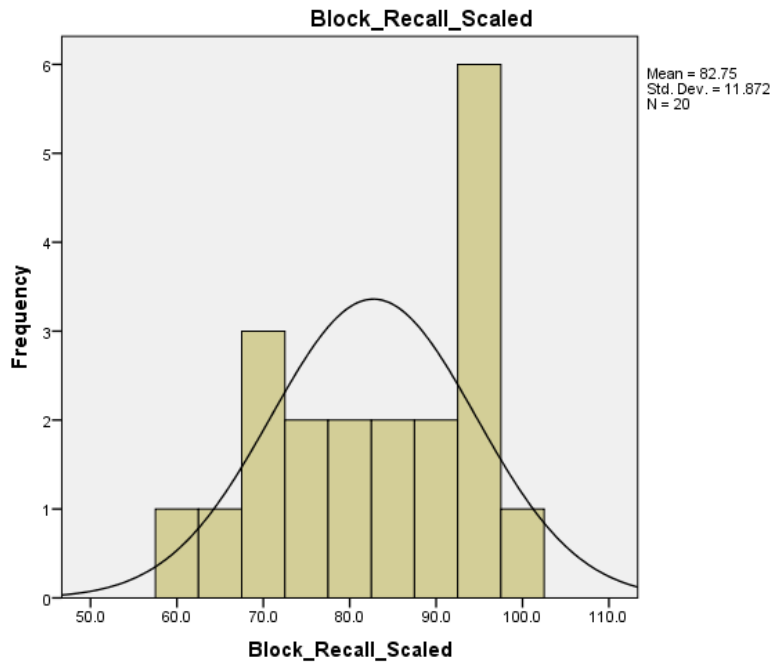

Figure 17A. Histogram of the distribution of data from the AWMA Block Recall subtest.

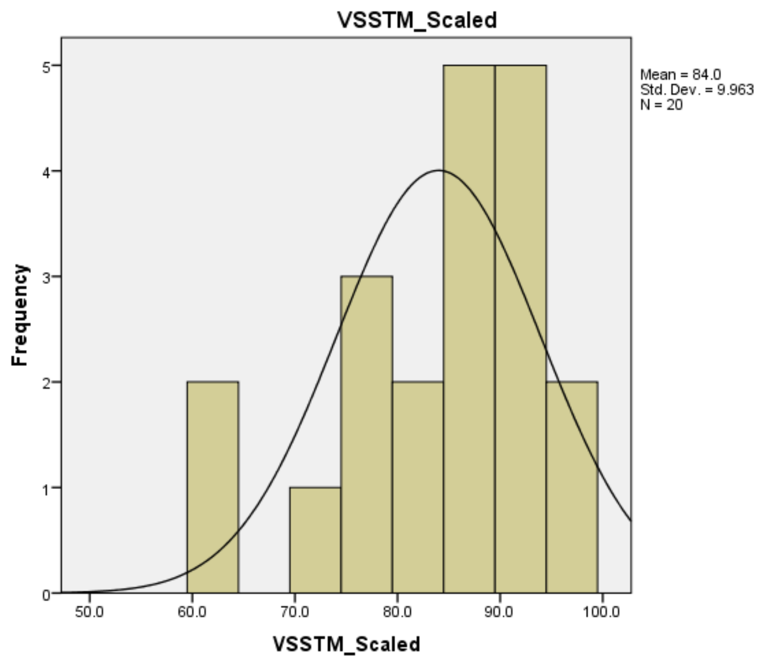

Figure 18A. Histogram of the distribution of data from the AWMA Visuo-Spatial Short Term Memory scores.

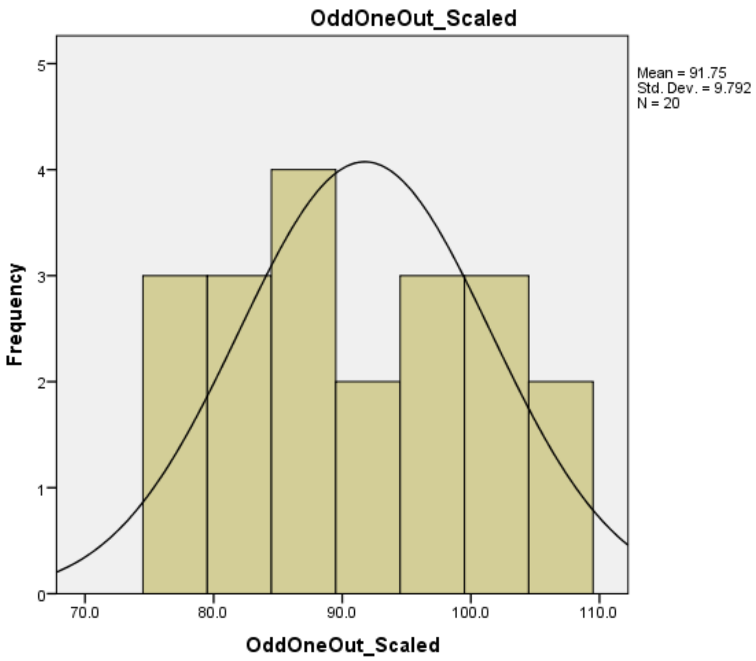

Figure 19A. Histogram of the distribution of data from the AWMA Odd One Out subtest.

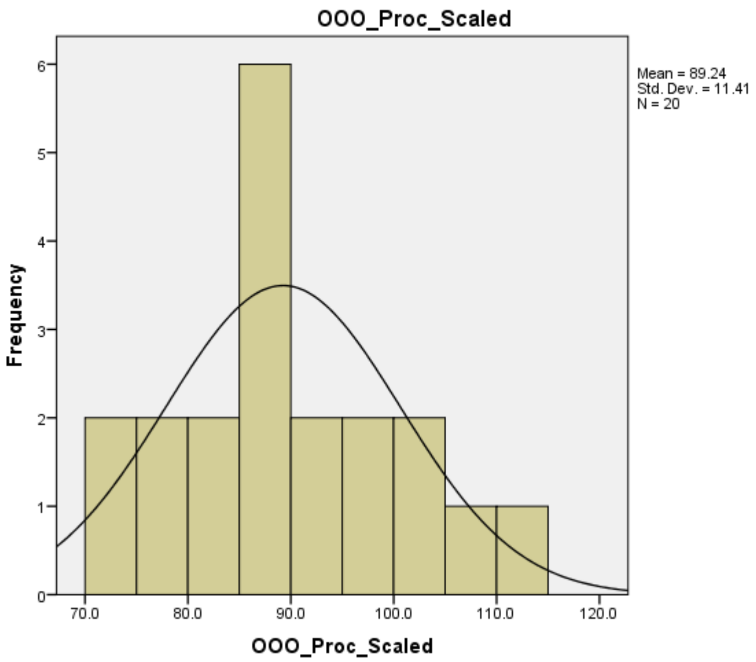

Figure 20A. Histogram of the distribution of data from the AWMA Odd One Out Processing subtest.

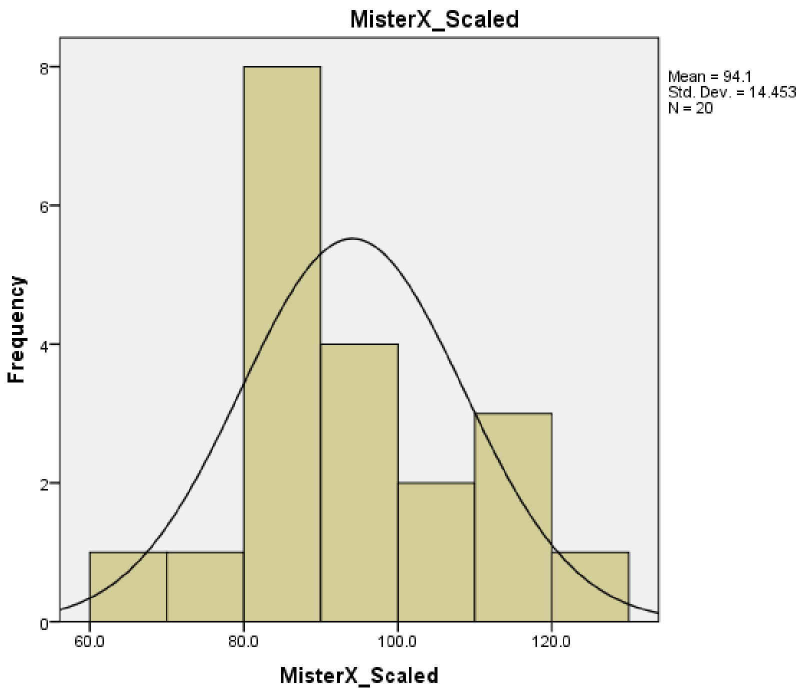

Figure 21A. Histogram of the distribution of data from the AWMA Mister X subtest.

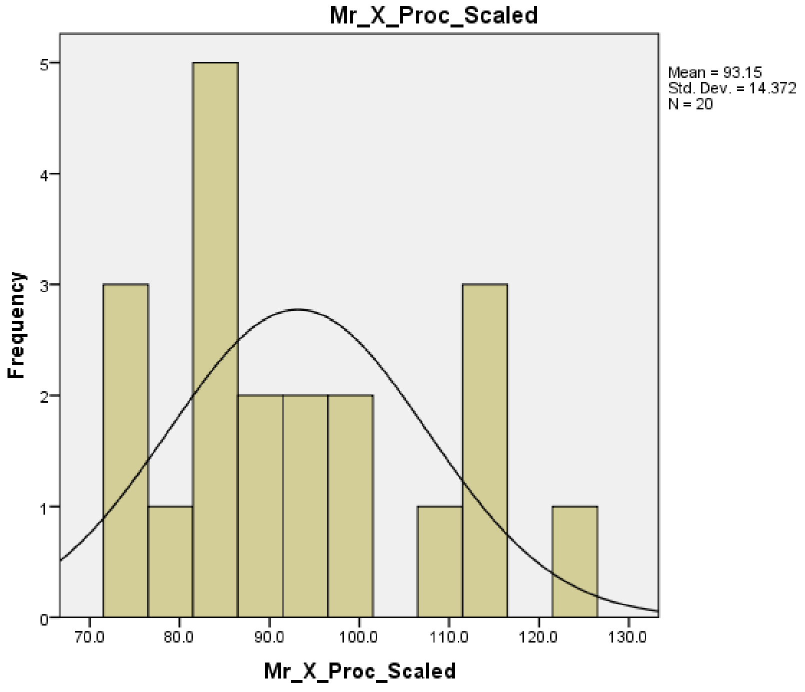

Figure 22A. Histogram of the distribution of data from the AWMA Mister X Processing scores.

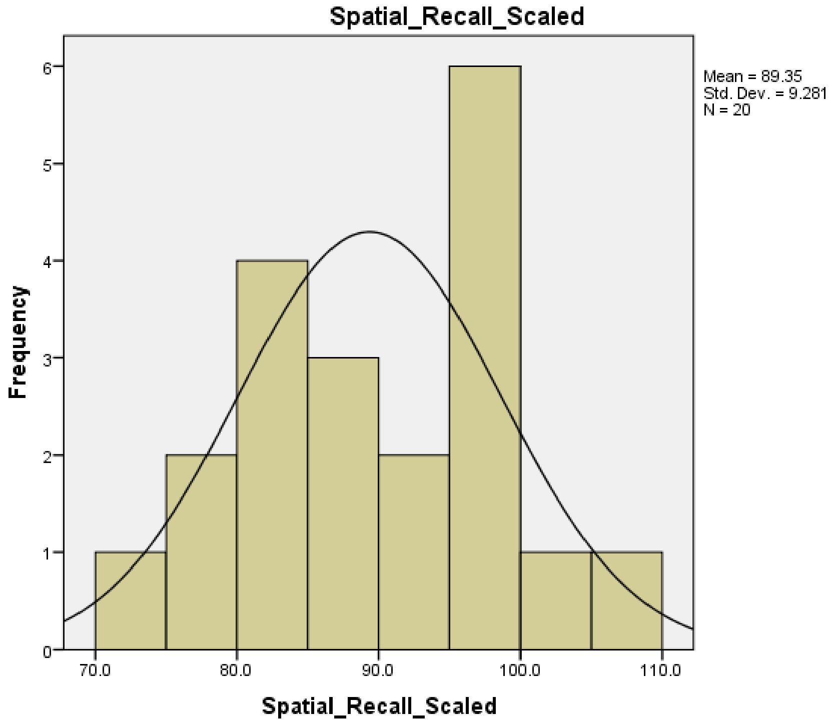

Figure 23A. Histogram of the distribution of data from the AWMA Spatial Recall subtest

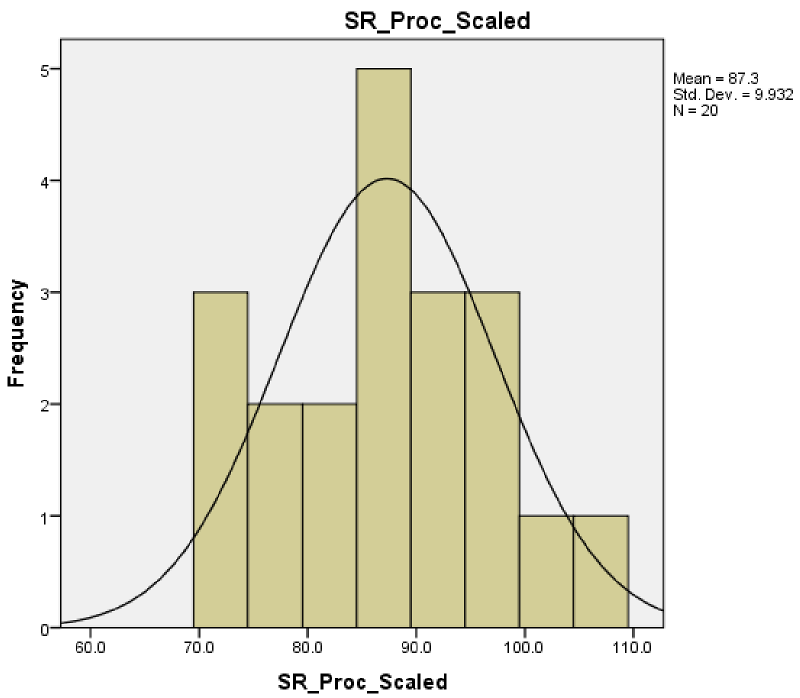

Figure 24A. Histogram of the distribution of data from the AWMA Spatial Recall Processing scores.

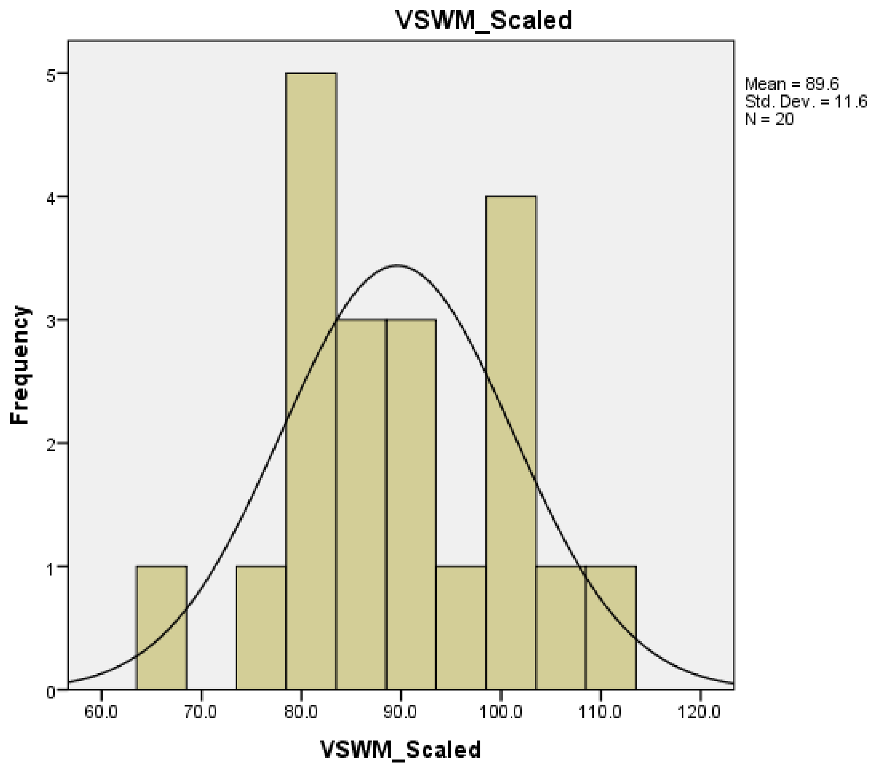

Figure 25A. Histogram of the distribution of data from the AWMA Visuo-Spatial Working Memory scores

Table 31: The results of the Kolmogorov-Smirnov Test for normality

		Voc	Sim	BD	MR	DR	WR	NWR	VSTM	LR	LRP	CR	CRP	BDR	VWM	DM	MM	BR	VSSTM	OOO	OOOP	MrX	MrXP	SR	SRP	VSWM
N		20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Normal Parameters[a,b]	Mean	11.80	10.400	9.150	11.15	85.000	91.100	98.945	89.900	93.000	87.945	89.750	87.350	84.450	88.800	90.850	87.650	82.750	84.000	91.750	89.245	94.095	93.150	89.350	87.300	89.600
	Std. Deviation	2.1909	2.2100	2.2775	2.2308	12.7568	16.0457	16.3333	14.3046	12.3927	11.2917	12.8386	12.1407	23.9747	11.2418	13.7430	14.8440	11.8716	9.9631	9.7919	11.4101	14.4525	14.3720	9.2809	9.9319	11.6004
Most Extreme Differences	Absolute	.142	.143	.226	.177	.281	.139	.195	.135	.103	.153	.185	.240	.223	.132	.138	.237	.156	.142	.111	.143	.138	.166	.129	.098	.126
	Positive	.094	.143	.226	.177	.281	.098	.195	.135	.103	.153	.100	.240	.192	.132	.138	.237	.101	.114	.111	.143	.138	.166	.071	.088	.122
	Negative	-.142	-.098	-.123	-.153	-.123	-.139	-.114	-.086	-.093	-.113	-.185	-.197	-.223	-.080	-.115	-.158	-.156	-.142	-.104	-.122	-.083	-.115	-.129	-.098	-.126
Kolmogorov-Smirnov Z		.637	.640	1.012	.791	1.258	.623	.874	.603	.460	.684	.828	1.073	.999	.592	.616	1.060	.698	.636	.495	.642	.616	.741	.575	.438	.563
Asymp. Sig. (2-tailed)		.812	.808	.258	.559	.085	.833	.430	.860	.984	.738	.500	.200	.271	.875	.842	.211	.715	.814	.967	.805	.842	.643	.895	.991	.909

Note. a. Test distribution is Normal. b. Calculated from data.

Appendix H: Distribution of Multilingual Data

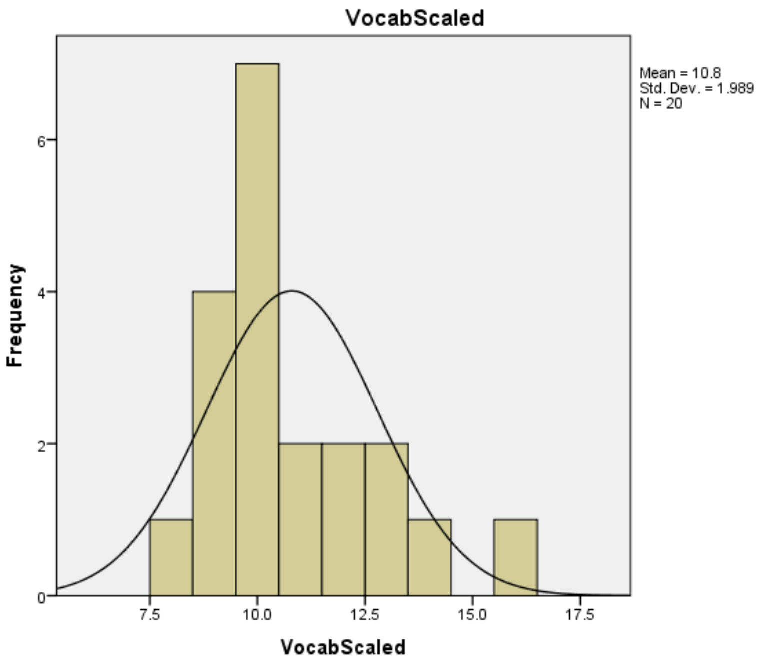

Figure 26A. Histogram of the distribution of data from the WAIS-III Vocabulary subtest.

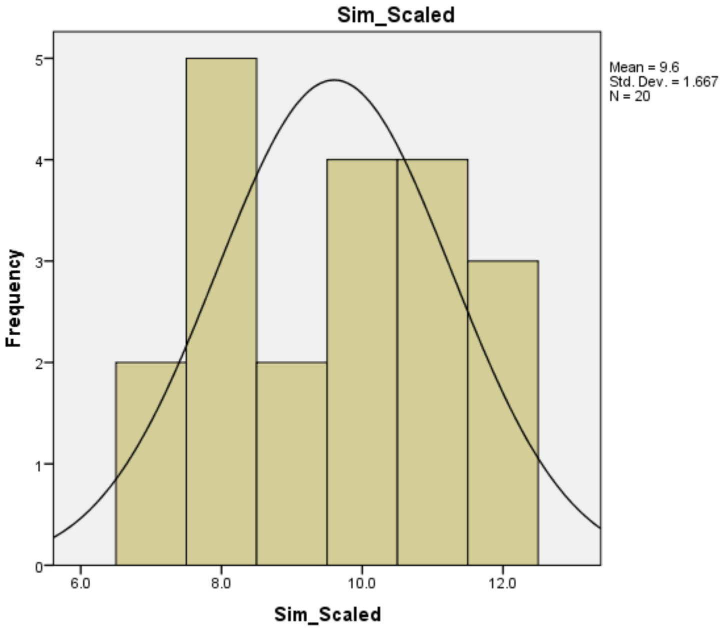

Figure 27A. Histogram of the distribution of data from the WAIS-III Similarities subtest

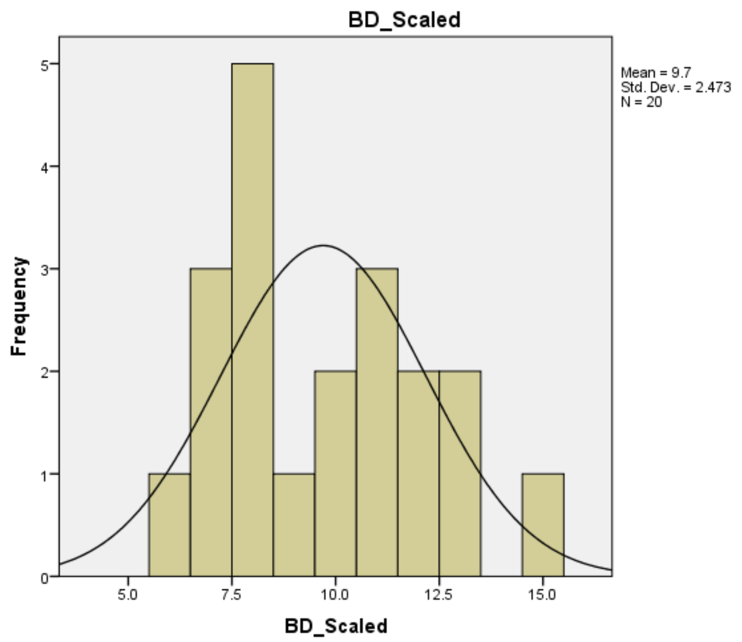

*Figure 28A.*Histogram of the distribution of data from the WAIS-III Block Design subtest.

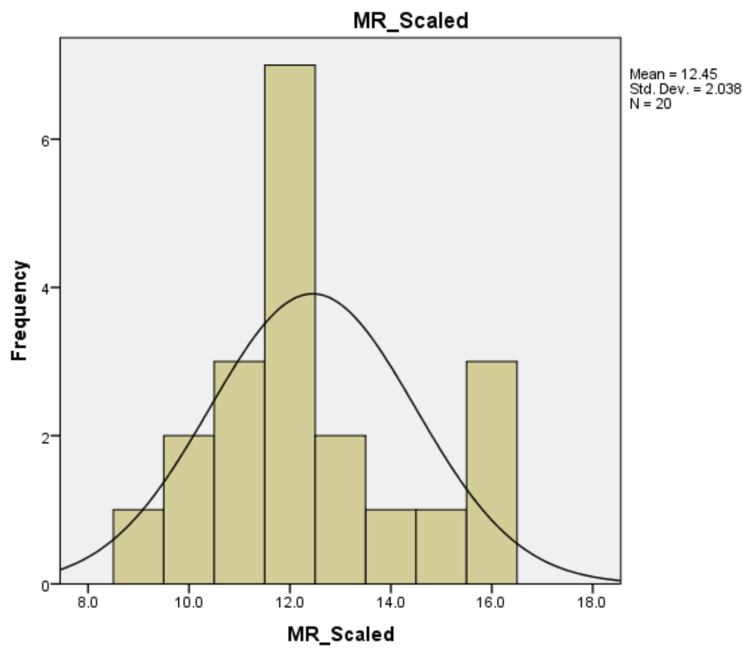

Figure 29A. Histogram of the distribution of data from the WAIS-III Matrix Reasoning subtest.

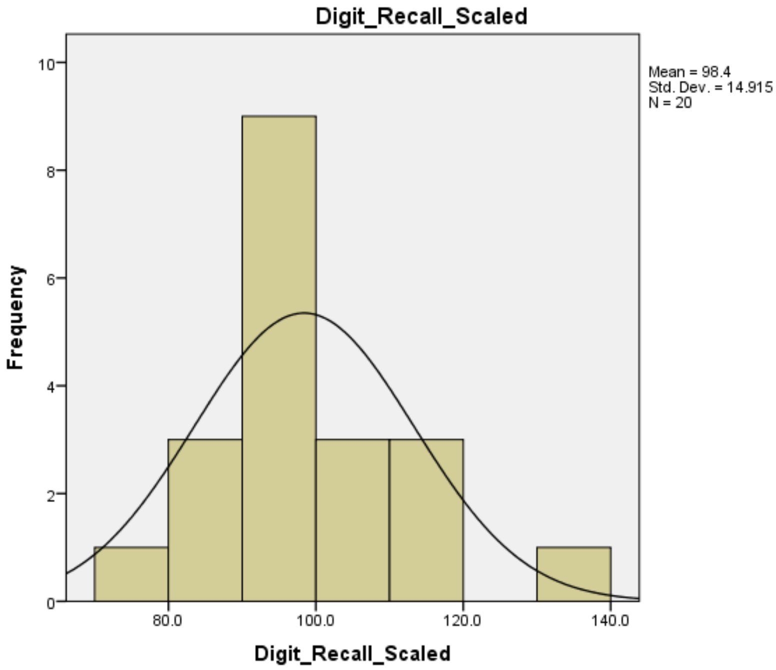

Figure 30A. Histogram of the distribution of data from the AWMA Digit Recall subtest.

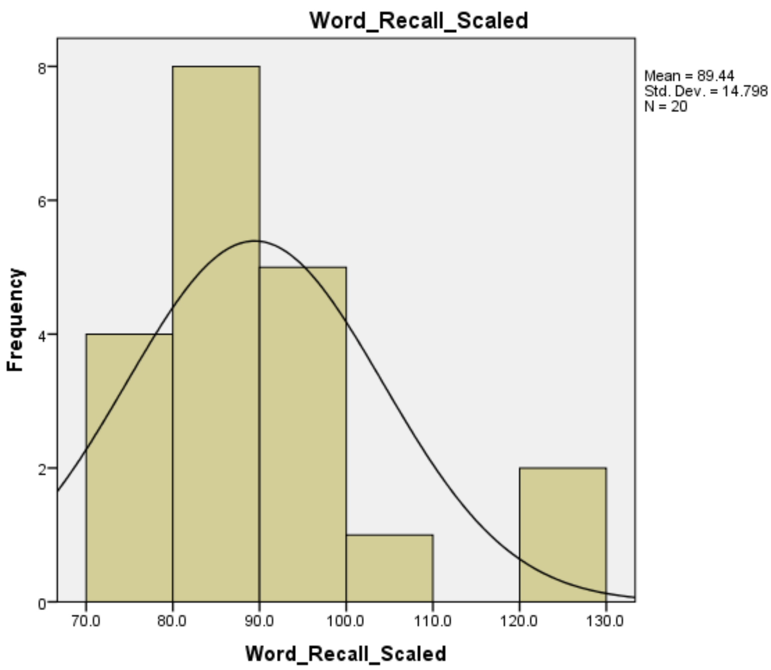

Figure 31A. Histogram of the distribution of data from the AWMA Word Recall subtest.

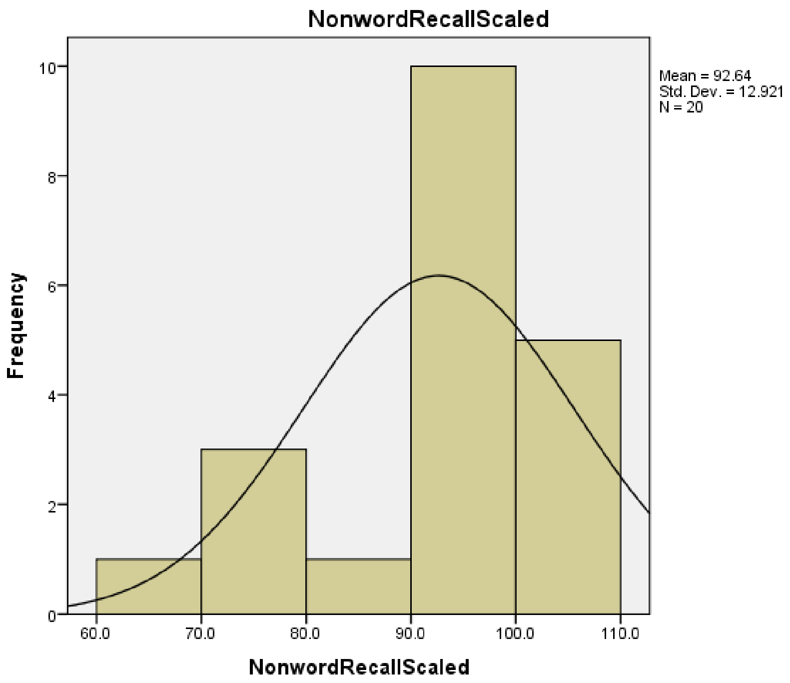

Figure 32A. Histogram of the distribution of data from the AWMA Non-Word Recall subtest.

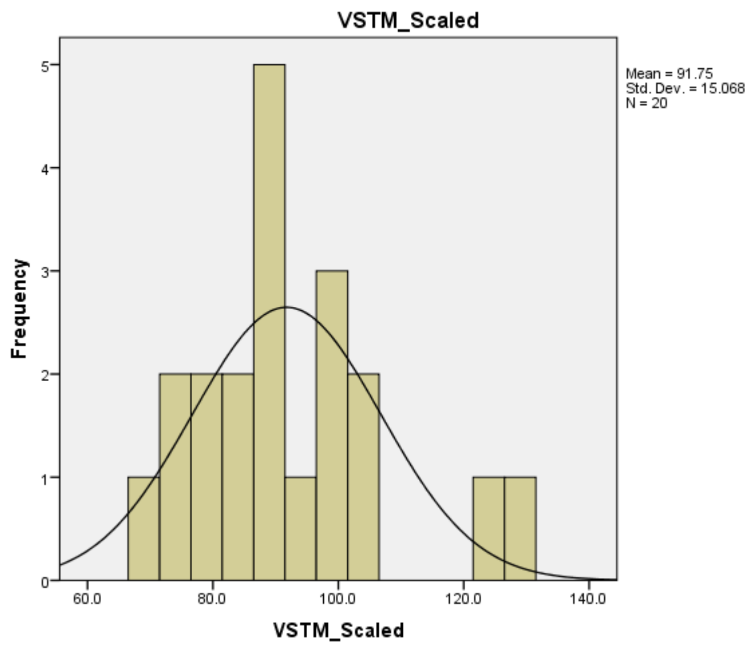

Figure 33A. Histogram of the distribution of data from the AWMA Verbal Short Term Memory scores.

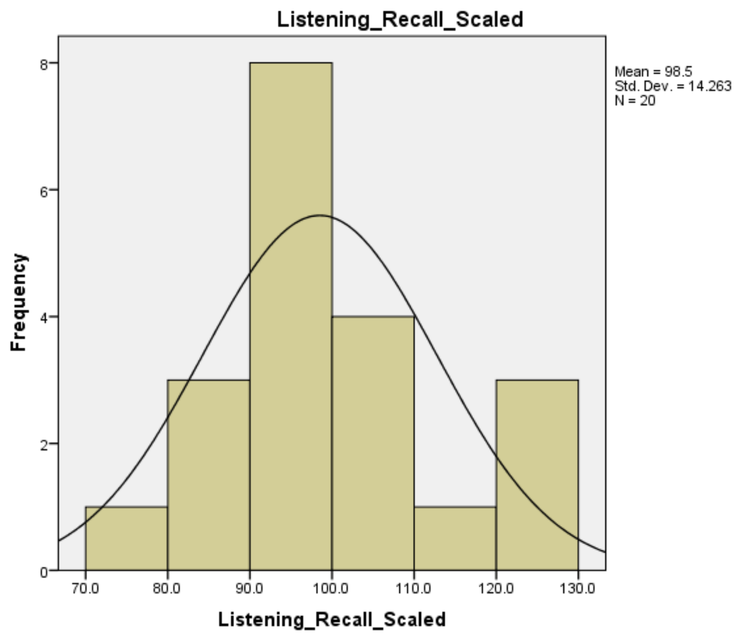

Figure 34A. Histogram of the distribution of data from the AWMA Listening Recall subtest.

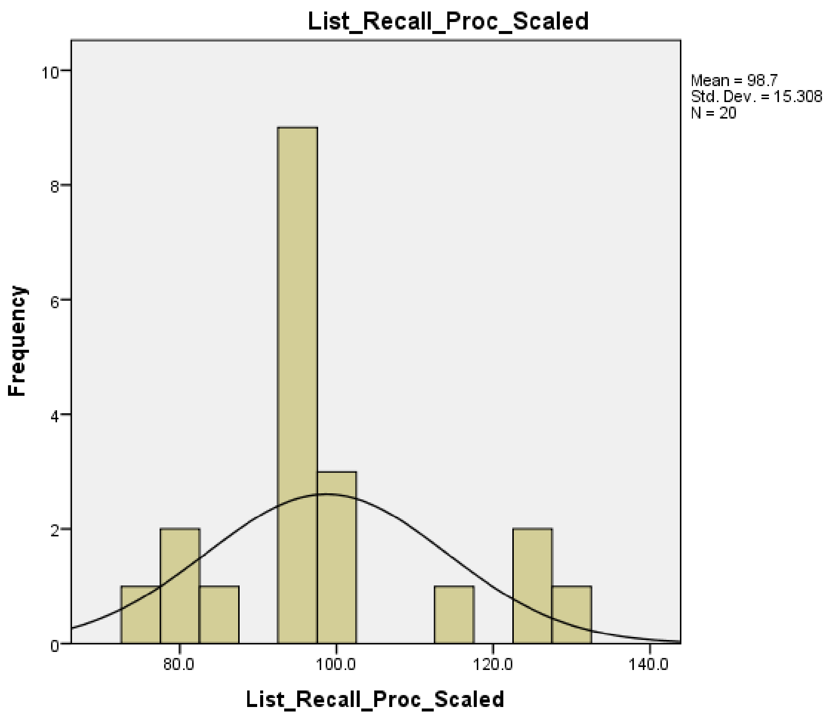

Figure 35A. Histogram of the distribution of data from the AWMA Listening Recall Processing scores.

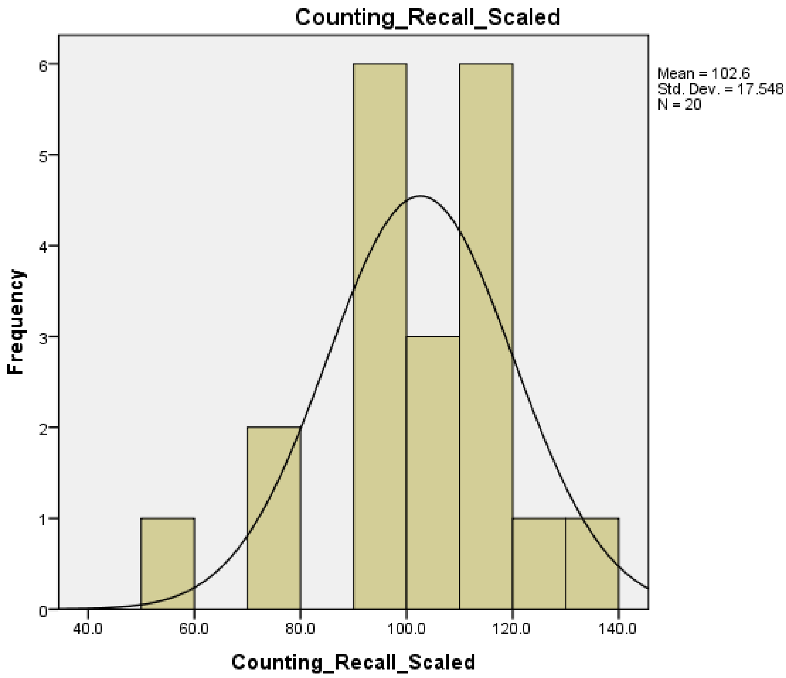

Figure 36A. Histogram of the distribution of data from the AWMA Counting Recall subtest.

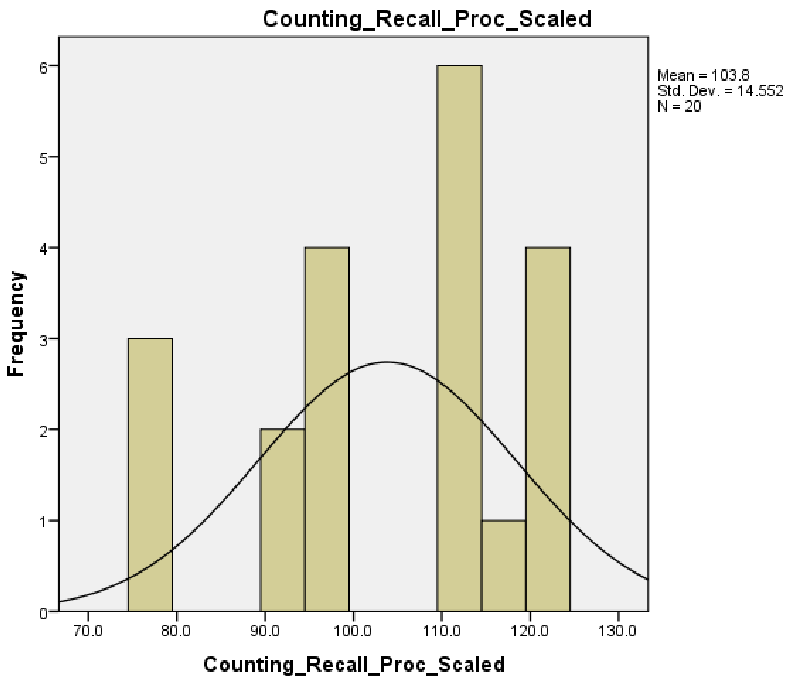

Figure 37A. Histogram of the distribution of data from the AWMA Counting Recall Processing scores.

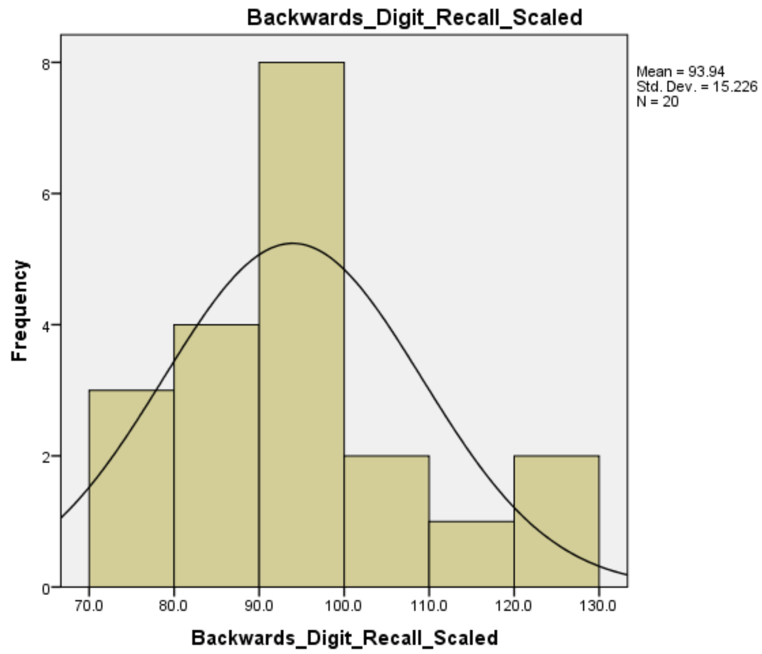

Figure 38A. Histogram of the distribution of data from the AWMA Backwards Digit Recall subtest.

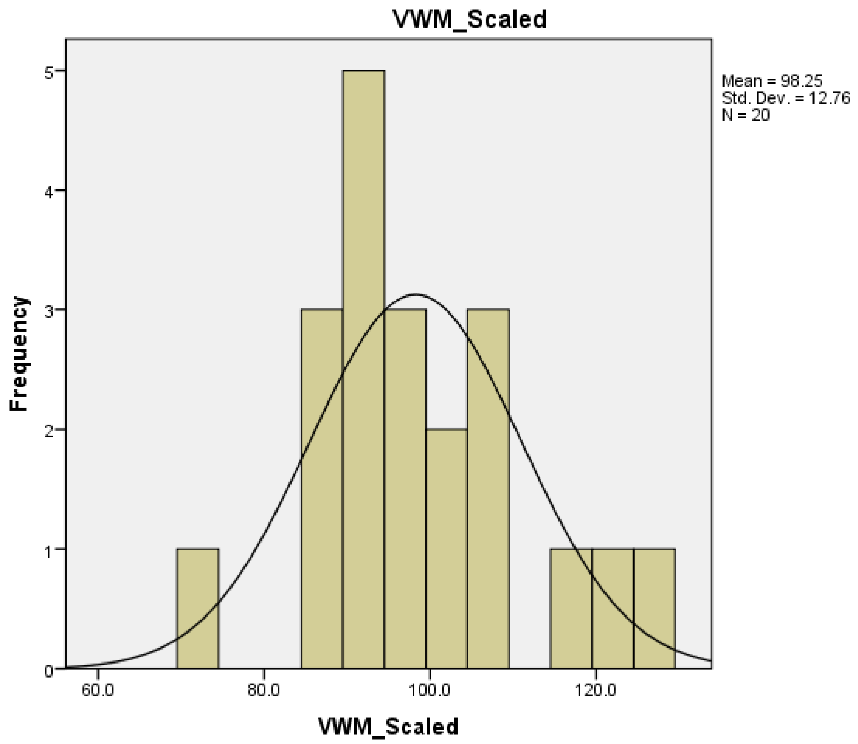

Figure 39A. Histogram of the distribution of data from the AWMA Verbal Working Memory (VWM) scores.

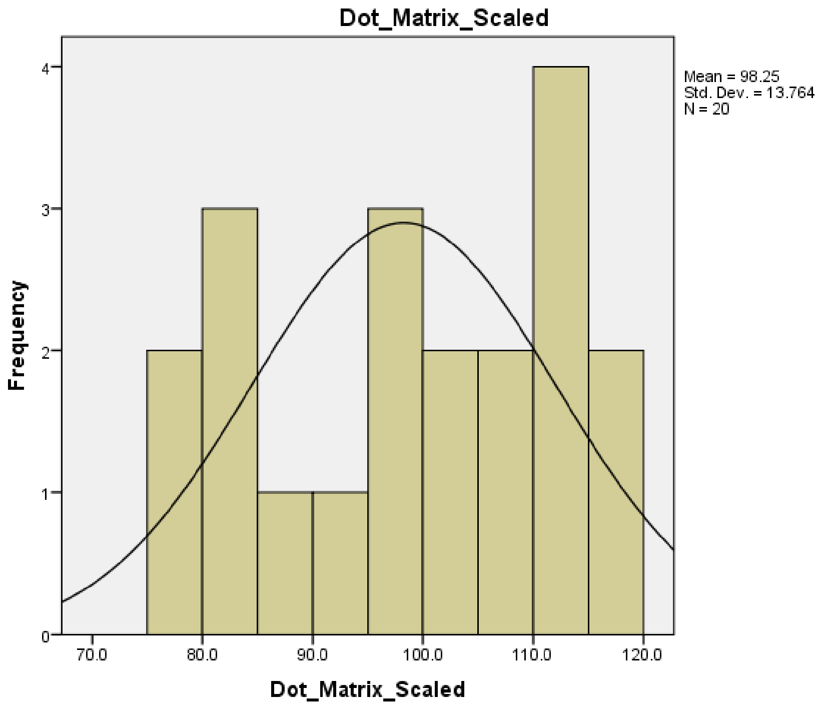

Figure 40A. Histogram of the distribution of data from the AWMA Dot Matrix subtest.

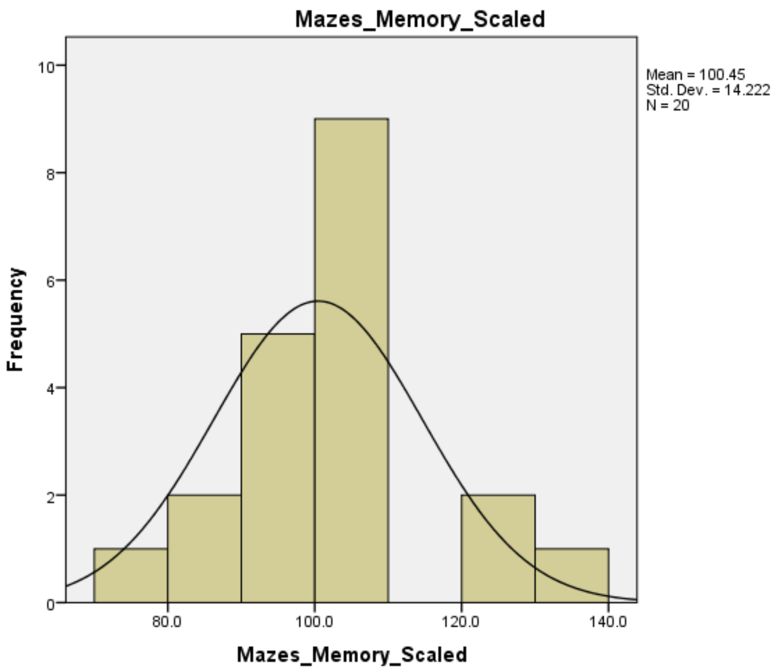

Figure 41A. Histogram of the distribution of data from the AWMA Mazes Memory subtest.

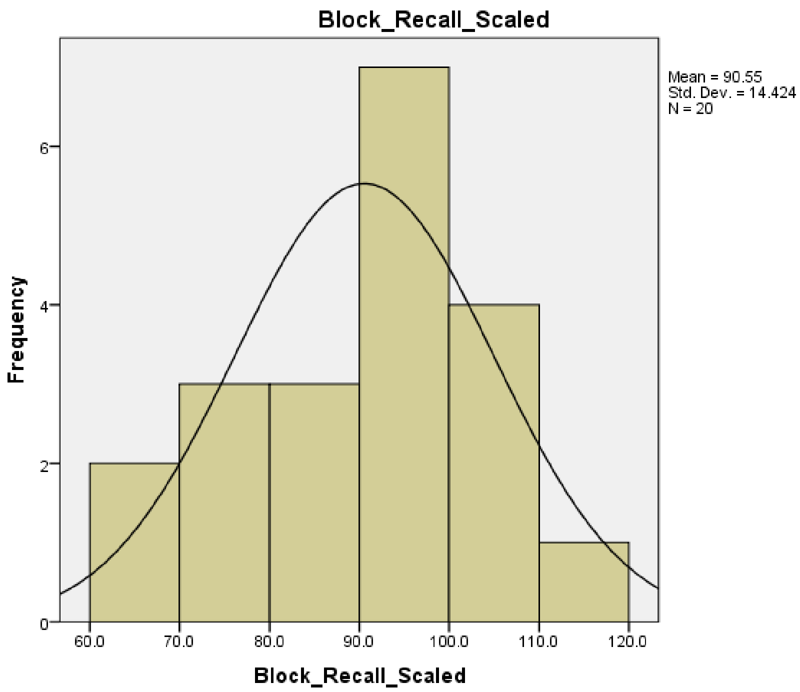

Figure 42A. Histogram of the distribution of data from the AWMA Block Recall subtest.

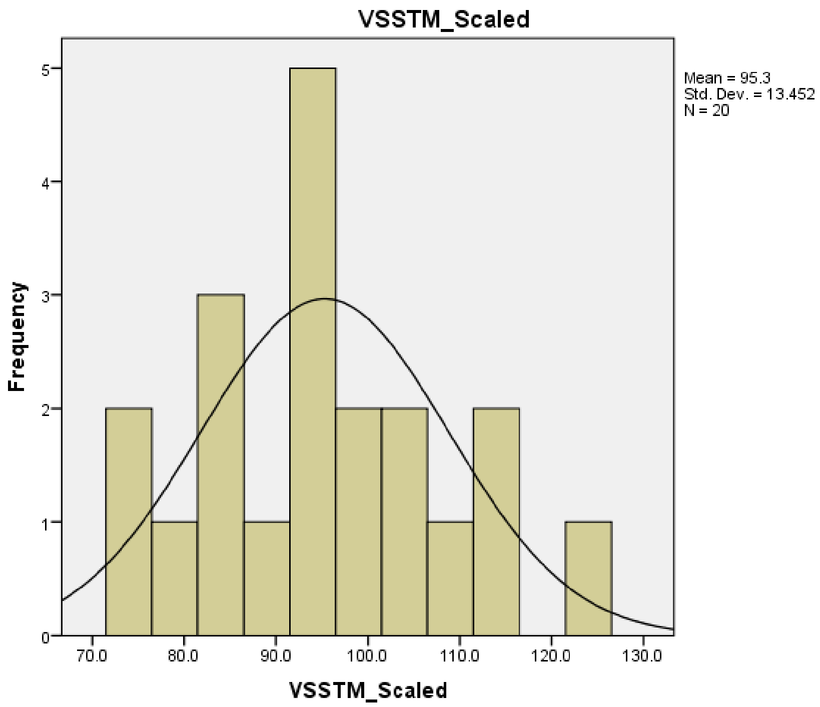

Figure 43A. Histogram of the distribution of data from the AWMA Visuo-Spatial Short Term Memory scores.

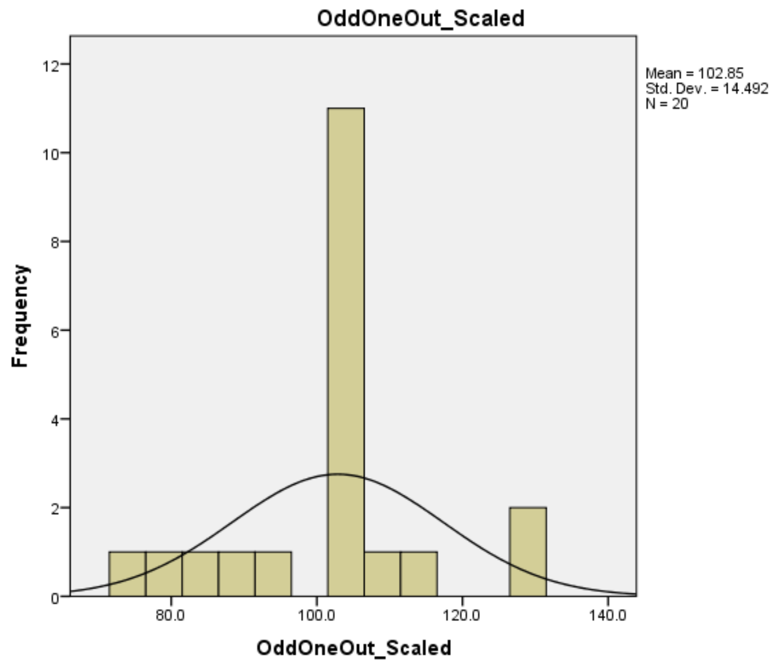

Figure 44A. Histogram of the distribution of data from the AWMA Odd One Out subtest.

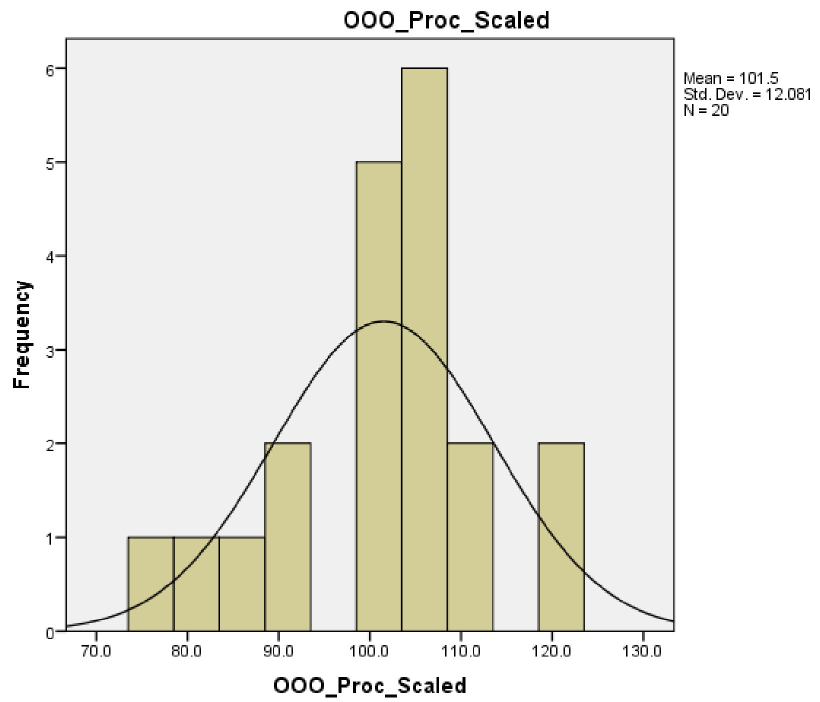

Figure 45A. Histogram of the distribution of data from the AWMA Odd One Out Processing subtest.

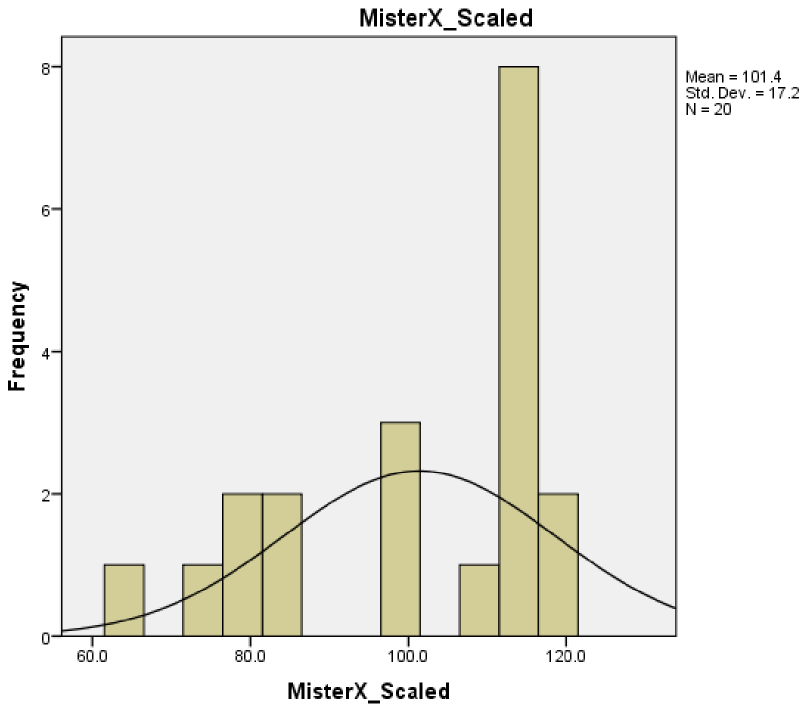

Figure 46A. Histogram of the distribution of data from the AWMA Mister X subtest.

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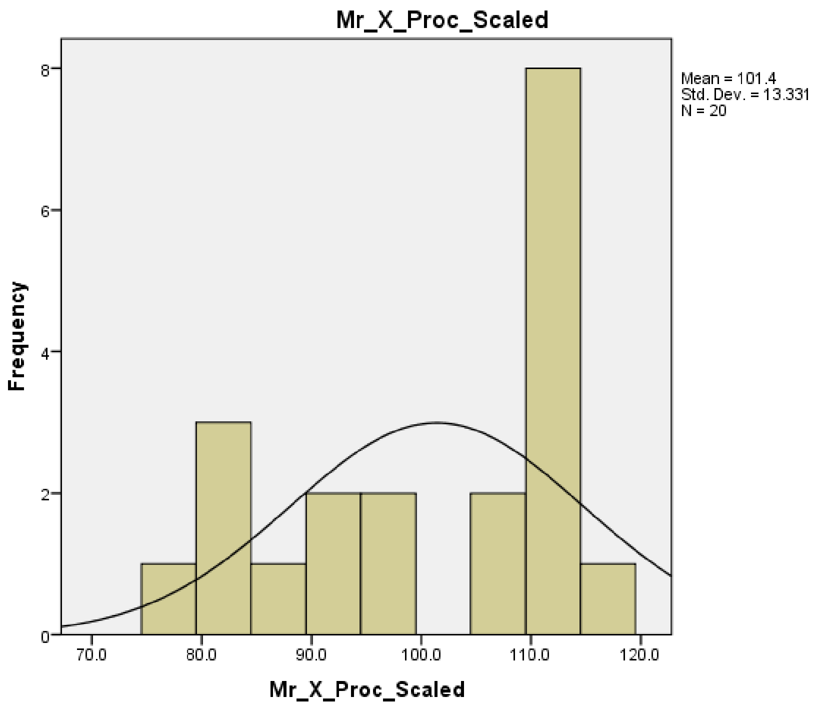

Figure 47A. Histogram of the distribution of data from the AWMA Mister X Processing scores.

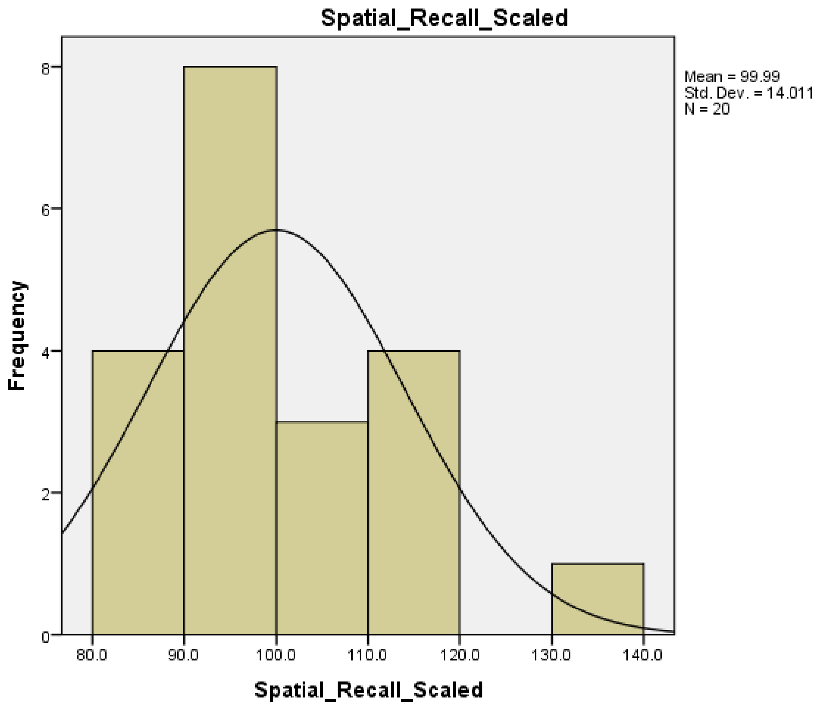

Figure 48A. Histogram of the distribution of data from the AWMA Spatial Recall subtest.

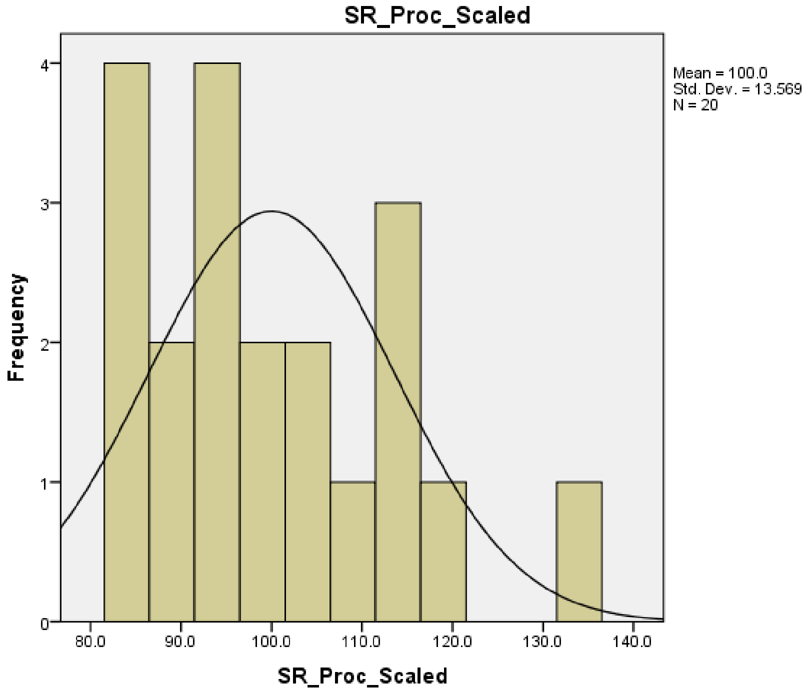

Figure 49A. Histogram of the distribution of data from the AWMA Spatial Recall Processing scores.

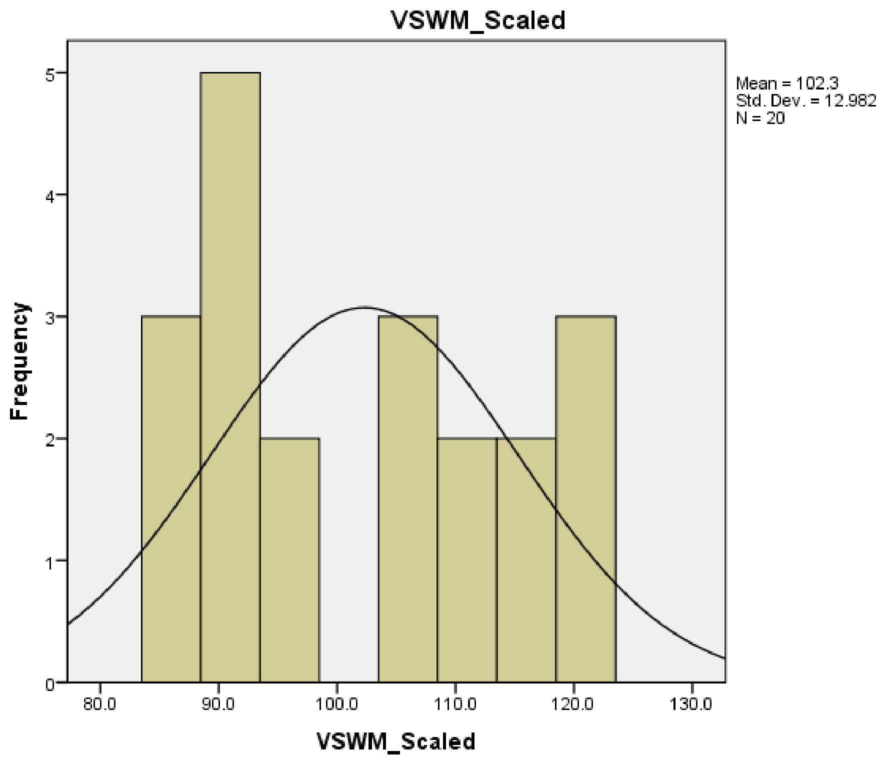

Figure 50A. Histogram of the distribution of data from the AWMA Visuo-Spatial Working Memory scores.

Table 32: The results of the Kolmogorov-Smirnov Test for normality

		Voc	Sim	BD	MR	DR	WR	NWR	VSTM	LR	LRP	CR	CRP	BD	VWM	DM	MM	BR	VSSTM	OOO	OOOP	MrX	MrXP	SR	SRP	VSWM
N		20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Normal Parameters[a,b]	Mean	10.80	9.600	9.700	12.45	98.400	89.440	92.635	91.750	98.500	98.700	102.60	103.80	93.940	98.250	98.250	100.45	90.550	95.300	102.85	101.50	101.40	101.40	99.990	100.00	102.30
	S.D.	1.9894	1.6670	2.4730	2.0384	14.9152	14.7982	12.9211	15.0678	14.2626	15.3077	17.5481	14.5515	15.2256	12.7604	13.7645	14.2218	14.4239	13.4521	14.4924	12.0809	17.1998	13.3314	14.0113	13.5685	12.9822
Most Extreme Differences	Absolute	.256	.181	.204	.237	.187	.218	.200	.172	.180	.242	.203	.215	.171	.170	.138	.307	.157	.150	.282	.267	.262	.266	.103	.187	.213
	Positive	.256	.181	.204	.237	.187	.218	.117	.172	.180	.242	.123	.119	.171	.170	.131	.307	.124	.150	.214	.186	.132	.122	.103	.187	.213
	Negative	-.133	-.149	-.100	-.113	-.087	-.150	-.200	-.081	-.126	-.155	-.203	-.215	-.104	-.139	-.138	-.132	-.157	-.112	-.282	-.267	-.262	-.266	-.088	-.119	-.120
Kolmogorov-Smirnov Z		1.146	.811	.913	1.062	.838	.975	.893	.771	.807	1.083	.910	.961	.767	.760	.615	1.371	.703	.670	1.259	1.192	1.170	1.188	.459	.838	.953
Asymp. Sig. (2-tailed)		.145	.526	.375	.210	.484	.298	.403	.592	.533	.191	.379	.314	.599	.610	.844	.047	.706	.761	.084	.117	.129	.119	.984	.483	.324

Note. a. Test distribution is Normal. b. Calculated from data.