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ABSTRACT:
The influence of Age of Onset (AO) of Second Language Acquisition (SLA) on learners' Ultimate Attainment (UA) potential is well documented. The issue of Second Language Acquisition (SLA) potential enters a qualitatively different, pragmatic dimension in most multilingual developing nations (including Papua New Guinea), where English, a second language for most children, is also the language of education, and where, consequently, students' English proficiency necessarily affects their academic potential and the quality of their education. This study investigates whether the academic performance of students in the School of Humanities and Social Sciences (SHSS) University of Papua New Guinea (UPNG) is affected by their linguistic backgrounds. Specifically, we examined the effect of three factors in the students' Early Language Education – their Age of Onset of learning English (AO), their Age at Literacy (AGELIT), and their Early Learning Language (ELL) – on their Semester 1, 2017 Grade Points Average (GPA). A purposive cross-sectional sampling method was used for the selection of students. All full-time registered students in the SHSS during the 2017 academic session were eligible to participate in the study. A self-designed pretested questionnaire consisting of nine short questions was used to collect data on SHSS students' language education backgrounds, including their AO, AGELIT and ELL. Our results show a strong and statistically significant inverse correlation between students' AO/AGELIT and their GPAs, as well as a strong positive link between ELL English and students' GPAs, which contrasts sharply with a significant decrease in GPAs in the presence of ELL Tok Pisin. The ELL Vernacular category was too small (sample size N=34) to yield statistically significant results. Our current results corroborate the findings of our earlier studies which established a highly significant inverse correlation between students' AO and their academic performance in the National High Schools, as well as in the University of Papua New Guinea.

Keywords: Second Language Acquisition (SLA), brain maturation, myelination, language education policy, Early Learning Language (ELL), Age of Onset (AO), Age of Literacy (AGELIT), language circuit.

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INTRODUCTION:

Advances in neuro- and cognitive sciences have transformed our understanding of post-natal brain development, language origins and language acquisition. The biological foundations of language became the focus of neuroscience research since 1960s, when neurobiologists Penfield & Roberts [1] and Eric Lenneberg [2] first postulated the existence of a Critical Period (CP) in first language acquisition. Vygotsky's ideas regarding the development of verbal thought in the course of social interaction [3, 4] have now been borne out by new imaging technologies which can capture thought development "live". These technologies, particularly functional magnetic resonance imaging (fMRI), have tracked brain development, and mapped brain anatomy to brain function [5].

Researchers now have evidence that language processing is impossible without an efficient transfer of information between various language-supporting regions in separate parts of the brain [6]. Thick bundles of myelinated axons enable those "high-power" connections required for all language-relevant regions to work together as one system. Figure 1 shows that this neural ***language circuit*** has at least two dorsal and two ventral pathways: the connection between temporal and premotor cortex supports speech production, the connection between temporal cortex and Broca's area supports complex syntax, and the ventral fiber tracts sub-serve semantic and basic syntactic processes [6].

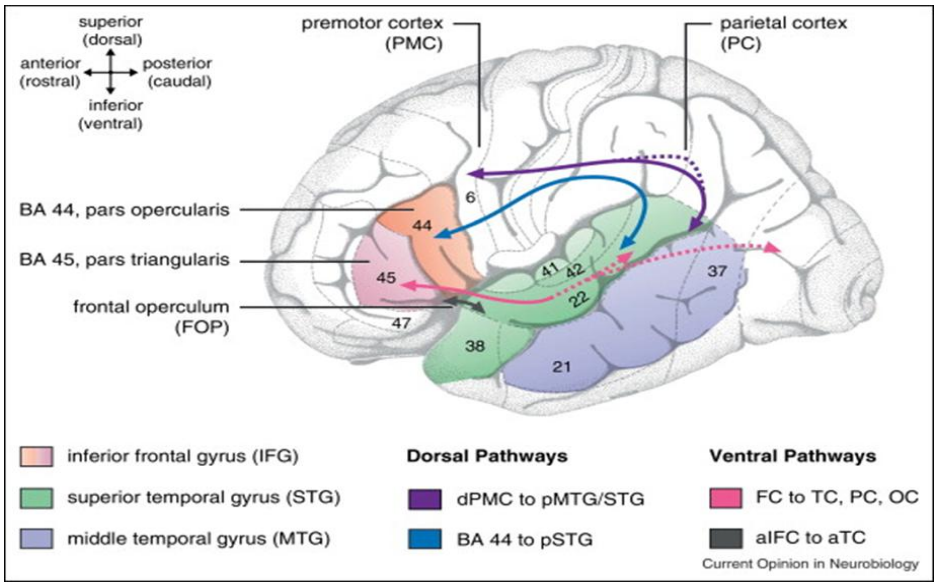

Fig. 1: Language-related regions and high-speed fiber connections in the human brain {*From: Friederici & Gierhan 2013*} [6]

This biological "language system" is not present at birth; it develops in the course of post-natal brain maturation in response to environmental stimuli (social interaction). The build-up of the "language network" gives rise to what Vygotsky called those structures of language that later become the structures of our thought: "Grammar precedes logic; the speech structures mastered by the child become the basic structures of his thinking" [4].

This integrated *language-thought* structure is unified by high-speed information transfer pathways which develop in the process of myelination of neuronal axons. Myelination starts at the fetus stage and proceeds rapidly in a caudo-cranial direction from the brain stem, advancing from deep to superficial, and from posterior to anterior structures in the brain [7]. By the age of twelve months, the primary sensory and motor areas are myelinated, integrating the processing of visual/auditory signals, and motor functions, necessary for language acquisition.

The higher-order association areas of the cortex in the frontal lobe are myelinated much later, and some neurons in these regions remain unmyelinated in adults [8]. It is now clear that First Language Acquisition (FLA) is a function of the gradual integration of all language-related areas in the course of brain maturation [5, 9, 10]. Bundles of myelinated axons "… form a complete 'ring' that … must be in place in order that syntactic processing work" [10]. To support this claim, Berwick and Chomsky [10] cite diffusion tensor imaging MRI (Fig. 2) to show "how these fiber tracts mature over time, between newborns and adults" [10]. According to the authors, in Fig 2, panel (A) illustrates adult connectivity, in both the left and right hemispheres, while panel (B) displays newborn connectivity. In adults (panel A) the "ring" connecting ventral to dorsal areas is complete, with green, yellow and blue portions indicating the ventral and dorsal fiber connections. However, at birth (panel B), the blue connections are missing; they are not yet myelinated. These are the connections to Broca's area. It is as if the brain is not properly 'wired up' at birth to do syntactic processing.

These fiber tracts mature and become functional by about ages two to three, in line with what we know about language development. The authors also stated that in contrast, at birth the tracts responsible for auditory processing are functional, and during the first year of life children acquire the sound system for their language [10].

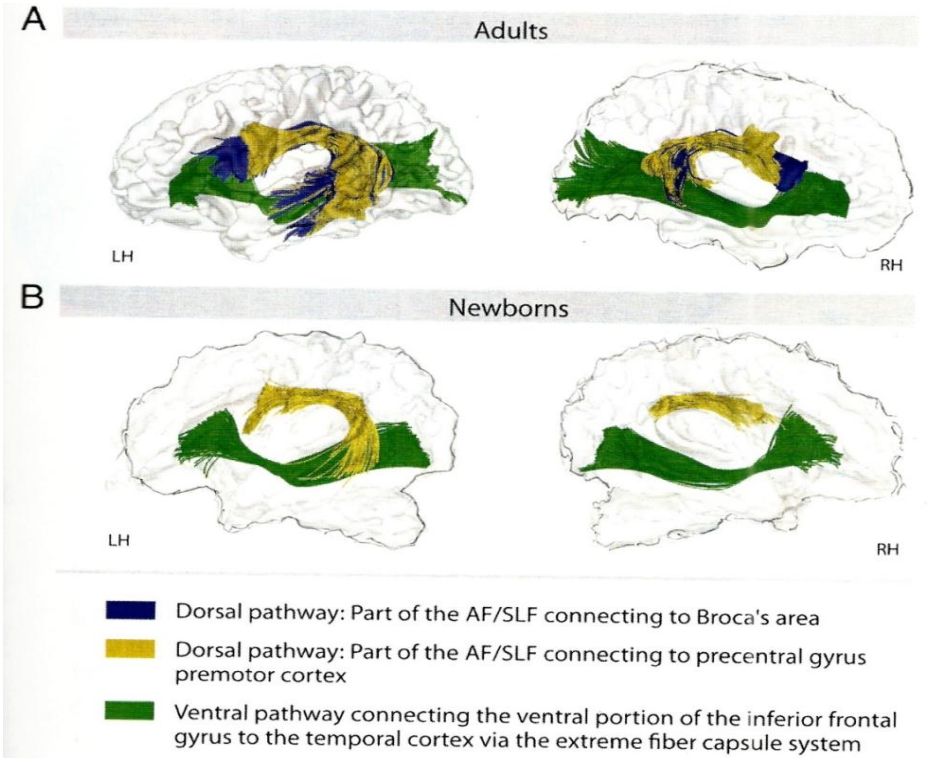

Fig. 2: Dorsal and ventral pathway connectivity in adults vs. newborns (DTI MRI) {From: *Berwick & Chomsky 2016, Plate 3 (figure 4.5)*} [10]

Cortical myelination causes the brain size to increase dramatically, particularly in the first three years of life. The findings by Kuniyoshi et al. [11] indicated a clear correlation between typical First Language Acquisition (FLA) and a massive increase in brain growth caused by myelination (Fig. 3). According to these authors, speech in babies develops from babbling at around 6 to 8 months of age, to the one-word stage at 10 to 12 months, and then to the two-word stage around 2 years. These obvious developmental milestones of speech production are conditioned by prior speech sound perception which develops much earlier, within the first months after birth, with the myelination of the primary sensory (visual / auditory) and motor areas [11].

MRI studies have consistently found that myelination of language-related areas occurs in two stages: in infancy, and then again at adolescence [12]. Broca's and Wernicke's areas 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" [8]. Nitin Gogtay et al [7] illustrated (Fig. 4) the extent of the second stage of myelination at puberty.

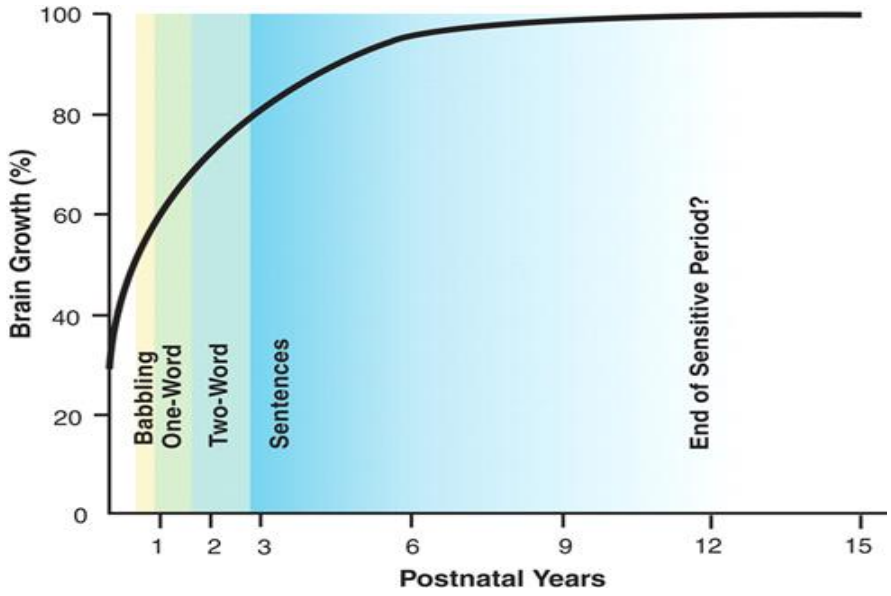

Fig. 3: Myelination, brain growth and first language acquisition (FLA). Human brain weight is presented as a function of age, where 100 on the ordinate correspond to the mean adult value (10). Approximate times of milestones in normal speech development are also indicated. {From*: Kuniyoshi et al*.} [11].

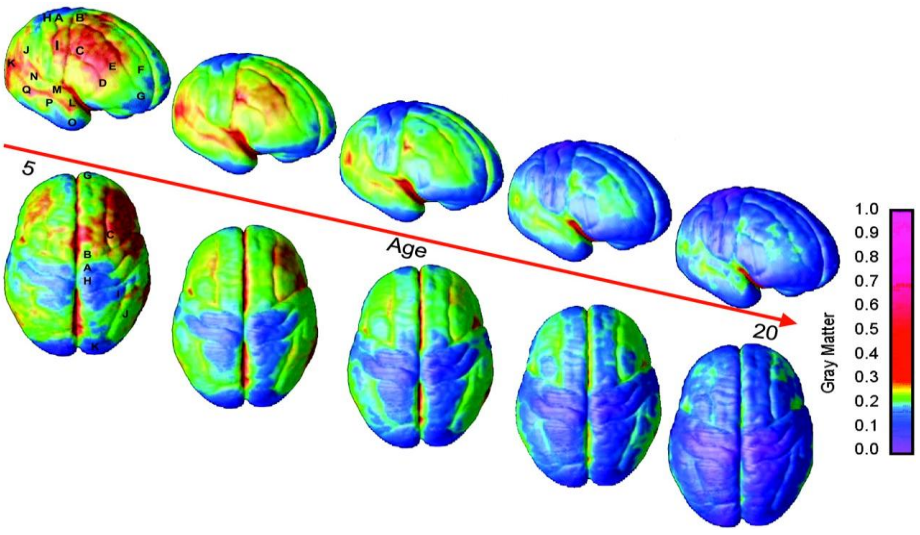

Fig. 4: Right lateral and top views of the dynamic sequence of Grey Matter (GM) maturation over the cortical surface. The side bar shows a color representation in units of GM volume. {From: *Nitin Gogtay et al*} [7]

These significant changes in the brain occur around the time when language acquisition outcomes begin to differ systematically; therefore, there must be a certain "correlation between the two" [8]. This correlation seems to prove the existence of a Critical / Sensitive Period, when humans can learn language with optimal ease [1, 2, 8]. The age constraints on language acquisition potential have been linked to brain maturation [8, 13]. It has been shown that myelin sheaths enveloping neuronal axons make long-distance signal transmission a hundred times faster, but that they also inhibit axons' ability to make short-distance connections with basal dendrites close to the cell body and local branches of the axons (axon "collaterals"). Thus, rapid myelination of the "language areas" at adolescence changes the neurobiological mechanism of Language Acquisition [13].

First Language Acquisition (FLA) relies on short-distance "local" connections between neurons within the "language areas" of the brain. Because those become unavailable as a result of myelination, the higher-order association areas in the frontal lobe become involved in SLA, and learning from direct input, or mere exposure, becomes ineffective. This change in connectivity, it has been argued [8; 13; 15; 17], removes the biological advantage children have in second language acquisition. These claims have attracted a lot of research interest to the issue of age constraints in SLA in recent years [11, 14], albeit with a focus mainly on Ultimate Attainment (UA) or 'native-likeness' in SLA after puberty [15 – 20].

Unfortunately, our new understanding of the biological foundations of language is yet to influence language education in multilingual societies. The logic of the prevailing view that "children learn better in their mother tongue" (MT) appears to be self-evident; supported by a large body of research [21 – 25] and promoted by UNESCO since 1953 [26], this relatively unquestioned principle has shaped language policy in many post-colonial multilingual societies, where Mother Tongue is widely viewed as the most effective language for literacy and learning throughout primary school [27].

In Papua New Guinea (PNG), Vernacular Education (VE) reform was enacted in 1995 [27]. By 2000, the national formal education system was providing instruction in kindergarten (the Preparatory Year) and Grades 1 and 2 (Elementary 1 and 2) in 380 national languages [27]. With the number of vernacular languages reportedly used in the first three years of formal education exceeding 430 by 2003, VE reform was viewed by UNESCO as an unqualified success, particularly because it allayed the "widespread popular fears that English-only education was alienating children from their cultures and

communities, and failing to prepare them to live and be active in their communities after schooling" [27].

With the rapid integration of PNG into the world economy, popular perceptions and expectations of what constitutes quality education, as well as the needs and demands of the national economy have also changed. Shortage of indigenous expertise in science and technology became an issue of government concern in PNG, prompting a major policy shift from Vernacular Education (VE) to Tuition Fee Free (TFF) Universal Basic Education (UBE) [28]. Designed to raise literacy levels and quality of education in the country, these policies gave hope to millions of Papua New Guineans who flooded the nation's classrooms with the desire to learn.

There is now better ACCESS to basic education, and higher RETENTION of students enrolled; however, the QUALITY index is still "low and steadily declining" [29]. Numerous descriptive studies have been conducted to assess the seriousness of the situation; "reports of national committees have been produced by commissions, external consultants, missions, workshops and seminars" [30]. Yet, few attempts to analyze the *causes* of this decline have been made in the context of the prevailing international opinion on the value of Mother Tongue (MT) use in the first three years of formal schooling. The UBE policy, introduced in 2013, is largely viewed as a step backward by Summer Institute of Linguistics (SIL) [21, 31 - 33] and international education consultants and agencies, including UNESCO.

Notwithstanding, there has been a profound shift in public opinion and parental expectations regarding the value of English in formal education, and questions started being asked about the effect of the delayed exposure to English (mandated by VE) on students' academic performance in secondary and tertiary education. Several studies, conducted by the Linguistics Department, School of Humanities and Social Sciences (SHSS) University of Papua New Guinea (UPNG) have established a significant inverse correlation between the Age of Onset (AO) of English learning and the academic performance of students in the six National High Schools (NHSs) of PNG [34 – 36]. A recent study, conducted at the UPNG in 2015, reported statistically significant relationship between UPNG students' Early Learning Language (ELL) backgrounds and their Grade Point Averages (GPAs) [37]. The authors suggested that a more detailed study should be carried out to reassess their findings.

The aim of the present study was to measure the influence of three factors in the linguistic backgrounds of students in the School of Humanities and Social Sciences (SHSS)

University of Papua New Guinea (UPNG) – the students' Age of Onset (AO) of English learning, their Age at Literacy (AGELIT), and their Early Learning Language (ELL) – on their academic performance, measured by the students' GPAs for the First Semester of the 2017 academic session.

Our main objective was to explore the possible causes of falling academic standards in SHSS UPNG and, thus, to help remedy the situation.

METHODOLOGY:

This study was carried out in the SHSS UPNG during the Second Semester of the 2017 academic session. A purposive cross-sectional sampling method was used for the selection of students. All the 966 full-time registered students in the SHSS during the 2017 academic session were eligible to participate in the study.

A self-designed pretested questionnaire, consisting of nine short questions was used to collect data on SHSS students' language education backgrounds, including their Age of Onset (AO) of learning English, Age at Literacy (AGELIT) and Early Learning Language (ELL).

The questions were as follows: *Your name and student Identification number (ID#)? Your gender? Your year of study? Your major in SHSS program? What was your first language spoken at home? How old where you when you learned to read and write? At what age did you learn English? In which Province did you learn to read and write? In what language did you learn to read and write? (Please tick the appropriate box: Vernacular-only, Tok Pisin mostly; English mostly)*.

Students' language education details were entered into Excel spreadsheets, coded, and matched with the respective students' GPAs for Semester 1, 2017, forming our final dataset. All data were then entered into SPSS Version 20 for Windows.

The continuous AO and AGELIT variables were separately transformed into three groups each (Early, Normal and Late). Descriptive statistics, comparison of means, correlation, linear regression, and nonparametric analyses were performed, as appropriate.

RESULTS:

Of the 966 questionnaires distributed, 507 (52.5%) were completed and returned. The 47.5% (459/966) non response rate was due to time constraints for data collection, as well as to logistical problems. The variables used for the statistical analysis of the data are presented in Table 1.

Table 1: Description of variables used in the statistical analysis

	Variables	Age (years)	Number of students (%)
1	AO	1 – 15	
2	AO groups: Early	1 – 5	90 (17.7%)
	AO groups: Normal	6 – 8	302 (59.6%)
	AO groups: Late	9 – 15	115 (22.7%)
3	AGELIT groups: Early	4 – 5	89 (17.5%)
	AGELIT groups: Normal	6 – 8	303 (59.8%)
	AGELIT groups: Late	9 – 15	115 (22.7%)
4	ELL: English		338 (66.6%)
	ELL: Tok Pisin		120 (23.7%)
	ELL: Vernacular		34 (6.7%)
	ELL: TokPisin – Eng		14 (2.8%)
	ELL: Vernacular – Eng		1 (0.2%)
5	GPA	Mean GPA = 2.40	Highest GPA = 4.67 Lowest GPA = 0.25

The research questions and hypotheses were as follows:

Q 1: Does the AO of learning English affect SHSS students' academic performance?

1st H_0: AO has no effect on SHSS students' GPAs.

Q 2: Does SHSS students' AGELIT affect their academic performance?

2nd H_0: SHSS students' AGELIT has no effect on their GPAs.

Q 3: Does the ELL affect SHSS students' academic performance?

3rd H_0: ELL has no effect on SHSS students' GPAs.

Various statistical tests were performed; comparisons of means, ANOVA, correlation and linear regression analyses, with the aim of measuring the strength of association between each of the three predictors (AO, AGELIT and ELL) and the students' GPAs obtained during the first semester 2017 academic session. Non-parametric tests were run to verify the validity of the null hypotheses.

For ANOVAs, the continuous variables AO and AGELIT were transformed into three categories each:

The AO variable was transformed into 3 AO Groups (AOG): Early (AO: 1-5 years); Normal (AO: 6-8 years); and Late (AO: 9-15 years).

Of the 507 students, 90 (17.7%) were in the Early AO group, 302 (59.6%) in the Normal AO

group and 115 (22.7%) in the Late AO group (Table 1).

The AGELIT variable was also transformed into three AGELIT Groups: Early (4 – 5 years); Normal (6 – 8 years); and Late (9 – 15 years). AGELIT Group distribution amongst the 507 student responders is presented in Table 1.

For Linear regression analyses, the AO and AGELIT were used as continuous variables, in line with Vanhove's recommendations [14].

Table 1 also shows the distribution of the Early Learning Language (ELL). Out of 507 students, 338 (66.6%) had done their elementary schooling in English; 120 (23.7%) were taught in TokPisin; 34 (6.7%) were taught in Vernacular; 14 (2.8%) were taught in a mixture of English and TokPisin, and just one student (0.2%) had been taught in both Vernacular and English. The mean GPA for all the 507 students was 2.40, the highest was 4.67 and the lowest was 0.25.

Tests of 1st H_0 validity:

Comparison of Means

The mean GPA values for the AOG Early, AOG Normal and AOG Late were 3.00 ± 0.53, 2.52 ± 0.53, and 1.59 ± 0.45, respectively. The mean GPA for the AOG Late was significantly lower ($p = 0.000$) than that for the Early and Normal AO groups. The GPA for the Normal AO group was significantly lower ($p < 0.05$) than that for the Early AO group.

Further analysis, using One-way ANOVA, was carried out to compare the mean GPA between the groups and within groups. The results attest to the statistically significant ($p = 0.000$) variance in the mean GPA values in AOG.

R Squared (0.428) and Eta Squared (0.455) values, the Measures of Association between AOG*GPA, show a medium effect size, indicative of a significant mean GPA variation between the AO Groups

Fig. 5 illustrates the decline in the mean GPAs between the Early, Normal, and Late AO Groups, pointing to a robust *causal* link between students' AO and their academic performance.

Thus, comparison of means and ANOVA showed a medium strength association (Eta Squared = 0 .455) between AOG and GPA variables, indicating a significant inverse correlation between the age when the students started learning English, and their academic performance at UPNG.

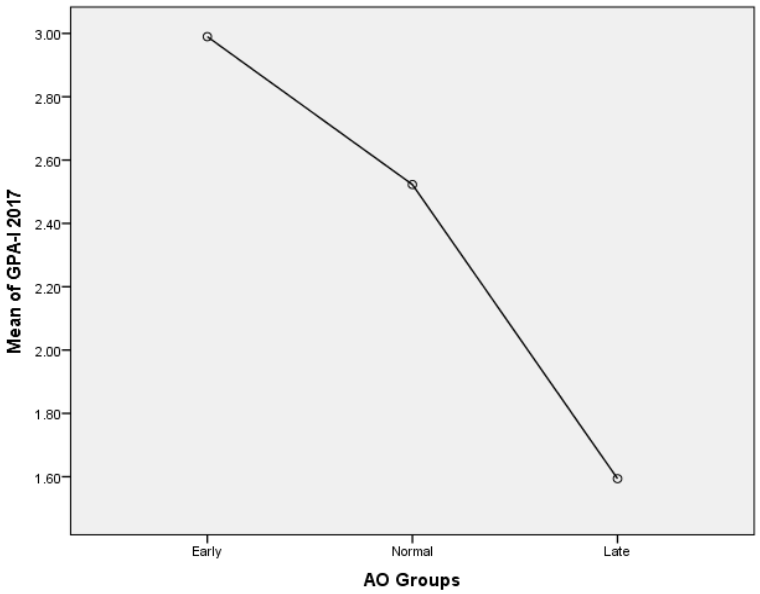

Fig. 5: Means Plot (one-way ANOVA). Age of Onset Groups GPA

Table 2. Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	3.608	.088		41.050	.000	3.436	3.781
	AO	-.168	.012	-.541	-14.448	.000	-.191	-.145

a. Dependent Variable: GPA-I 2017

Nonparametric analysis revealed a strong negative correlation (rho = – 0.683, p = 0.000, 2-tailed) between the AOG and GPA variables. The Pearson correlation analysis gave a similar result.

Linear Regression analysis corroborated these findings. The results show that AO had a statistically significant effect size (R Square = 0.292, adjusted R square = 0.291) on students' GPAs.

An increase in AO reduces the English score, as shown in Table 2.

In terms of elasticity, an increase in AO by one year results in 1.68 % decrease in students' GPA (p=0.000).

Nonparametric Tests of 1st H_0 Validity:

Since the AOGs were of unequal sizes, nonparametric tests were carried out; they established highly significant (p = 0.0001) differences in GPA distribution across AOG categories.

Independent-Samples, Kruskal-Wallis test were used to test the null hypothesis, *"that the distribution of GPA is the same across categories of AO groups"*. The decision was to "Reject the null hypothesis", the significance was p = 0.000.

Thus, our 1st H_0: "*AO does not affect SHSS students' GPAs*" had to be rejected, and the alternate 1st H_1: "*AO significantly affects SHSS students' GPAs"* was accepted.

Tests of 2nd H_0 validity**:**

The mean GPA for the AGELIT Early, Normal and Late groups were 3.10 ± 0.51, 2.52 ± 0.58, and 1.86 ± 0.63, respectively. The mean GPA for the AGELIT Late was significantly lower (p = 0.000) than that for the Early and Normal AGELIT groups. The GPA for the Normal AGELIT group was also significantly lower (p <0.05) than that for the Early AGELIT group.

Further analysis using One-way ANOVA was carried out to compare the mean GPA between the groups and within groups.

The mean GPA for AGELIT Early, AGELIT Normal, and AGELIT Late Groups fell steadily from 3.09, to 2.52, and to 1.86, respectively. The effect size (Eta Squared = 0.279) of AGELIT on GPA between the groups is statistically significant (p = 0.000).

Comparison of means and ANOVAs showed considerable strength of association (Eta Squared = .279) between AGELIT and GPA variables, indicating a significant inverse correlation between the students' age at literacy and their academic performance at SHSS UPNG.

Nonparametric analysis revealed a strong negative correlation (rho = – 0.533, p = 0.000, 2-tailed) between AGELIT and GPA variables. The Pearson correlation analysis gave a similar result. These findings were corroborated by Linear Regression analysis. The results show that AGELIT had a statistically significant effect size (R Square = 0.278, adjusted R square = 0.276) on students' GPAs.

An increase in AGELIT was found to reduce the GPA score. In terms of elasticity, an increase in AGELIT by one year results in a 0.63% decrease in students' GPA (p = 0.000).

Nonparametric Tests of 2nd H_0

Independent-Samples, Kruskal-Wallis test were used to test our second null hypothesis, that: *"the distribution of GPA is the same across all categories of AGELIT groups"*. The decision

was to "*Reject the null hypothesis*", the significance was p = 0.000.

Therefore, we had to reject our $2H_0$ (that AGELIT does not affect SHSS UPNG students' GPAs), and accept the alternate 2nd H_1: "AGELIT significantly affects SHSS students' academic performance."

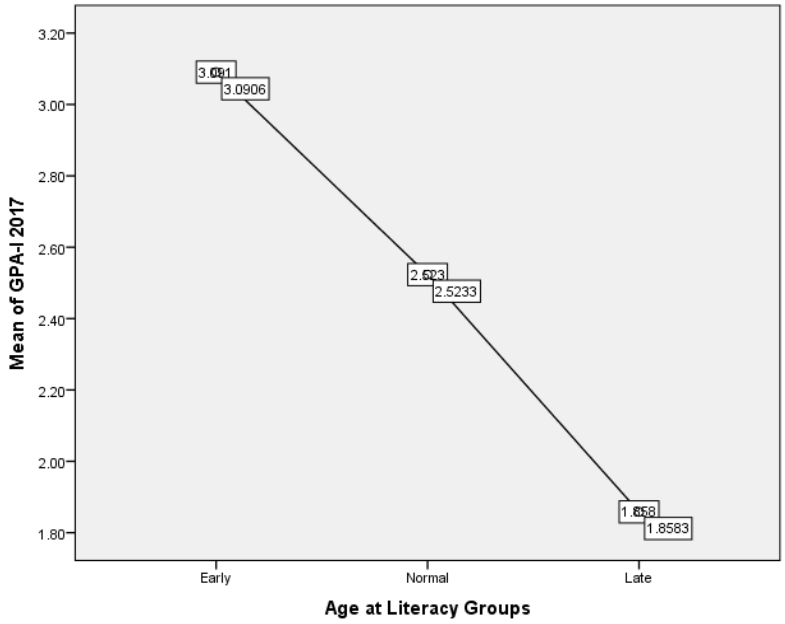

Fig. 6: Means Plot (one-way ANOVA). AGELIT Groups * GPA

Table 3: Mean GPA scores for Early Learning Language (ELL)

ELL	Mean GPA	Std. Deviation	N (%)
English	**2.52**	0.68	338 (66.7)
TokPisin	**1.99**	0.63	120 (23.7)
Vernacular	2.32	0.49	34 (6.7)
TP-Eng	2.98	0.51	14 (2.8)
V-Eng	2.50		1 (0.2)

Tests of 3rd H_0 validity**:**

The mean GPA for ELL English (2.52 ± 0.68) is higher than that for the other ELLs, except for ELL TP-Eng (2.98 ± 0.51). Since there were only 14 students in the TP-Eng category, however, this result is not statistically significant (Table 3). The Eta squared value was 0.124.

The ELL distribution in Table 1 shows that 66.6% (338/507) of the students that participated in the study reported English as their ELL. This, in itself, is an index of higher academic achievement by students who had been taught literacy in English during the time of predominantly Vernacular Education. ELL English students' mean GPA was 2.52 ± 0.68 compared to GPA of 1.99 ± 0.63 for those with ELL Tok Pisin (Table 2). GPA values for the relatively few students with ELL Vernacular, ELL Tok Pisin + English, and Ell Vernacular + English were not statistically significant, because of their small population sizes.

The GPA results indicate that SHSS students with ELL English outperform those with ELL Tok Pisin. It also shows that students with ELL Vernacular perform better than those with ELL Tok Pisin.

To verify these assumptions, and to measure the ELL effect on students' GPAs, a series of bivariate correlation analyses were carried out, examining the link between ELL English and GPAs, ELL Tok Pisin and GPAs, and ELL Vernacular and students' GPAs. For that purpose, the categorical variable ELL was transformed into five independent variables (Table 1). Three of them were further analysed: ELL English, ELL TokPisin, and ELL Vernacular. The Spearman's rho correlation of coefficient shows statistically significant linear correlation (rho = 0.318, p = 0.000, 2-tailed) between the GPA and ELL English. A statistically significant inverse correlation (rho = – 0.326, p = 0.000, 2-tailed) was shown between GPA and ELL TokPisin. A weak non-statistically significant inverse correlation (rho = – 0.028, p =0.532, 2-tailed) was shown between GPA and ELL Vernacular.

The contrast between ELL English and ELL TP is evident; with Spearman's rho correlation coefficients of 0.318 and -0.326, respectively, these results show that students with ELL English do much better in the SHSS UPNG than those with ELL TP.

In order to rule out multi-collinearity issues, we first ran a series of collinearity diagnostic tests which established the absence of collinearity between the three predictors (ELL English, ELL TokPisin and ELL Vernacular). Linear Regression analyses, run to determine how each of the three independent variables (ELL English, ELL Tok Pisin, and ELL Vernacular) affected the students' GPAs, also corroborated the correlation results.

The Beta coefficients represent the rate of change in GPA as a function of each predictor ELL. Our results show that ELL English increased students' GPAs by 0.46%. Standardized coefficients Beta = 0.309, p = 0.000.

The ELL Tok Pisin decreased student's GPAs by 0.52%. Standardized coefficients Beta = –0.32, p = 0.000. This means that the GPA of students with ELL English backgrounds is likely to be higher than that of students with ELL Tok Pisin backgrounds by as much as 0.98%.

ELL Vernacular group size (N=34) was too small to produce statistically significant results. The low proportion (relatively small number) of SHSS students with ELL Vernacular backgrounds may be due to either poor implementation of the Vernacular Education policy, to a negative effect of using ELL Vernacular, or to both.

The Linear Regression results, therefore, indicate that ELL English benefits the students most, as it gives them those English skills they need in order to do well at all subsequent stages of their formal education.

Nonparametric Tests of 3rd H_0 validity:

The nonparametric tests of the 3rd H_o validity corroborated our linear regression findings.

Independent-Samples, Kruskal-Wallis test were used to test our third null hypothesis, that: *"the distribution of GPA is the same across categories of ELL"*. The decision was to "*Reject the null hypothesis*"; the significance was p = 0.000.

Therefore, we had to reject the 3rd H_0 and accept the alternate 3rd H_1: That the distribution of GPAs is not the same across categories of ELL.

DISCUSSION:

The results of our data analysis, therefore, support the following broader conclusions:

AO has a significant inverse effect on SHSS students' GPAs:

English proficiency is a prerequisite for comprehension of course content in all academic subjects taught at Primary, Secondary, and Tertiary levels of education; consequently, AO is strongly linked to students' overall performance. The established inverse correlation between AO and SHSS UPNG students' GPAs suggests that the earlier the students began to learn English, the better they do at UPNG. Delayed exposure to English, mandated by the Vernacular Education policy, appears to have inhibited the students' general academic potential, ultimately reducing the quality of their education at all post-elementary levels.

UBE Syllabus 2015 offers only 1 hour of English learning a day (5 hours a week) in the 4 years of Elementary school [28]. This is insufficient for effective acquisition of English skills. Though the normal age for enrolment into Elementary school in PNG is six years, our results indicate that students will perform better, if they start learning English in pre-school, before the age of six. There is a strong link between students' AO and their GPAs;

therefore, the earlier students are taught English, the better.

AGELIT has a significant inverse effect on SHSS UPNG students' academic performance: There is a strong link between students' Age at Literacy (AGELIT) and their GPAs. English Literacy is the tool that students in Papua New Guinea must use at all post-elementary levels of education. The Age factor impacts all aspects of language education; if children are not taught to read and write in early childhood, their learning potential is likely to decrease. Therefore, students will benefit most, if they acquire English literacy skills in Elementary Prep or earlier, before they enrol into Primary school. Apart from potentially promoting learning among primary school pupils, this would also reduce the work burden of primary school teachers, and allow them to focus more on the actual content of the subjects they teach.

GPA distribution is not the same across categories of ELL:

The mere fact that 66% of all SHSS students had English ELL speaks for itself: the 'survival of the fittest' principle applies equally in education. The under-representation of ELL Vernacular students in the wake of the Vernacular Education 'era' is not less telling: only 7% of SHSS students in 2017 had ELL Vernacular backgrounds. This could be explained by the lack of qualified teachers and teaching resources in Vernacular languages, as well as by the fact that many of the indigenous vernacular languages of Papua New Guinea are still exclusively oral. ELL Tok Pisin background students (24% of the school population) had the lowest GPAs; the reasons for this should be further investigated. It is clear, however, that students with English ELL perform significantly better than those with Tok Pisin ELL. Therefore, it seems equally clear that children should be taught to read and write in English, and not in Tok Pisin.

We are acutely aware of the complexity and interrelatedness of all the socio-economic and cultural factors impacting on the quality of education. Government action is required to ensure quality teacher training and adequate support of the teaching and learning processes in all schools. However, our findings have reliably established a causal link between three of many other interrelated factors (AO, AGELIT, ELL) and students' academic performance. Students will do better at all levels of education, if they acquire English skills in early childhood – the earlier, the better. Despite our stated support for bilingual education, these findings seem to contradict the current emphasis on MT education, stressed in most unequivocal terms in the recent UNESCO guidelines and recommendations [38]:

"UNESCO emphasizes the central role of mother tongue instruction in achieving quality

Education for All and affirms research demonstrating that use of L1 is crucial to effective learning in school. At the same time, UNESCO has a stated commitment to the use of "multilingual education" to support full participation in the regional, national, and global economies and social worlds. These position statements should not be misconstrued to mean that UNESCO accepts 'short cut' transition or transfer programmes into L2; rather, UNESCO advocates for the fundamental role of literacy and academic proficiency in L1 as the foundation of academic success in any language. UNESCO holds that children ought not to be compelled by language-in-education policies to sacrifice their right to develop L1 in favour of acquiring a majority language. 'Short cut' transition programmes tend to result in subtractive bilingualism. UNESCO works to raise awareness of the need to support children in becoming fully literate and highly proficient in their first language to create a foundation for the acquisition of additional language(s)" [38].

"Clarify the number of years required to become proficient in a language:

Creating a strong linguistic foundation typically requires at least six years of formal schooling in L1 as the medium of instruction. Current research calls for a revision of UNESCO's guideline of providing mother tongue instruction up to age 6 to 8 years, pointing instead to the need for mother tongue instruction up to primary year 6 or 8" [38].

Most research in MT/Vernacular education has been descriptive, however; we have not come across any other study, conducted in PNG or elsewhere, with similar aims, objective and design; therefore, it is difficult to compare our findings with literature that informs UNESCO educational guidelines.

CONCLUSIONS:

The results in the present study have produced concrete and unequivocal evidence of a strong causal link between three predictor variables (the age at which those SHSS students that participated in this study had started learning English (AO); the age at which they learned to read and write (AGELIT); and ELL, the language of instruction in their elementary schools) and the dependent variable, the students' Semester 1, 2017 GPAs (these provide an objective measure of their overall academic performance). Our findings show that students' academic performance is likely to be higher, if they start learning English and acquire English literacy skills at a younger age (English is the language of instruction in all schools, colleges and universities in Papua New Guinea).

The Universal Basic Education (UBE) Elementary English syllabus 2015 [39] offers 1 hour of English learning a day (5 hours per week) in elementary school. This is certainly not enough for children to acquire the English skills they need at later stages of formal education. Compounded by the consequences of inadequate teacher education, the lack of focus on teaching English from Elementary Prep onwards results in students' low academic performance at primary, secondary, and tertiary levels of education. For too long, language

education policy in developing multilingual societies has been influenced by Appeal to Emotion (i.e., language is "the shrine of a people's soul" [40]). In the face of complex new socio-economic realities, it is high time that education policy be informed by our deepened understanding of brain development, and the effect of students' AO of SLA on their ability to obtain quality education.

REFERENCES:

1. Penfield W. and L Roberts. Speech and Brain Mechanisms. Princeton 1959; Princeton University Press.
2. Lenneberg, E. H. Biological Foundations of Language. Wiley. 1967; ISBN 0-89874-700-7
3. Vygotsky, L. Consciousness as a problem in the psychology of behaviour. 1925 www.marxists.org/archive/vygotsky/works/1925/consciousness.htm
4. Vygotsky, Lev. Thought and Language, trans. Alex Kazulin. 1986; The MIT Press, Massachusetts.
5. Friederici, A. Current Opinion in Neurobiology 2013; 23: 250–254.
6. Friederici, A. and S Gierhan. The language network. Current Opinion in Neurobiology 2013, 23:250–254. https://doi.org/10.1016/j.conb.2012.10.002
7. Nitin Gogtay, J. N. Giedd, L. Lusk, K. M. Hayashi, D. Greenstein, A. C. Vaituzis, T. F. Nugent III, D. H. Herman, L. S. Clasen, A. W. Toga, J. L. Rapoport, and P. M. Thompson. Dynamic mapping of human cortical development during childhood through early adulthood PNAS May 25, 2004. 101(21)8174-8179; www.doi.org/10.1073/pnas.0402680101
8. Hyltenstam K. and N. Abrahamsson. Maturational Constraints in SLA, in The Handbook of Second Language Acquisition (eds CJ Doughty and MH Long), 2003; Blackwell.
9. Mayberry R. and R. Kluender. Rethinking the critical period for language: New insights into an old question from American Sign Language. Bilingualism: Language and Cognition: pp. 1-20 Cambridge University Press 2017 doi:10.1017/S1366728917000724
10. Berwick and Chomsky. 2016. Why Only Us: Language and Evolution. The MIT Press Cambridge, Massachusetts.
11. Kuniyoshi L. Sakai, et al. Language Acquisition and Brain Development. Science: Vol. 310, Issue 5749; 2005 pp. 815-819
12. Blakemore and Choudhury. Development of the adolescent brain: implications for executive function and social cognition. J Child Psychol Psychiatry. 2006 Mar-Apr; 47(3-4): 296-312.
13. Pulvermüller, F. and J H Schumann. Neurobiological Mechanisms of Language Acquisition. Language Learning, 1994; 44: 681–734. doi: 10.1111/j.1467-1770.1994.tb00635.x
14. Vanhove, J. 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.
15. DeKeyser, R. M. Age effects in second language learning. In S. M. Gass and A. Mackey (Eds.), The Routledge handbook of second language acquisition 2012, (pp. 442–460). London: Routledge.
16. DeKeyser, R. M. Interactions between individual differences, treatments, and structures in SLA. Language Learning, 2012; 62 (Supplement 2), 188–199.
17. DeKeyser, R. M., and J. Koeth. Cognitive aptitudes for second language learning. In E. Hinkel (Ed.), Handbook of research in second language teaching and learning. 2011; Vol. 2, pp. 395–406. London: Routledge.
18. DeKeyser, R. M., and J Larson-Hall. What does the critical period really mean? In J.

F. Kroll and A. M. B. de Groot (Eds.), Handbook of bilingualism: Psycholinguistic approaches (pp. 89–108). 2005; Oxford, UK: Oxford University Press.

19. Dekeyser, R., Alfi-Shabtay, I. and D Ravid. Cross-linguistic evidence for the nature of age effects in second language acquisition. Applied Psycholinguistics, 2010; 31: 413–438.
20. DeKeyser, R.M. Age Effects in Second Language Learning: Stepping Stones Toward a Better Understanding. Language Learning; 2012; ISSN 0023-8333.
21. Kosonen, K. Education in local languages: Policy and practice in Southeast Asia. First languages first: Community-based literacy programmes for minority language contexts in Asia. 2005; Bangkok: UNESCO Bangkok.
22. Benson, C. The importance of mother tongue-based schooling for educational quality. Background paper prepared for the Education for All Global Monitoring Report 2005. The Quality Imperative.
23. Hovens, M. Bilingual education in West Africa: Does it work? International Journal of Bilingual Education and Bilingualism. 2002; 5: 5, 249-266.
24. Bialystok, E. and K Hakuta. Confounded Age: Linguistic and Cognitive Factors in Age Differences for Second Language Acquisition. 1999; Ch. 7 in Birdsong, D. (Ed.).
25. Cummins, J. Language, Power and Pedgogy: Bilingual Children in the Crossfire. 2000; Clevedon: Multilingual Matters.
26. UNESCO. The use of the vernacular languages in education. Monographs on Foundations of Education,No.8.Paris:UNESCO1953.http://unesdoc.unesco.org/images/0000/000028/002897EB.pdf
27. UNESCO. Mother Tongue Matters: Local Language as a Key to Effective Learning. Paris: UNESCO. 2008c. http://unesdoc.unesco.org/images/0016/001611/161121e.pdf
28. Achieving Universal Education for a Better Future: Universal Basic Education Plan 2010 - 2019 National Executive Council December 2009; www.education.gov.pg/quicklinks/documents/ube-plan-2010-2019.pdf
29. Devete-Chee, K. and P. M. Magury. The Current State of Education in Papua New Guinea. 2017 NRI Blog: www.pngnri.org/the-current-state-of-education-in-papua-new-guinea-some-facts-and-figures-on-access-and-quality-of-education/
30. Baptiste, L. A challenge for DWU's administrative leadership to facilitate students' proficiency in English. Contemporary PNG Studies: DWU Research J, Vol. 16, 2012, pp. 79-92.
31. Litteral, R. Language development in Papua New Guinea. SIL Electronic Working Papers 1999-002. S.l.: 13. www.sil.org/resources/publications/entry/7832
32. Litteral, R. Language and education in Papua New Guinea. Workpapers in Papua New Guinea Languages 24. Ukarumpa: Summer Institute of Linguistics. 1978; Pp. 15-23.
33. Litteral, R. Vernacular education in Papua New Guinea. Background paper prepared for the Education for All Global Monitoring Report 2005. The Quality Imperative.
34. Temple O., Ezebilo, E., Hane-Nou G., and S. Kamene. The earlier PNG kids learn English, the better they do in school. PNG NRI BLOG (submitted for publication in Oct 2017) https://pngnri.org/blogs-2/
35. Temple, O., G. Hane-Nou, S. Kamene and E. Ezebilo. Effect of early language education on the academic performance of National High School (NHS) students in Papua New Guinea. LLM Vol. 35, 2017 (pp. 177-198).
36. Temple, O., Kamene, S., Guldan, G., & Maito M. Effect of Early Language Education on Students' Academic Performance: the POMNATH case study. Proceedings of the LSPNG 2016

International Conference in Ukarumpa,EasternHighlands Province, Papua New Guinea, pp.52-79. www.langlxmelanesia.com/Temple_LSPNG % 20 Proceedings % 202016% 20FV.pdf

37. Temple, O., Dalsgaard, S. & Kamene, S. Effect of Early Language Education on UPNG Students' Academic Performance. LLM Vol. 33(2), 2015, pp. 77-92. www.langlxmelanesia.com
38. UNESCO Enhancing Learning of Children from Diverse Language Backgrounds: Mother Tongue-Based Bilingual or Multilingual Education in the Early Years; Recommendations for UNESCOPolicyGuidelines,2011;50-56. www.unesdoc.unesco.org/images/0021/002122/212270e.pdf
39. Elementary English Syllabus 2015 www.education.gov.pg/quicklinks/elementary-syllabus/English.pdf

40. G.J. Platten. The Use of Vernacular Languages as Vehicles of Instruction Both in School and Out of School and the Related Problems of Teaching in Languages Other Than the Vernacular in the South Pacific. UNESCO 1951.