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Effect of Early Language Education on Students' Academic Performance: POMNATHS case study

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ABSTRACT
Our investigation into the *Effect of Early Language Education on UPNG Students' Academic Performance* (Temple et al., 2015) revealed a statistically significant ($p < 0.05$) inverse correlation between UPNGstudents' Early Learning Language (ELL) backgroundsand their overall academic performance at the university. This paper reports on a similar study, conducted in Port Moresby National High School in May-June 2016. Survey data on the students' linguistic backgrounds were matched with their Term 1, 2016 English and overall academic scores, provided by the school administration. A series of ANOVAs and correlation analyses, conducted using SPSS 20, showed a significant inverse correlation between the students' Age of Onset of English learning (AO) and their English/overall scores. These findings point to the adverse effect of delayed AO – the result ofVernacular Education (VE) policy practiced in PNG from mid-1990s up to 2013 – on students' proficiency in English, the language of instruction at post-elementary levels. The results of both studies support the notion that the 'Critical Period Hypothesis' (CPH) extends to second language acquisition (SLA).

Key words: Vernacular Education (VE), Second Language Acquisition (SLA), Age of Onset of English Acquisition (AO), literacy, Critical Period Hypothesis (CPH), Papua New Guinea

INTRODUCTION
Professional expertise is essential in economic management, and human resource development has been recognized as the crucial key to sustainable national growth: "Papua New Guinea's future success depends on the quality of its human resources" (Vision 2050, p. 33). Over the past two decades, however, high school and university students'academic performance has been declining steadily (Honan 2003; Romanyshyn 2010; Unage 2012; Temple et al., 2015), causing an acute deficit of quality human resources in all sectors of the economy. Thus, falling academic standards around the country have become a threat to national security and future development of Papua New Guinea.This study aimed to 'dig up' the root causes of this disturbing development by answering the following research questions:

- **Could Vernacular Education (VE) policy have contributed to the problem by delaying the Age of Onset (AO) of learning English, a second language for most PNG children?** VE policy not only mandated teaching literacy in vernacular languages, but also deliberately pushed back the AO of English learning; this is why, under the VE system, most children first started learning English at (and often after) adolescence.
- **Does the delayed AO affect children's ability to learn English and, therefore, impede their general academic progress?** As the issue of whether AO is a significant factor in attaining proficiency in SLA is still hotly debated, further research and analysis of an expanded data base will help in solving the ultimate question:
- **Does the Critical Period Hypothesis (CPH) extend to SLA?** The future success of modern multilingual Papua New Guinea depends on how well its education system accomplishes its main function: production of quality human resources. This functionality is largely predicated on government language policy, particularly on early learning language education which must provide the students with the master key to all knowledge – proficiency in the language of instruction.

LITERATURE REVIEW

Currently, there is no consensus on whether CPH extends to SLA (Birdsong, D.2014; Temple et al., 2015). Most neuroscientists believe that it does (Penfield & Roberts 1959; Pulvermüller & Schumann 1994; Hyltenstam & Abrahamsson 2003; Schouten 2009; Vanhove, J. 2013), while most TESOL professionals (Marinova-Todd et al. 2000; Singleton 1995; Makoto 2010) and SIL linguists (Foley 2015; Litteral 2016; Petterson 2016) argue that maturational constraints on SLA are highly questionable and cannot be proven.

Penfield and Roberts explained children's effortless L2 acquisition by a neurological advantage young brains have which makes direct learning from input possible. At later ages of onset (AOs), they claimed, it disappears – children become more analytical and begin to learn indirectly, via their first language (1959). Recent research (Hyltenstam & Abrahamsson 2003) has revealed that significant changes occur in the brain around the time when language acquisition outcomes begin to differ *systematically*; this suggests a certain correlation between the two, and begs the question: What is the neurobiological advantage that young brains have in language learning?

THEORETICAL FRAMEWORK

Neurobiological Mechanism of Language Acquisition

All cognition (and that includes language learning) is based on *communication* between nerve cells, on neurons' ability to network, and the type of *connections* they make. A nerve cell or neuron communicates with other nerve cells through a long "cable" called an axon. Axons are electrically active. Here is a drawing of two neurons connected by one of their axons (Fig. 1):

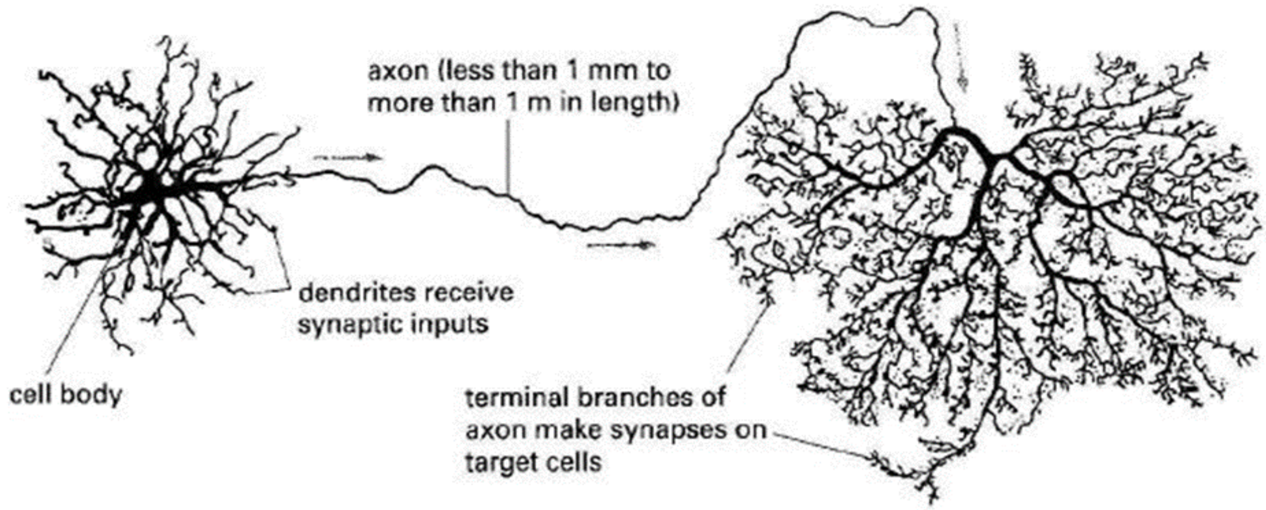


Fig. 1. Neural communication
From B. Alberts et al., Molecular Biology of the Cell, Fourth Edition: Garland Science 2002, p. 1228

Every nerve cell has three distinctive portions -- a cell body, one axon, and several dendrites. Axons (those nerve cell protuberances that transmit signals from one cell to another) can be over 1 m long, or over 10 000 times as long as the cell body is wide (Fig. 2); hence, the need for faster connections.

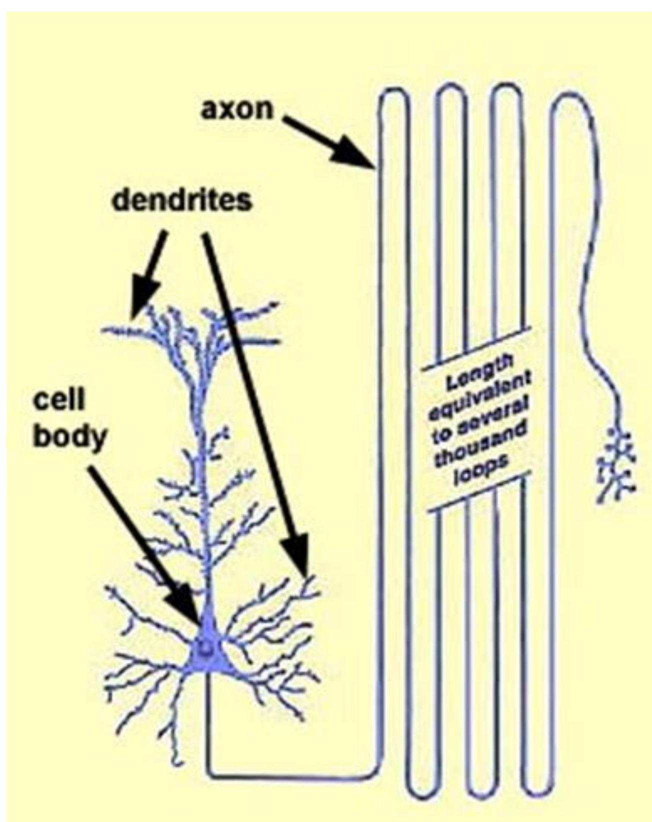


Fig. 2. Axons can be thousands of times longer than the soma (cell body) width

http://biology.stackexchange.com/questions/44082/can-the-dendrites-of-sensory-neurons-be-a-meter-long

The speed of neurotransmission becomes much faster, if a segmented insulating sheath covers the axon, allowing the electrical signal to jump over its segments (nodes), as shown in Fig. 3:

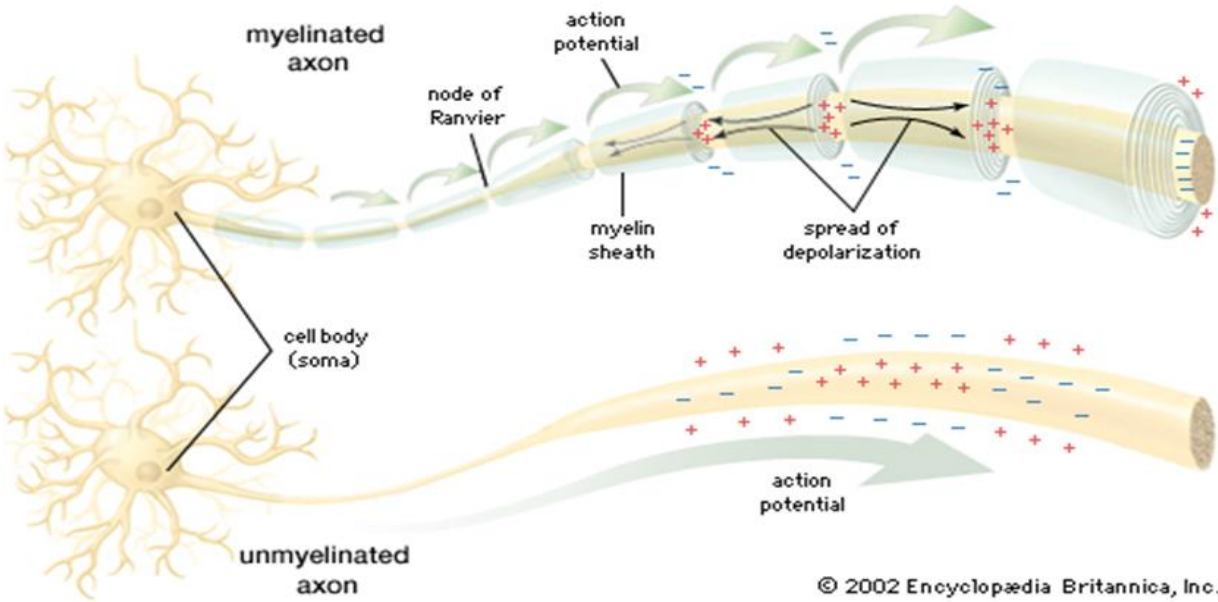


Fig. 3. Nerve signal jumping over sheath segments

https://www.britannica.com/science/myelin-sheath

In a myelinated axon, the myelin sheath prevents the local current (small black arrows) from flowing across the membrane. This forces the current to travel down the nerve fibre to the unmyelinated nodes of Ranvier, which have a high concentration of ion channels. Upon stimulation, these ion channels propagate the action potential (large green arrows) to the next node. Thus, the action potential jumps along the fibre as it is regenerated at each node, a process called saltatory conduction. In an unmyelinated axon, the action potential is propagated along the entire membrane, fading as it diffuses back through the membrane to the original depolarized region (Encyclopædia Britannica, Inc.)

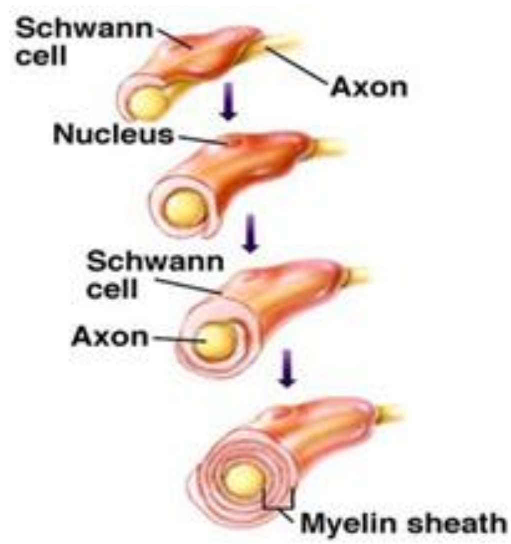


Fig. 4. Myelin sheath formation

http://www.mhhe.com/biosci/genbio/enger/student/olc/art_quizzes/genbiomedia/0644.jpg

Myelin is a fatty substance contained in the glial (Schwann) cells that wraps around many nerve fibers, forming an electrically insulating sheath which increases the speed at which impulses are conducted. "The myelination of cortical neurons is a physical-chemical process in the brain in which glial cells wrap the axons of the neurons with myelin (Hyltenstam & Abrahamsson 2003).

Myelin sheaths provide the neurons with nutrition and greatly increase their ability to conduct electrical signals more rapidly, and at longer cerebral distances. At the same time, however, these insulating **myelin sheaths make connections between *neighboring* neurons increasingly more difficult**.

The process of *myelination*

- Starts at the fetus stage; by the age of 12 months, the primary sensory and motor areas are myelinated.
- Higher-order association areas of the cortex are myelinated much later, and it is in these regions that some neurons remain unmyelinated in adults.
- The language areas around the Sylvian fissure myelinate after the primary sensory and motor areas, but before the higher-order association areas:

"Around puberty, all cortical areas, except perhaps the higher-order association cortices, have reached their full level of myelination" (Pulvermüller & Schumann 1994, p. 713).

Thus, the functions and effects of myelin sheaths are complex: on the one hand, they greatly increase the speed of connections between distant neurons; on the other, they insulate neighboring neurons, thus blocking connections between them. This is very important, because language acquisition potential is dependent on both the *type* and the *speed* of connections in the cortical network.

There are two types of cortical connections between neurons (Fig. 5):

1. **Long-distance connections:** these are made via ***apical dendrites*** and ***axons*** which reach far from the cell body and connect different cortical areas, while
2. **Short-distance connections:** these are made via ***basal dendrites*** which transmit 'local calls' to neighboring neurons.

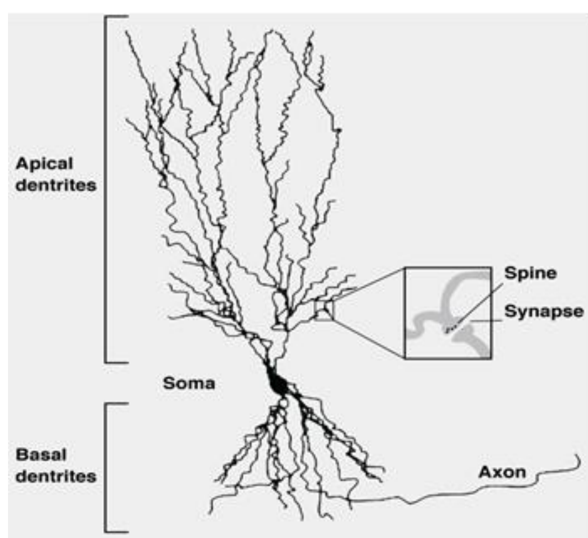


Fig. 5. Two types of cortical connections

https://images.google.com/imgres?imgurl=http%3A%2F%2Fopeni.nlm.nih.gov%2Fimgs%2F512%2F262%2F3181796%2F3181796_DialoguesClinNeurosci-6-171-g004.png&imgrefurl=http%3A%2F%2Fwww.keyword-suggestions.com%2FYmFzYWwgIGRlbmRyaXRlcw%2F&docid=LYSJaCg6nI0RWM&tbnid=bknWswlE-eBJXM%3A&vet=1&w=512&h=546&source=sh%2Fx%2Fim

Myelination speeds up long-distance signal transmission through the axons, but it also insulates the axon fiber, inhibiting its ability to connect with basal dendrites, which are close to the cell body, and with local branches of the axons (axon 'collaterals'). However,

Language Acquisition Relies on 'Local' Connections within the 'Language Areas'

Language acquisition relies on 'local' connections within a limited '**language areas**' of the brain (See Fig. 6):

- ***Broca's*** area: control of muscles for speech production and ability to comprehend grammatical structures;
- ***Wernicke's*** area: comprehension of speech sounds (language) around the **Sylvian fissure**

Communication between the still unmyelinated language areas in prepubescent brains is largely short-distance, via the basal dendrites (Fig. 5). Progressive myelination of these language areas changes the *type* of cortical connections to long-distance, which involves the frontal lobe, responsible for the higher-order mental functions of logical thinking, problem-solving, emotional expression and creativity.

The arrows in **Fig. 6** show how signals from the visual and auditory cortices are processed during auditory/visual language perception and language production (speaking or writing):

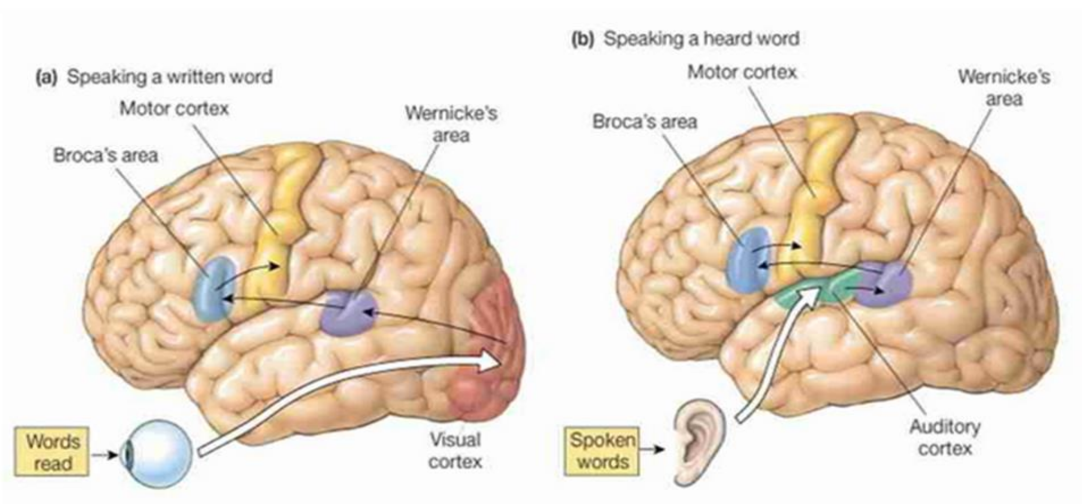


Fig. 6. Auditory and Visual signal processing

https://goo.gl/images/miBLMS

The same areas of the cortex are involved in language acquisition: before myelination, the neurons in Broca's and Wernicke's areas are able to make 'local' connections with neighboring neurons, so language is learned by direct input, through mere exposure. After their axons are myelinated, language acquisition mechanism 'switches gears' – neurons within the language areas are no longer able to make short-distance connections, and language learning occurs via the higher-order association areas in the frontal lobe. Those areas of the brain are myelinated much later in the process of maturation, with some neurons remaining unmyelinated even in adults.

In the past, the structure of the human brain could only be studied during post-mortems; as the supply of children's brains for autopsy has always been scanty, little was known about brain development during adolescence. Until recently, it was thought that the brain was formed in early childhood. Modern non-invasive brain imaging technologies, such as Magnetic Resonance Imaging (MRI), have revealed that the brain continues to develop after childhood, and that it undergoes particularly radical structural changes during adolescence. MRI studies have consistently found that there is a steady increase in *white matter*[1] in certain brain regions in childhood and adolescence (Blakemore & Choudhury 2006).

Recent studies have also revealed that myelination of language-related areas occurs in two stages– in infancy, and then again at adolescence:

1) At the age of about one and a half years, coinciding with the rapid increase in vocabulary development (Pujol et al. 2006);
2) At adolescence, when there is a lateralized increase in **arcuate fasciculus** (Fig. 7) – the white matter tracts, linking Wernicke's and Broca's areas in the left hemisphere (Schmithorst et al., 2002).

arcuate fasciculus

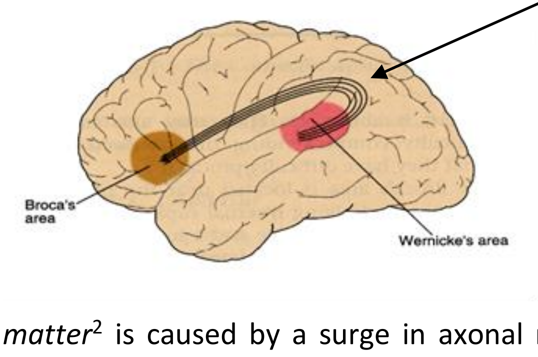


Fig. 7. The Arcuate Fasciculus

http://wikivisually.com

The increase in white matter and decrease in *grey matter*[2] is caused by a surge in axonal myelination during this time. At adolescence, a rapid increase in white matter volume and density was observed particularly in the left **arcuate**

[1] White matter is composed of bundles of myelinated nerve cell projections (or axons), which connect various gray matter areas (the locations of nerve cell bodies) of the brain to each other, and carry nerve impulses between neurons. (Wikipedia)

[2] Grey matter (or gray matter) is a major component of the central nervous system, consisting of neuronal cell bodies, neuropil (dendrites and myelinated as well as unmyelinated axons), glial cells (astroglia and

fasciculus, the bundle of myelinated axons that connects anterior speech regions (Broca's area) and posterior language regions (Wernicke's area) – indicating more efficient connections between them.

"The maturation of myelin may contribute to adult learners' inability to develop a native-like second language," admits the Routledge Encyclopedia of Second Language Acquisition (2013, p.149); taken in isolation from a multitude of other variables that affect SLA outcomes, these age-dependent structural changes in the brain do, indeed, seem to support the 'critical period' hypothesis (CPH). CPH states that, compared to adults, children learn language – be it first or second – effortlessly, directly, through mere exposure, due to the difference in the *mechanism* of language acquisition in childhood. Neuronal communication within the language areas of pre-adolescent brains is still in the 'local call' mode, allowing short-distance connections with neighboring neurons.This 'age advantage' disappears with age; in adulthood, language learning requires conscious effort and logical thinking, because the mechanism of language acquisition is now based on long-distance connections with the 'higher-order' association areasin the frontal lobe, conducted bidirectionally via the fully myelinated arcuate fasciculus. Fig. 8 illustrates the radical structural changes that occur in the human brain in the course of its maturation, and particularly during adolescence:

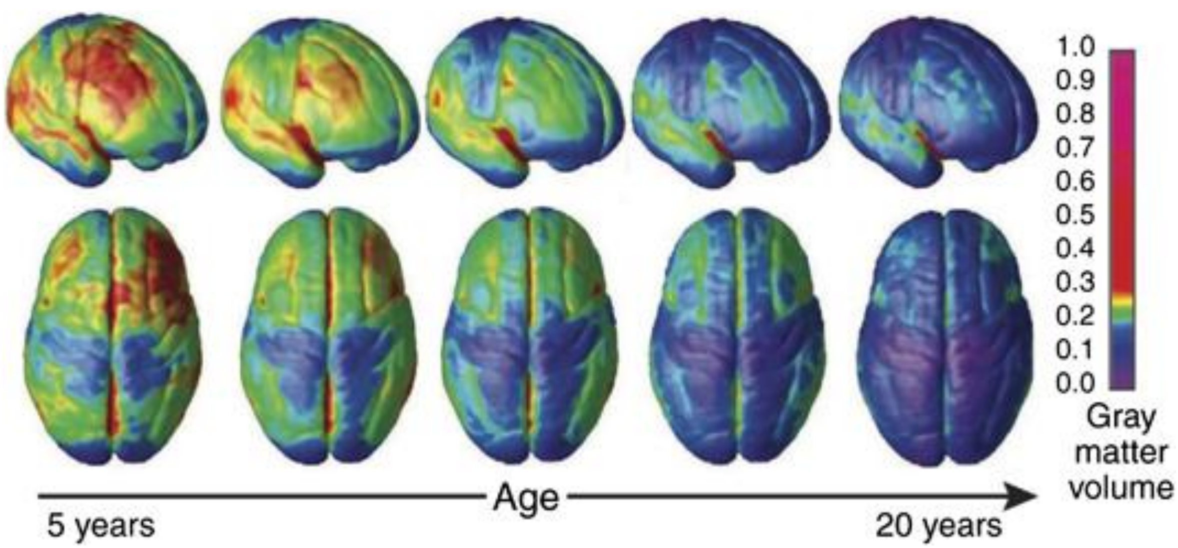


Fig. 8. Decrease in grey matter volume and density in the process of maturation.

Source: National Institute of Mental Health, UCLA Laboratory of Neuro Imaging:

The decrease in grey matter at adolescence can be explained by axonal myelination which increases white matter volume, thus decreasing the grey matter viewed by MRI. Another

oligodendrocytes), synapses, and capillaries. Grey matter is distinguished from white matter, in that it contains numerous cell bodies and relatively few myelinated axons, while white matter contains relatively very few cell bodies and is composed chiefly of long-range myelinated axon tracts (Wikipedia) contributing factor could be the synaptic reorganization after puberty (Huttenlocher, 1979; Bourgeois et al., 1994). Due to synapse proliferation, grey matter density first increases at the onset of puberty, and then gradually decreases after puberty due to post-pubescent synaptic pruning (Giedd et al., 1999a; Gogtay et al., 2004). In other words, the increase in grey matter at puberty reflects a sudden increase in the number of synapses. At some point after puberty, there is a process of refinement, such that these excess synapses are eliminated, resulting in a steady decline in grey matter density.

The age factor is, without question, one of many that influence the outcomes in SLA. Yet, in the multilingual and multicultural society of Papua New Guinea, it is imperative to investigate the extent to which it affects high school and universitystudents' academic performance, in order to develop an optimally efficient language education policy. We now know that there is a **qualitative change in the *mechanism* of language acquisition** after adolescence, which explains why first language acquisition becomes impossible after puberty, while second language acquisition becomes increasingly more effortful with the process of myelination in the 'language areas' (Pulvermüller & Schumann 1994, p. 562). This study seeks to provide statistical evidence to support or invalidate the hypothesis that CPH extends to SLA.

STUDY AIMS & OBJECTIVES

This study aimed to investigate the effects of **Age of Onset (AO)** of English acquisition on Port Moresby National High (POMNATH) school students' academic performance, measured by their Term 1, 2016 English and overall average performance scores. We also tried to determine whether **Age at Literacy (AL)** affected the students' performance in later years. The effect of **Early Learning Language (ELL)** in the students' pre-school and elementary education, yet another major focus of this study, was likewise determined by correlating the students' ELL backgrounds with their academic scores. Indisputably, correlation does not imply causation; however, we hope that another confirmation (or invalidation) of an inverse relationship between AO and SLA may contribute to the ongoing debate.

MATERIALS & METHODS

At the beginning of May 2016, we conducted a survey of POMNATH students' early education backgrounds, using a pre-tested questionnaire (Fig. 9). It had 8 straightforward and easy-to-answer questions that took not more than five minutes to complete.

Permission to conduct the survey was obtained from the POMNATH administration, securing their full cooperation. Participation in this study was entirely voluntary, and informed consent was obtained from each student. The questionnaires were administered, using purposive convenience sampling.

The students' Term 1 2016 academic scores, which included the continuous assessment and examination scores, were obtained from the school Academic Office. Survey data on students' early language education backgrounds were then matched with their academic scores and entered into Excel spreadsheets, ordered according to grades.

The effect of early language education on POMHNATH students' performance

You are invited to participate in a collaborative research project conducted by the School of Humanities & Social Sciences and the School of Medicine & Health Sciences (UPNG). This study aims to help develop effective education strategies for sustainable national development. The success of this study depends on the accuracy of your responses. We guarantee total confidentiality – none of your personal information shared with us will be disclosed in this study. Your participation, however, is entirely voluntary.

ANSWER THE EIGHT (8) QUESTIONS BELOW:

1. **Please state your name & surname**:

2. **Gender:** ☐ Male ☐ Female

3. **Grade details**:
   ☐ Grade 11 (Arts) ☐ Grade 11 (Science)
   ☐ Grade 12 (Arts) ☐ Grade 112 (Science)

4. **What is the first language that you spoke at home as a child?**
   ☐ Vernacular (give the language name): ……………………………………………………………
   ☐ Tok Pisin ☐ English

5. **At what age were you taught to read and write?**

6. **Where did you do your elementary schooling?**

7. **How old were you when you first started learning English?**

8. **In what language did you first learn to read and write?**
   ☐ Vernacular ☐ TokPisin ☐ English

THANK YOU FOR PARTICIPATING IN THIS IMPORTANT STUDY!

Fig. 9. Sample of the Questionnaire used in the POMNATH survey

For correlation analysis between students' Age of Onset of English learning (AO) and their academic performance, the students were separated into 3 categories, based on their AO. These categories were: (a) **Early** group (AO from 1 to 5); (b) **Normal** group (AO from 6 to 8); and (c) **Late** group (AO from 9 to 13).

For correlation analysis between students' Age at Literacy (AL) and their academic performance, the students were also divided into 3 categories: (a) **Early** group (AL from 4 to 5); (b) **Normal** group (AL from 6 to 8); and (c) **Late** group (AL from 9 to 13).

The SPSS version 20 for Windows was used for statistical analysis of the data. Descriptive, correlation and linear regression analyses of the match-up between our data sets were used to explore the strength of potential association between the students' AO/AL/ELL and their mean English/Overall academic scores at the end of Term 1, 2016 academic year.

RESULTS & DISCUSSION

The information contained in five hundred and twelve (512) questionnaires was coded and successfully matched with the respective academic scores, forming the final dataset. The data collected was descriptive only and therefore explains how the current students performed but not why they performed the way they did.

Distribution of the results shows that 85% (279 out of 330) of all Grade 11 students and 77% of the Grade 12 students (233 out of 304) participated in the study. Lower participation by Grade 12 students was due to poor school attendance on the day of data collection, caused by the UPNG student unrest at the time. Thus, a total of 81% (512/634) of the entire school population took part in the study.

The average academic scores for the grade 11 and grade 12 students were pooled and analyzed. The distribution of the 512 scores is presented in the histogram in Fig. 10:

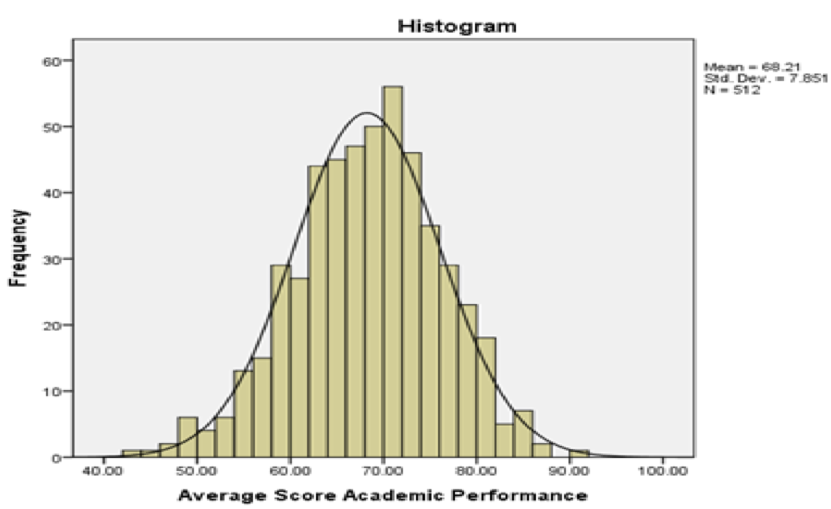


Fig. 10. Average Score Academic Performance

The data in Fig. 10 shows a normal distribution, with a mean (± standard deviation) of 68.2 ± 7.9%. The mode was 68.0% and range was 43.5 – 90.2%. The median was 68.4% and the Interquartile Range (IQR) was 63.0 – 73.4%.

All the students that participated in this study were educated under the VE policy, which mandated the use of the child's 'home' language as the Early Learning Language (ELL). While the questionnaire contained a range of questions, this paper focuses on the results from three independent variables [Age of Onset of English (AO), ELL and Age at Literacy (AL)].

Our variables of measurement, the dependent variables, were the students' Term 1, 2016 English and overall scores.

Because these independent variables were categorical and the dependent were linear, we used several series of ANOVAs, and ran an eta (η) on all ANOVAs to investigate the Covariance of the categories. For two of the three independent variables (AO and AL), divided into three groups (early/normal/late), we ran an F-test for significance. For the independent variable 'gender' a t-test for significance was performed. Our general findings follow the Sample Description section below.

Sample Description

Gender Distribution

Gender distribution of the 512 students shows that 44% were female and 56% were male students (Fig. 11). The gender parity index (GPI), or female to male ratio obtained in the present study, was 0.77 (44/56). This value (GPI 0.77) is very low compared with the values obtained for the Philippines, where the high school GPI is 1.17 (117 girls to 100 boys), the Cook Islands (GPI 1.13), the Solomon Islands (GPI 0.92), and even with the overall average GPI for the Pacific Region of 0.82 (*Statistical Yearbook for Asia & the Pacific 2011, UNESCO Institute for Statistics*).

Comparison of GPIs in both grade levels showed a relatively even gender distribution, with female students making up 42% of all Grade 11 students, and a slightly greater percentage (46%) of Grade 12 students (Figs. 11A & 11B). In grade 11 the GPI was 0.72 compared to 0.85 in grade 12.

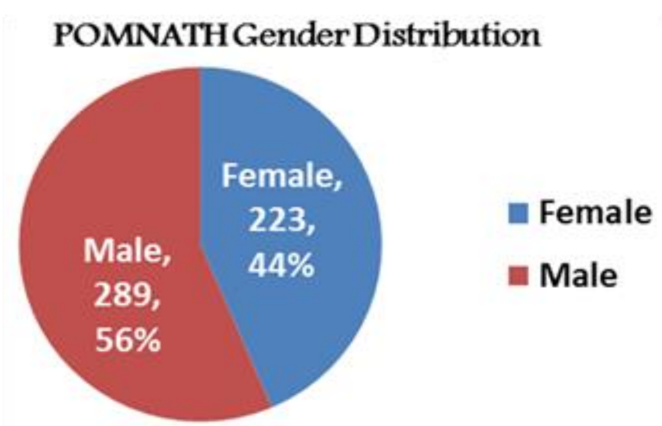


Fig. 11. POMNATH Gender Distribution (n =512)

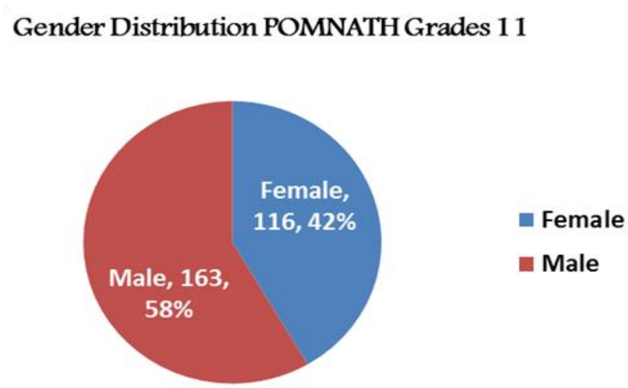


Fig. 11-A. Gender in POMNATH Grades 11

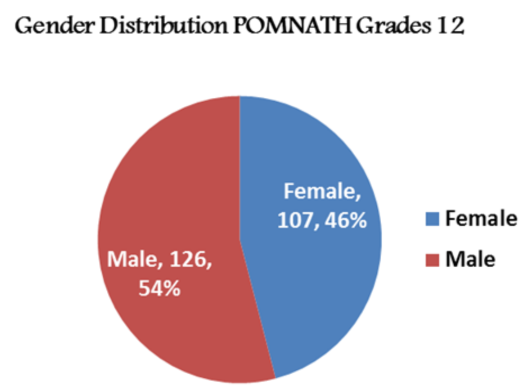


Fig. 11-B. Gender in POMNATH Grades 12

Early Learning Language (ELL) distribution

Figures 12 A & B show the early learning language backgrounds of POMNATH students:

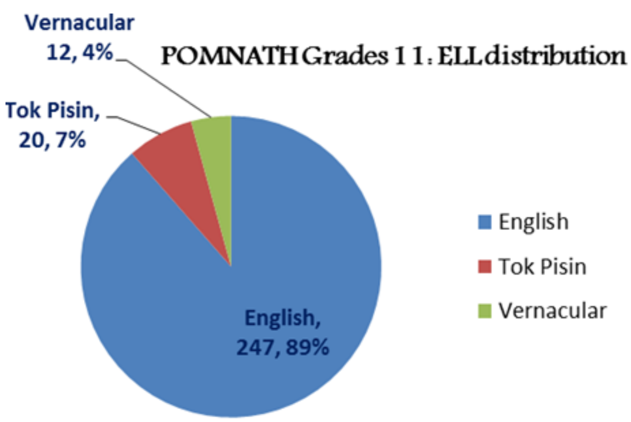


Fig. 12-A. ELLs in Grades 11

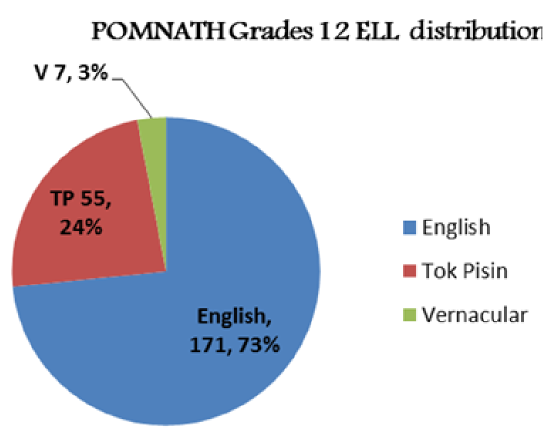
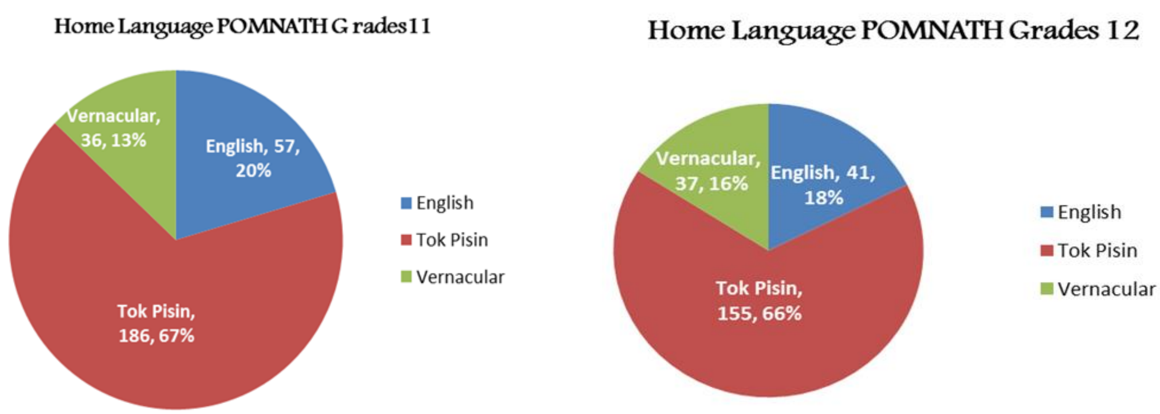


Fig. 12-B. ELLs in Grades 12

When the 512 students were distributed according to their ELL backgrounds, 82% (418/512) listed English, 15% (75/512) listed Tok Pisin, and 4% (19/512) listed vernacular. What could be the major reason, at the height of the Vernacular Education policy in PNG, for 82% (418/ 512) of all the students in our present study to have listed English as their ELL? For more detailed analyses of the data, the students in grades 11 and 12 were distributed according to their ELL backgrounds. The data obtained is presented in Figs 12 A & B. Together with the extremely low numbers of students with Vernacular ELL backgrounds, 4% (12/279) in Grades 11 and 3% (7/233) in Grades 12, these numbers might indicate lower competitiveness of students with Vernacular ELL backgrounds for entry into the POMNATH, but they could also reflect the more general cultural and demographic trends in urban populations. The smaller percentage of students with Tok Pisin ELL in Grades 11 (7% or 20/279) as compared to Grades 12, where they make up 24% (55/233), might be indicative of falling levels of competitiveness of students with Tok Pisin ELL backgrounds.

Home Language

Data on the home language backgrounds for the 512 students indicated that 67% (341/512) listed TokPisin, 19% (98/512) listed English and 14% (73/512) listed Vernacular. Figs. 13 A & B show the distribution of home language backgrounds amongst the students in Grades 11 and 12, respectively. In both grade levels, two thirds of the students were native Tok Pisin speakers, while about 1/3 of them listed Vernacular and English as their home language.



Figs. 13 A & B. Home language backgrounds of students in Grades 11 and 12

Our data showed that 67% of POMNATH students came from Tok Pisin backgrounds. However, although 19% (98/512) of the students listed 'English' as their home language, very few of them (<1%) were grew up in Australia. The relatively large number of students who listed English as their home language may be explained by the fact that most POMNATH students came from the 'melting pot' of Port Moresby (Fig. 14); it might also be that very few students from vernacular backgrounds succeeded in gaining entrance to POMNATH.

Location of students' elementary schooling

Even though some POMHATH students in our sample did come from other Provinces in PNG, our results show that they had overwhelmingly attended elementary schools in Port Moresby

(National Capital District). These cohorts make up 71% and 70% of student populations in Grades 11 and 12, respectively. Among the other cohorts, Central and Morobe students are relatively more represented, but no group reaches even 6% of the student population in either grade level (Figs. 14 A & B):

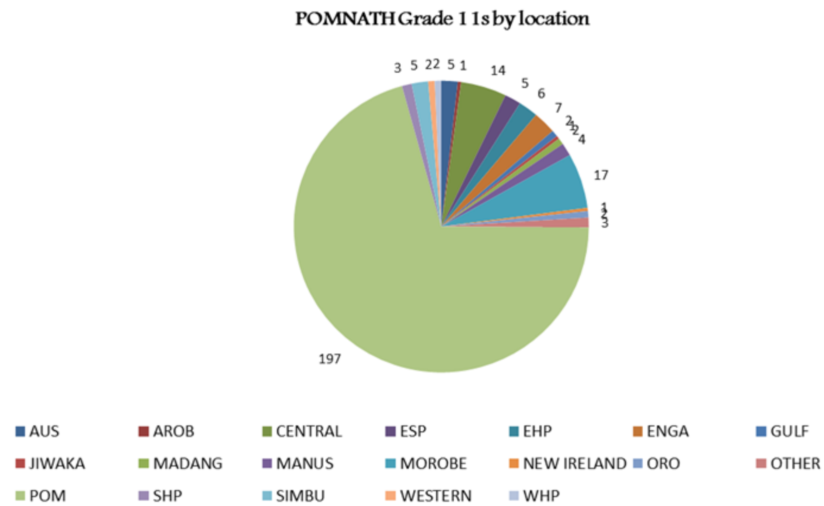


Fig. 14-A. Distribution of students' provinces in Grades 11

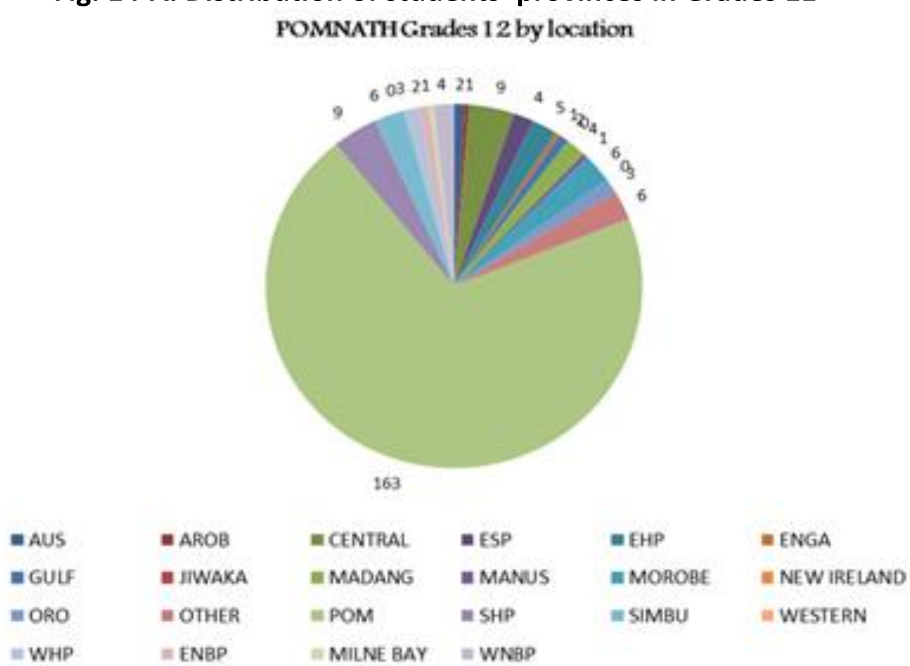


Fig. 14-B. Distribution of students' provinces in Grades 12

DATA BY LOCATION KEY: 1=AUS; 2=AROB; 3=CENTRAL; 4=ESP; 5=EHP; 6=ENGA; 7=GULF; 8=JIWAKA; 9=MADANG; 10=MANUS; 11=MOROBE; 12=NEW IRELAND; 13=ORO; 14=OTHER; 15=POM; 16=SHP; 17=SIMBU; 18=WESTERN; 19=WHP; 20=ENB; 21=MILNE BAY; 22=WNB

ANOVAs & CORRELATIONS

- **Between Age of Onset (AO) & Academic Scores**

For more detailed statistical analysis the 512 students were separated into 3 categories based on their Age of Onset of English learning (AO): (a) Early (1-5 years), (b) Normal (6-8 years) and (c) Late (9-13 years). 38% of the students (195/512) were in the early category, 51% (261/512) – in the normal category, and 11% (56/512) – in the late category.

One-Way ANOVA was used to determine the extent of variance in the mean English and Overall Scores for Term 1, 2016 between the three AO groups. Fig. 15 shows the mean English and Overall Academic Scores obtained by each of the three AO groups. The mean English scores for the Early, Normal and Late categories were 72.6%, 67.3%, and 61.4% respectively; a slightly more balanced, but still significant variation was observed in overall performance:

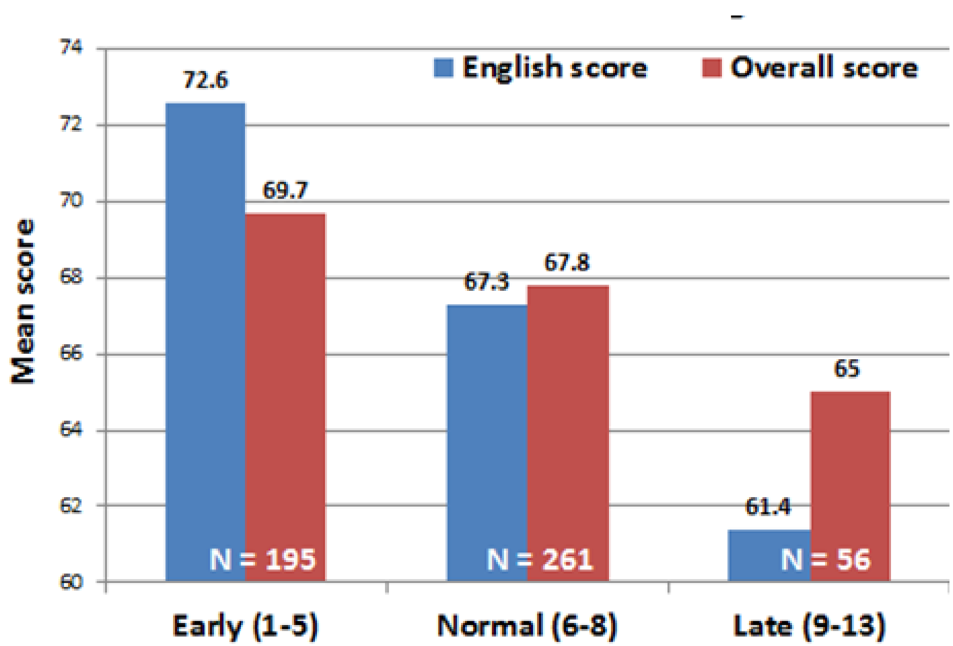
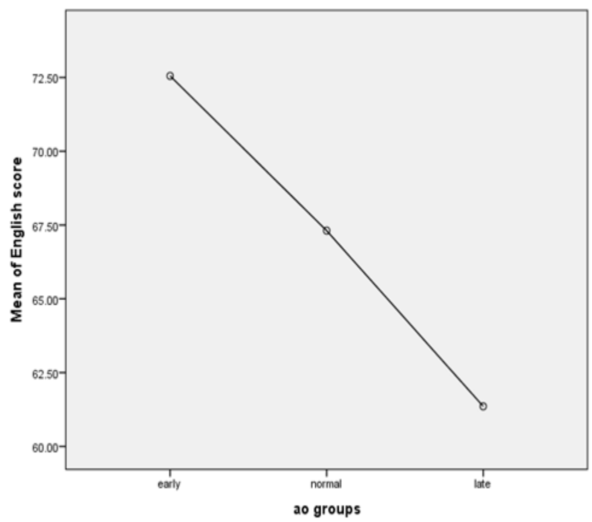


Fig. 15. Mean English and Overall Academic Scores for the 3 categories

Multi variant analysis of the data obtained showed a statistically significant inverse correlation between the Age of Onset of English learning by AO groups and mean English, as well as Overall mean scores (Figs. 15A and 15B; Table 1).



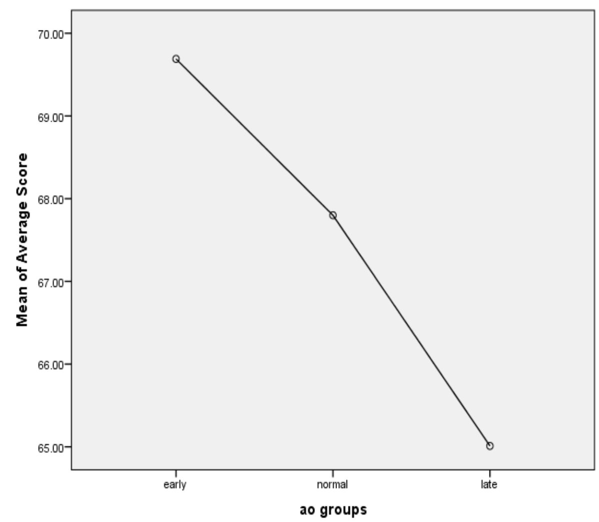


Fig. 15A. Mean English Scores by the 3 AO categories

Fig. 15B. Mean Overall cores by the 3 AO categories

Table 1: MULTIPLE COMPARISONS - Dependent Variable: English score

	(I) age groups	(J) age groups	Mean Difference (I-J)	Std. Error	**Sig.**	95% Confidence Interval Lower Bound	Upper Bound
Scheffe		**normal**	5.24350*	.90513	**.000**	3.0214	7.4656
		late	11.19670*	1.44975	**.000**	7.6376	14.7558
	normal	**early**	-5.24350*	.90513	**.000**	-7.4656	-3.0214
		late	5.95320*	1.40826	**.000**	2.4960	9.4104
	late	**early**	-11.19670*	1.44975	**.000**	-14.7558	-7.6376
		normal	-5.95320*	1.40826	**.000**	-9.4104	-2.4960
Bonferroni	**early**	**normal**	5.24350*	.90513	**.000**	3.0694	7.4176
		late	11.19670*	1.44975	**.000**	7.7145	14.6789
	normal	**early**	-5.24350*	.90513	**.000**	-7.4176	-3.0694
		late	5.95320*	1.40826	**.000**	2.5707	9.3357
	late	**early**	-11.19670*	1.44975	**.000**	-14.6789	-7.7145
		normal	-5.95320*	1.40826	**.000**	-9.3357	-2.5707

*. The mean difference is significant at the 0.05 level.

Since the variance between the mean English scores of the AO groups was highly significant, we ran the parametric (Pearson test: Table 2) and nonparametric (Spearman's rho: Table 3) correlation analyses to determine the strength of association between them.

Table 2. Parametric test of the correlation between AO and mean English scores

		English score	age groups
	Pearson Correlation	1	**-0.348****
English score	Sig. (2-tailed)		.000
	N	512	512
	Pearson Correlation	**-0.348****	1
age groups	Sig. (2-tailed)	.000	
	N	512	512

****. Correlation is significant at the 0.01 level (2-tailed).**

The Pearson coefficient of correlation ($r = -0.348$) showed a statistically significant ($p < 0.001$; two-tailed) inverse relationship between the AO and students' English performance.

The nonparametric correlation analysis also showed statistically significant ($p < 0.001$; two-tailed) inverse correlation (Spearman rho = - 0.349) between the AO and English performance.

Table 3. Nonparametric test of correlation between AO and mean English scores

			English score	age groups
Spearman's rho		**Correlation Coefficient**	1.000	**-0.349****
	English score	Sig. (2-tailed)	.	.000
		N	512	512
		Correlation Coefficient	**-0.349****	1.000
	age groups	Sig. (2-tailed)	.000	.
		N	512	512

****. Correlation is significant at the 0.01 level (2-tailed).**

Confirmation of the statistically significant inverse correlation between the Age of Onset of English learning and the degree of proficiency in SLA is strong scientific evidence that invalidates our H_0. Therefore, we must reject it and accept the alternate hypothesis (H_1) which states that there is a statistically significant correlation between these variables. Thus, the results obtained in the present study strongly support the idea of CPH effects extending to SLA.

- **Between Age at Literacy (AL) and English scores, and Overall Scores**

In order to assess the degree of variance between the students' age at literacy (AL) and their mean English / Overall scores, the 512 students were separated into 3 groups (Early, Normal and Late). The groups were: (a) **Early**: those students (118/512; 23%) that learned to read and write between the ages of 4 and 5; (b) **Normal**: those students (313/512; 61%) that learned to read and write between the ages of 6 and 8; (c) **Late**: those students (81/512; 16%) that learned to read and write between the ages of 9 and 13 years.

The English and overall scores for the three groups were compared using One-Way ANOVA. The results obtained are presented in Fig. 16. The 'early' group did better than the 'normal' and 'late' groups.

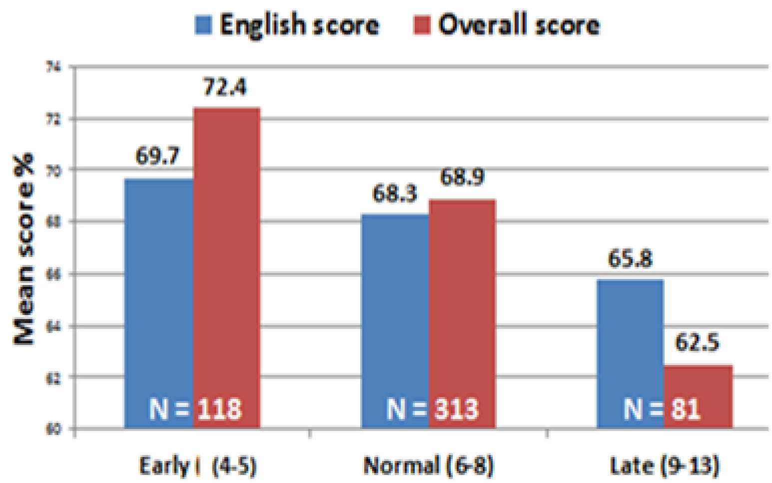


Fig. 16. Mean English and Overall scores for the early, normal and late AL groups

Summary of the ANOVA results for the three groups is presented in Table 4. The results show a statistically significant variance between and within the AL groups in their means for both English and Overall Average scores.

Table 4: Variation between mean English/ Average scores between/within AL groups

ANOVA						
		Sum of Squares	df	Mean Square	F	**Sig.**
	Between Groups	4787.509	2	2393.755	25.292	**.000**
English score	Within Groups	48173.991	509	94.644		
	Total	52961.500	511			
	Between Groups	725.523	2	362.761	6.000	**.003**
Average Score	Within Groups	30775.083	509	60.462		
	Total	31500.606	511			

For more detailed statistical analysis of the data, Post-Hoc (Bonferroni) test was performed. The results obtained are presented in Table 5 below. The results obtained were consistent with the ANOVA results (Table 4), both showing statistically significant variation in means scores between the three AL groups. The variation in the mean scores between the groups is further illustrated graphically in Figs. 16A and 16B.

Table 5: Results of Post-Hoc test (Bonferroni)

Multiple Comparisons							
Bonferroni							
Dependent Variable	(I) AL groups	(J) AL groups	Mean Difference (I-J)	Std. Error	**Sig.**	95% Confidence Interval Lower Bound	Upper Bound
English score	early	normal	3.61320*	1.05093	**.002**	1.0890	6.1374
		late	9.95920*	1.40375	**.000**	6.5875	13.3309
	normal	early	-3.61320*	1.05093	**.002**	-6.1374	-1.0890
		late	6.34599*	1.21278	**.000**	3.4330	9.2590
	late	early	-9.95920*	1.40375	**.000**	-13.3309	-6.5875
		normal	-6.34599*	1.21278	**.000**	-9.2590	-3.4330
Average Score	early	normal	1.45634	.83997	.251	-.5612	3.4739
		late	3.88161*	1.12198	**.002**	1.1867	6.5765
	normal	early	-1.45634	.83997	.251	-3.4739	.5612
		late	2.42526*	.96934	**.038**	.0970	4.7535
	late	early	-3.88161*	1.12198	**.002**	-6.5765	-1.1867
		normal	-2.42526*	.96934	**.038**	-4.7535	-.0970

*. The mean difference is significant at the 0.05 level.

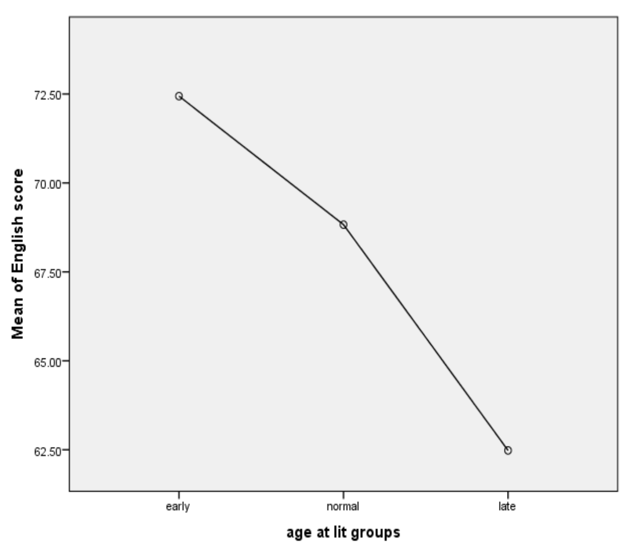


Fig.16A. Mean English scores by AL group variance

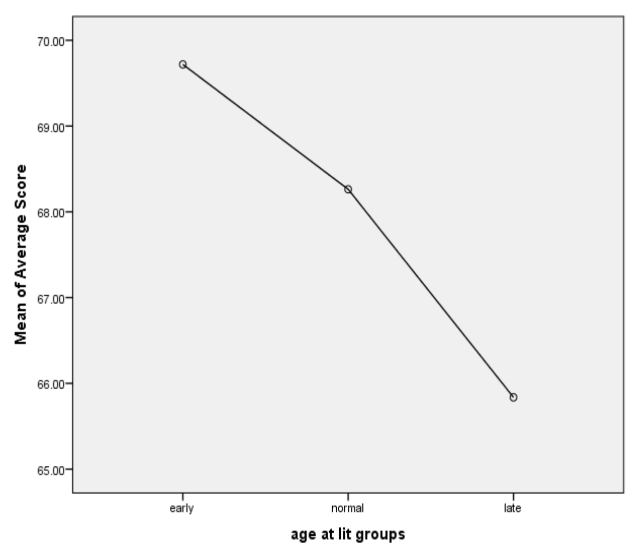


Fig. 16B. Mean Overall scores by AL group variance

Since the variance between the mean English scores of the AL groups was highly significant, we ran the parametric (Pearson: Table 6) and nonparametric (Spearman rho: Table 7) correlation analyses to determine the strength of association between them. The Pearson coefficient of correlation, showed statistically significant ($p < 0.001$; two tailed) inverse correlation ($r = -.294$) between the AL groups and English scores. Similar relationship was obtained for the non-parametric analysis (Spearman rho = -0.293; $p<0.001$, two tailed).

Table 6. Parametric correlation between English scores by AL groups analysis

		AL groups	English score
AL groups	**Pearson Correlation**	1	**-0.294****
	Sig. (2-tailed)		**.000**
	Sum of Squares and Cross-products	196.326	-946.719
	Covariance	.384	-1.853
	N	512	512
English score	**Pearson Correlation**	**-.294****	1
	Sig. (2-tailed)	**.000**	
	Sum of Squares and Cross-products	-946.719	52961.500
	Covariance	-1.853	103.643
	N	512	512
	**. Correlation is significant at the 0.01 level (2-tailed)		

Table 7: Non-Parametric correlation between English scores by AL groups analysis

AL groups	**Spearman's rho**		
	Correlation Coefficient	1.000	**-0.293****
	Sig. (2-tailed)	**.**	**.000**
	N	512	512
English score	**Correlation Coefficient**	**-.293****	1.000
	Sig. (2-tailed)	**.000**	.
	N	512	512
	**. Correlation is significant at the 0.01 level (2-tailed)		

Thus, even though the strength of association between the AL and English proficiency was slightly weaker, these results show a significant inverse correlation and, thus, invalidate our H_0; therefore, we must reject it and accept the alternate hypothesis (H_1) which states that a significant correlation does, in fact, exist between these variables.

Linear regression analysis: The slopes of the regression lines (Figs.17A and 17B), show a degree of inverse correlation between Age at Literacy and academic performance. Admittedly, the correlation between the age at literacy and English scores, represented by the steeper slope of the regression line (in Fig. 19A) is greater, but the correlation between the age at literacy and the students' overall mean scores is also statistically significant. These findings also appear to support the idea of CPH effects extending to learning literacy.

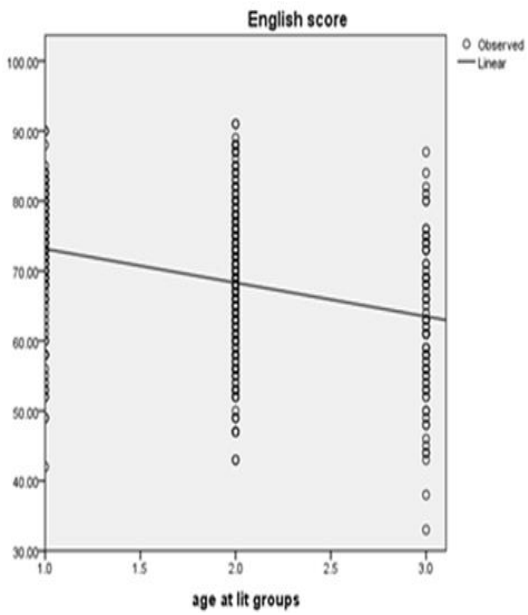


Fig. 17A.English scores by AL groups

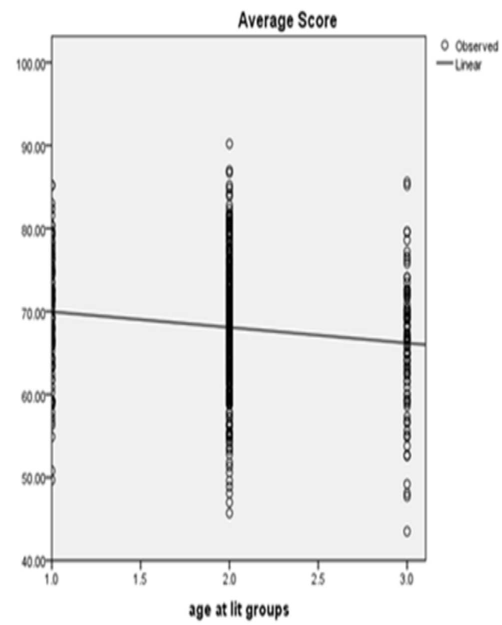


Fig.17B. Overall scores by AL groups

- **Between Early Learning Language (ELL) and Mean Academic Scores**

Of the 512 students that participated in this study, 419 (82%) indicated English as their early learning language (ELL), which implies that they learned literacy in English; the fact that so many of them got admission into POMNATH is a significant indicator of their higher competitiveness.

Just over 14% (74/512) of the total number of students indicated Tok Pisin as their ELL, compared to just 3.7% (19/512) that indicated Vernacular as their ELL. The mean scores of the students in the three ELL groups are presented in Fig 18 below. The mean English score of students with English ELL background was higher than those with TokPisin and Vernacular ELLs. Statistical analyses of the data using ANOVA indicated statistically significant differences ($p<0.001$) between the three groups.

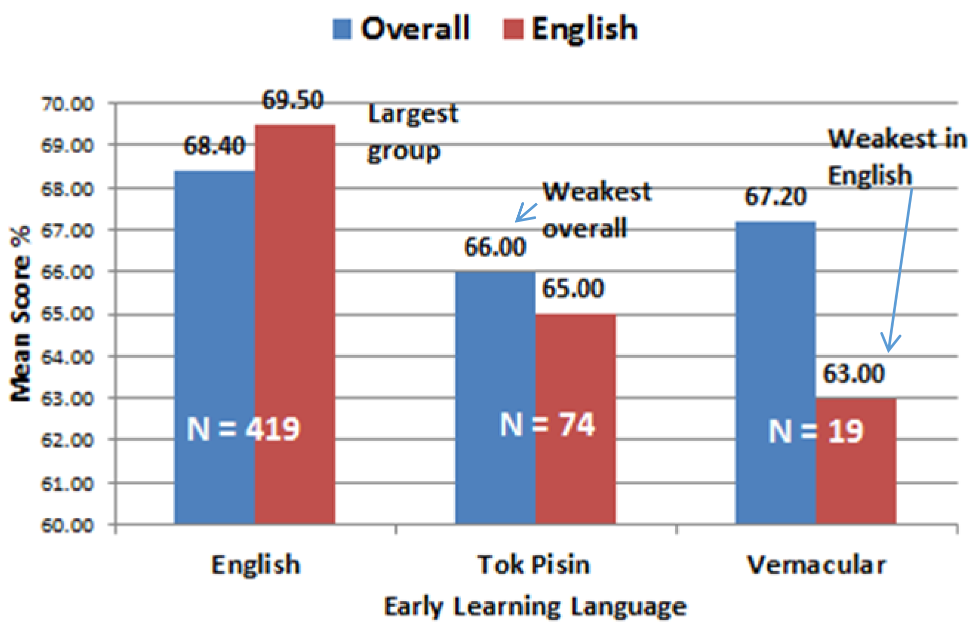


Fig. 18. Overall & English mean scores by ELL groups

The results obtained for the Post Hoc tests for Variance in English scores by ELL groups are presented in Table 8. No statistically significant difference (p = 0.722) was observed between the Tok Pisin and Vernacular ELL groups.

Table 8. Post Hoc tests: Variance in English scores by ELL

Multiple Comparisons

Dependent Variable: English score

	(I) Early Learning Language	(J) Early Learning Language	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Scheffe	English	TokPisin	4.46307*	1.26315	.002	1.3621	7.5641
		Vernacular	6.54415*	2.34968	.021	.7758	12.3125
	TokPisin	English	-4.46307*	1.26315	.002	-7.5641	-1.3621
		Vernacular	2.08108	2.57635	**.722**	-4.2438	8.4059
	Vernacular	English	-6.54415*	2.34968	.021	-12.3125	-.7758
		TokPisin	-2.08108	2.57635	**.722**	-8.4059	4.2438
Bonferroni	English	TokPisin	4.46307*	1.26315	.001	1.4291	7.4971
		Vernacular	6.54415*	2.34968	.017	.9004	12.1879
	TokPisin	English	-4.46307*	1.26315	.001	-7.4971	-1.4291
		Vernacular	2.08108	2.57635	**1.000**	-4.1071	8.2693
	Vernacular	English	-6.54415*	2.34968	.017	-12.1879	-.9004
		TokPisin	-2.08108	2.57635	**1.000**	-8.2693	4.1071

***. The mean difference is significant at the 0.05 level.**

The results obtained by multiple comparisons Post Hoc tests for Variance in Overall Average scores by the ELL groups are presented in Table 9 below. The difference in the mean overall scores of students with English and Vernacular ELL backgrounds was not statistically significant (p = 0.757); a similar result was obtained for students with Tok Pisin and Vernacular (p = 8.18). This may indicate that the larger, more widely spoken, written vernacular languages have been effectively used as ELLs, and served to equip the students with the skills necessary to continue their education. The very small percentage of students with Vernacular ELL backgrounds, however, suggests that perhaps

- The number of functional vernaculars used for the purpose of literacy education is insignificant,
- There might be a shortage of teachers, trained to teach in Vernacular languages,
- POMNATH is a day school; thus, majority of the students selected were resident in Port Moresby and the nearby areas in Central Province.

The overall performance of students with Tok Pisin ELL backgrounds was significantly lower than that of the other two groups.

Table 9. Post Hoc tests: Variance in Overall Average scores by ELL

Multiple Comparisons
Dependent Variable: Overall Average Score

	(I) ELL	(J) ELL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Scheffe	English	TokPisin	2.63978*	.98478	**.028**	.2222	5.0574
		Vernacular	1.36759	1.83185	.757	-3.1295	5.8647
	TokPisin	English	-2.63978*	.98478	**.028**	-5.0574	-.2222
		Vernacular	-1.27219	2.00857	.818	-6.2032	3.6588
	Vernacular	English	-1.36759	1.83185	.757	-5.8647	3.1295
		TokPisin	1.27219	2.00857	.818	-3.6588	6.2032
Bonferroni	English	TokPisin	2.63978*	.98478	**.023**	.2744	5.0051
		Vernacular	1.36759	1.83185	1.000	-3.0324	5.7676
	TokPisin	English	-2.63978*	.98478	**.023**	-5.0051	-.2744
		Vernacular	-1.27219	2.00857	1.000	-6.0966	3.5522
	Vernacular	English	-1.36759	1.83185	1.000	-5.7676	3.0324
		TokPisin	1.27219	2.00857	1.000	-3.5522	6.0966

*. The mean difference is significant at the 0.05 level.

The variance in mean overall average scores between the English and Vernacular ELL background groups was not significant; however, variance in overall average scores between Tok Pisin and both English and Vernacular ELL groups was significant ($P<0.05$). Correlation analyses were then performed to determine the strength of association between ELL and the mean scores.
The Pearson coefficient of correlation showed a statistically significant ($p < 0.001$; two tailed) inverse correlation ($r = -0.186$) between the ELL groups and English scores. Non-parametric analysis showed similar relationship (Spearman's rho = -0.134; $p = 0.002$, two tailed).

For the overall average scores the Pearson coefficient of correlation showed a weak ($r = -0.10$) but statistically significant ($p = 0.024$; two tailed) inverse correlation between the ELL groups and Overall average score. Similar relationship was obtained for the non-parametric analysis (Spearman's rho = -0.293; $p<0.01$, two tailed).

As both parametric and nonparametric analysis results showed significant inverse correlation between ELL and mean English/Overall average scores, the third H_0 should also be rejected. This validates the alternate hypothesis (H_1) which states that a significant correlation does, in fact, exist between these variables.

CONCLUSIONS

The findings in the present study suggest a significant inverse correlation between the students' Age of Onset of English learning (AO) and their mean English/mean Overall performance scores. A slightly weaker inverse correlation was observed between the students Age at Literacy (AL) and their mean English/mean Overall performance scores. Early Learning Language (ELL) backgrounds were also found to significantly affect POMNATH students' academic performance.

These results allow us to conclude that one of the major factors that may be responsible for the decline in high school and university students' academic performance over the past two decades may have been caused by the delayed age of onset of English learning (AO), mandated by the Vernacular Education (VE) policy implemented in PNG from mid-1990s to 2013. Amplified by multiple complex and interrelated socio-economic and cultural factors, and compounded by logistical difficulties of implementing the VE policy in a uniquely multilingual but rapidly changing and integrating socio-economic environment, these issues present serious challenges in raising educational and literacy levels in PNG.

The disproportionate predominance of students with English ELL backgrounds amongst POMNATH students may be an indication of the higher competitiveness of these students; it could also be the consequence of the dynamics of urban demographics and the logistics of a day-school set-up.

Further research is needed to confirm these findings and assumptions. In stage two of this investigation, we will analyze data from all six National High Schools in Papua New Guinea (POMNATH, Sogeri, Aiyura, Wawin, PASSAM and Kerevat). With a database far in excess of 3000 students, this expanded study will add to the ongoing research on the effects of AO on SLA.

Although many recent studies (Hyltenstam and Abrahamsson 2003; Dekeyser, R. et al. 2010; Schouten, A. 2010, etc.) have provided convincing evidence of the 'age factor' in SLA, they have also revealed an astounding complexity of interrelated socio-economic, cultural, physical and biological influences on people's ability to learn a second language. In that respect, Carmen Miñoz noted that

> "Researchers from different perspectives have argued that initial age of learning may be considered a macrovariable that includes, among other factors, state of neurobiological maturation, stage of cognitive development, levels of L1 proficiency, L1 and L2 use, and language dominance. In addition, a number of factors, such as the socio-cultural context, the quality of the L2 learning experience, and learners' attitudes and orientations have been observed to combine with initial age of learning, resulting in differences in L2 attainment. Hence, research is needed that integrates quantitative and qualitative methods in order to better grasp the individual and social determinants that interplay with age of learning. In the end, the isolation of age effects on L2 acquisition may be neither possible nor the most adequate aim in age-related investigation" (Carmen Miñoz: 2013).

While we certainly agree that both quantitative and qualitative methods must be used in order to grasp the complex dynamics of learning, the neurobiological mechanism of language acquisition, which changes with age, should be a focal point in this investigation, by virtue of its fundamental role in human cognitive development.

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REFERENCES

Bialystok, E., &Hakuta, K. 1994. *In other words: The science and psychology of second-language acquisition*. New York: Basic Books.

Bialystok, E. 1997. The structure of age: In search of barriers to second language acquisition. *Second Language Research*, 13, 116-137.

Bialystok, E. &Hakuta, K. 1999.Confounded Age: Linguistic and Cognitive Factors in Age Differences for Second Language Acquisition. Ch. 7 in Birdsong, D. (Ed.) 1999. *Second Language Acquisition and the Critical Period Hypothesis*. Mahwah, NJ: Lawrence Erlbaum Associates ISBN 0-8058-3084-7. (pp. 161-181)

Birdsong, D. (Ed.) 1999. Second Language Acquisition and the Critical Period Hypothesis. Mahwah, NJ: Lawrence Erlbaum Associates ISBN 0-8058-3084-7

Birdsong, D. 1999. Introduction: Whys and why nots of the critical period hypothesis for second language acquisition. In D. Birdsong (Ed.), *Second language acquisition and the critical period hypothesis* (pp. 1-22). Mahwah, NJ: Lawrence Erlbaum Associates.

Birdsong, D. 2006. Age and second language acquisition and processing: A selective overview. *Language Learning*, 56, 9-49.doi: 10.1111/j.1467-9922.2006.00353.x

Birdsong, D. 2013.*The Critical Period Hypothesis for Second Language Acquisition: Tailoring the Coat of Many Colors*. Essential topics in applied linguistics and multilingualism, 43-50 http://www.utexas.edu/cola/frenchitalian/_files/pdf/davidbpdfs/TailoringCoat_DBird.pdf Accessed 12/27/2015

Birdsong, D. 2014. Dominance and Age in Bilingualism.*Applied Linguistics* 2014: 1–20 Oxford University Press 2014 doi:10.1093/applin/amu031

Blakemore &Choudhury. Development of the adolescent brain: implications for executive function and social cognition. Journal of Child Psychology and Psychiatry 47:3 (2006), pp 296–312 doi:10.1111/j.1469-7610.2006.01611.x

Dekeyser, R., Alfi-Shabtay, I. &Ravid, D. 2010. Cross-linguistic evidence for the nature of age effects in second language acquisition. *Applied Psycholinguistics* 31: 413–438.

Foley, W. 2015.Learning about Language in Papua New Guinea Villages: Some Personal Vignettes. *Language & Linguistics in Melanesia*, Vol. 33/2, pp.45-59.www.langlxmelanesia.com

Honan, E. 2002/2003.Disrupting assumptions about vernacular education in Papua New Guinea.Reading Online, 6(5).www.readingonline.org/international/inter_index.asp?HREF=honan/index.html

Hyltenstam, K. and Abrahamsson, N. (2003) Maturational Constraints in SLA, in The Handbook of Second Language Acquisition (eds C. J. Doughty and M. H. Long), Blackwell Publishing Ltd, Oxford, UK. doi: 10.1002/9780470756492.ch17

Lenneberg, E. H. 1967. Biological Foundations of Language. Wiley.ISBN 0-89874-700-7.

Litteral, R. 2000. Four Decades of Language Policy in Papua New Guinea: The Move towards the Vernacular. http://www.radicalpedagogy.org/radicalpedagogy8/Four_Decades_of_Language_Policy_in_Papua_New_Guinea__The_Move_Towards_the_Vernacular.html

Makoto Tokudome. Unlikely Bedfellows: The Critical Period Hypothesis and its Effects on Second Language Acquisition. TPFLE Vol.14, No.1, Summer 2010, pp. 18-27.

Marinova-Todd, S. H., Marshall, D. B., & Snow, C. E. 2000.Three misconceptions about age and L2 learning. *TESOL Quarterly*, 34, 9-34.

Paraide, P. Challenges with the implementation of vernacular and bilingual education in Papua New Guinea. Contemporary PNG Studies: DWU Research Journal Vol. 21 (2014): 44-57.

Penfield W. & Roberts L. 1959.Speech and Brain Mechanisms. Princeton: Princeton University Press.

Piaget, Jean. 1972. The Psychology of Intelligence. Totowa, NJ: Littlefield.

Pulvermüller, F. and Schumann, J. H. (1994), Neurobiological Mechanisms of Language Acquisition. Language Learning, 44: 681–734. doi: 10.1111/j.1467-1770.1994.tb00635.x

Romanyshyn, B. & C. 2010. Obstacles to Student Success in Papua New Guinea - Canadian Volunteer Teachers, Keravat National High School - June 5 to October 22, 2010. Accessesed 12/28/2015 @ https://rausimobe.files.wordpress.com/2010/11/obstacles-to-student-success-in-papua-new-guinea1.pdf

Rumsey, A. 2014.Bilingual language learning. HAU: Journal of Ethnographic Theory, 4 (2): 119-140

Schouten, A. 2010. The Critical Period Hypothesis: Support, Challenge, and Reconceptualization. Teachers College, Columbia University, Working Papers in *TESOL & Applied Linguistics*, 2009, Vol. 9, No. 1.

Singleton, D. 1995. Introduction: A critical look at the critical hypothesis in second language acquisition research. In D. Singleton & Z. Lengyel (Eds.), *The age factor in second language acquisition* (pp. 1-29). Bristol, PA: Multilingual Matters.

Singleton, D. 1997. Second language in primary school: The age dimension. The Irish Yearbook of Applied Linguistics, 15, 155-1 66.

Singleton, D. 2001.Age and second language acquisition. Annual Review of AppliedLinguistics, 21, 77-91.

Singleton, D., & Ryan, L. 2004. Language acquisition: The age factor (2nd ed.). Clevedon: Multilingual Matters.

Singleton, D. 2005. The critical period hypothesis: A coat of many colours. *InternationalReview of Applied Linguistics*, 43, 269-285.

Temple, O. 2016. The Influence of Mobile Phones on the Languages and Cultures of Papua New Guinea.In L. E. Dyson, S. Grant, & M. Hendriks (Eds.), *Indigenous People and Mobile Technologies* (pp. 274 – 292). N.Y. and London: Routledge, Taylor & Francis Group. ISBN: 978-1-138-79331-6 (hbk); ISBN: 978-1-135-75936-4 (ebk).

Tokudome, M. 2010. Unlikely Bedfellows: The Critical Period Hypothesis and its Effects on Second Language Acquisition. *Texas Papers in Foreign Language Education* (TPFLE) Volume 14, Number 1 (Summer, 2010)

Unage, M. Outcome Based Education – A Phantom. http://edunewspng.com/2012/10/outcome-based-education-a-phantom/

Vanhove, J. 2013. The critical period hypothesis in second language acquisition: a statistical critique and a reanalysis. PLoS One. 2013 Jul 25; 8(7):e69172. doi: 10.1371/journal.pone.0069172. Print 2013.

Vygotsky, L. 1934, Language and Thought. http://www.marxists.org/archive/vygotsky/works/words/index.htm