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DOES THE AGE OF ONSET OF LEARNING ENGLISH (AO) AFFECT STUDENTS' ACADEMIC PERFORMANCE IN THE UNIVERSITY OF PAPUA NEW GUINEA?

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ABSTRACT:
Our previous studies established a negative correlation between students' Age at Onset of learning English (AO) / Age at Literacy (AGELIT) and their academic performance in all of the six National High Schools (NHSs) of Papua New Guinea, as well as in the University of Papua New Guinea (UPNG). Lower academic achievement was also associated with Early Learning Languages (ELLs) other than English, such as Tok Pisin or Tok Ples. The current study widens the scope of enquiry in terms of university-wide survey coverage and greater sample size (N = 2001). The relationship between UPNG students' language education backgrounds and their 2018 GPAs was analysed, using SPSS 20 and the Microsoft Excel Data Pack 2010. Our findings showed a significant negative relationship between AO and students' academic achievement – a year's increase in AO reduced the GPA by 0.208 grade points ($p < 0.001$). ELL Tok Pisin (ELL TP) reduced the students' GPA by 0.343 points, while ELL TPENG (Tok Pisin + English) – by 0.297 grade points, compared to ELL English ($p < 0.001$). Multiple regression analysis also showed that the academic achievement of students with ELL TP, ELL V, and ELL TPENG was significantly lower than that of students with ELL ENG. We conclude that these results corroborate our previous findings, and highlight the malleability of the developing brain during the critical 'windows of opportunity' in early childhood. We contend that early childhood education initiatives can yield enormous educational and social benefits for Papua New Guinea.

Keywords: Second Language Acquisition (SLA), Critical Period Hypothesis (CPH), age factor, Early Childhood Education (ECE), sensitive periods, biological foundations of language, Vernacular and English (VENG), Vernacular and Tok Pisin (VTP), Vernacular, Tok Pisin and English (VTPENG)

INTRODUCTION:

Half a century after Lenneberg [1] first linked "L2 learning difficulties in adulthood with hemispheric functional specialization and declines in plasticity that constrain primary language acquisition," the effect of age on language acquisition has been examined in hundreds of studies [2]. (L2 = second language). In recent years, neuroimaging technologies, and particularly functional magnetic resonance imaging (fMRI), have yielded remarkable insights into the workings of

living and developing human brains. As revealed by fMRI studies, "language processing is impossible without an efficient transfer of information between various language-supporting regions in separate parts of the brain" [3]. Postnatal development gradually 'wires' these separate language-relevant brain regions into one system, the 'language network' [4]. Robert C. Berwick and Noam Chomsky, referencing Perani's diffusion tensor imaging MRI (dMRI) study [5; 6], elaborated on how these fiber tracts, absent at birth, mature over time, until thick bundles of myelinated axons form a complete 'ring,' enabling syntactic processing and other forms of efficient Prefrontal Synthesis (PFS) [4].

Myelination and the formation of perineuronal nets (co-incident with the closure of critical periods) rapidly increase the brain size, particularly in the first three years of life [5; 7; 8; 9]. By twelve months, the primary sensory and motor areas are myelinated, which enables the integration and processing of sensory (visual and auditory) signals and motor functions, necessary for language acquisition. Shaped by early experience, the neural circuits are laid in place in the course of a "cascading sequence of multiple, overlapping periods of plasticity that enable the development of phonetic perception in the native language, starting with discrimination of linguistic sounds in the first few months of infancy through the structuring of word forms and phonological categories as children approach 20 months of age" [10; 11]. Early experiences "wire" the brain, literally building the infrastructure required for further development – Donald Hebb, whose phrase "Neurons that fire together, wire together" succinctly describes how pathways in the brain are formed and reinforced through repeated stimulation [12].

The existence of biological constraints with regard to First Language Acquisition (FLA) is indisputable; however, debate still rages over whether age is a significant factor in Second Language Acquisition (SLA). A leading authority in SLA and bilingualism, David Birdsong, has given one of the most comprehensive accounts of current Age at Onset of learning English (AO) in SLA research in his review article "Plasticity, Variability and Age in Second Language Acquisition and Bilingualism" [2]. In it, he outlines two neurobiological explanations for plasticity deficits over age:

- The "use it, then lose it" model: "after adolescence, the circuitry that is required for language learning is dismantled, because in adulthood there remains no selection pressure on humans to keep learning languages and the metabolically greedy neural systems that subserve language learning" [13; 14; 2].
- Myelination, which "insulates axons for efficient transmission of electrical impulses, but does so at the cost of

reducing the synaptic plasticity required for new learning" [15;16; 2].

These two explanations are, of course, interrelated and equally valid for FLA – in the absence of 'wiring' (a product of myelination) to integrate audio-visual signals and motor functions into one 'language circuit,' no human language is possible.

After a brief account of current research findings on the nature and mechanisms of the cascading and overlapping critical periods in FLA, Birdsong focuses on SLA, and the variability in SLA outcomes, as reported in a number of studies [17; 18]. On the question of age-conditioned plasticity in L2 learning, many of these studies reported significant AO effects on L2 attainment (i.e., Veríssimo et al. [18], who observed native-like priming for inflected German participle forms only when the study participants' learning began in early childhood, before the age of 5 years). So, while admitting that AO "is commonly employed as a predictive factor for learning outcomes in training studies," Birdsong looks at "variability and plasticity with respect to their underlying sources, and at age as a modulating factor in variability and plasticity." In terms of ultimate attainment (UA) in SLA classroom context, AO is indeed merely a 'meta-variable,' with a multitude of other important dimensions to explore (i.e., "critical period effects vs. bilingualism effects, early and late bilingualism, native-like and non-native-like L2 attainment, cognitive aging, individual differences in learning, and linguistic dominance in bilingualism").

Birdsong's review of current research into AO effects on L2 UA cites insights gleaned from studies in the context of classroom foreign language instruction/immigration into Western countries. Very little research has been done in multilingual developing nations where the so-called "foreign" languages (English, French, or Spanish/Portuguese) are no longer foreign - they are "owned" and used as the medium of instruction. The future socio-economic progress of these nations depends on their ability to produce home-grown quality human resources (HR). This, in turn, is predicated on the students' ability to learn in a so-called "foreign" language. This important practical distinction in SLA research has little relevance in the Western world and has, therefore, been of no concern to Western researchers, as is evident from Birdsong's review. That is why his concluding statement totally ignores this perspective:

"By demonstrating the connectedness of non-uniform outcomes with age and plasticity, the research reviewed here has shown that such variation is neither unexplainable nor unexpected. From this understanding, emerges heuristic guidance for further explorations of the richness of L2 acquisition and bilingualism" [2].

The findings in our studies so far have established a robust inverse correlation between students' age at onset of learning

English (AO) and their academic achievement in high school and university:

In 2015, the study conducted among students in the UPNG [19] revealed that, despite Vernacular Education practiced at the time, ELL Vernacular (ELL V) students were disproportionately underrepresented in all five schools, while ELL Tok Pisin (ELL TP) students' performance was far below that of ELL English and ELL V students.

In 2016, the study among students in the Port Moresby National High School (POMNATH) [20] established a significant inverse correlation between high school students' AO/AGELIT and their academic scores. ELL English students constituted the most numerous group of POMNATH students, and their mean academic grades were higher than those in other ELL groups.

In 2017, our survey of all six National High Schools (NHSs) of Papua New Guinea [21] found that AO increase by one year corresponded to a 1.37% decrease ($p < 0.001$) in students' academic scores.

Our studies in 2017 and 2018 among students in the School of Humanities and Social Sciences (SHSS) UPNG [22; 23] also established the negative impact of AO on the GPA of students.

These findings show that, in PNG, those who start learning English younger, fare better in high schools and university. The present study, which is a follow-up on our first UPNG survey in 2015, aims to give resonance to Hensch's recommendation, made over fifteen years ago: "An understanding of the neural basis of critical/sensitive periods of brain development should inform not only educational policy, but also clinical therapy and strategies for improved learning into adulthood" [8].

Research Questions and Hypotheses:

This study aimed to explore the impact of AO and ELLs on students' academic performance in UPNG. Our research questions addressed the relationship between students' AO/ELL and their academic performance, measured by their 2018 GPAs.

Our null hypotheses assumed no relationship between these factors and the students' GPAs.

METHODOLOGY:

The detailed methodology is presented in earlier studies [19, 20, 21]. During the 2019 academic year, a survey, using purposive cross-sectional sampling method, was carried out in all five schools of UPNG: SHSS, School of Natural and Physical Sciences (SNPS), School of Business and Public Policy (SBPP), School of Law (SOL), and School of Medicine and Health Sciences (SMHS). All full-time registered students were eligible to participate in the study. A self-designed, pretested, self-administered questionnaire yielded data on students' language education backgrounds (AO and ELL). The GPA for each of the students for the 2018 academic year was obtained by special request and permission from the

appropriate authorities in the UPNG Administration.

Students' responses were entered into Excel spreadsheets, coded, and matched with their respective GPAs, forming our final dataset. The SPSS software version 20 for Windows was used to conduct quantitative analysis. Normality of the data was assessed by the Shapiro-Wilks tests. Independent-Samples Mann Whitney U was used to determine differences between groups. Descriptive statistics, comparisons of means, nonparametric correlations, Ordinary Least Squares (OLS) and multiple regression models with bootstrapping were used as appropriate.

RESULTS:

Of the 3,918 questionnaires distributed, 2001 (51.1%) were completed and returned. This gave a non-response rate of 48.9%, which is lower than the 61.0% non-response rate obtained in our earlier study [19]. The high non-response rate was due to voluntary participation on the part of the students, and to some logistical and administrative issues.

Gender distribution:

Of the 2001 students that consented to participate in this study, 798 (39.9%) were female, and 1203 60.1%) were male. The Gender Parity Index (GPI) was 0.66 (789/2001), which is a slight improvement on the GPI of 0.60 obtained in earlier study [19].

Location of students' elementary schools:

The students were separated according to the location of the elementary schools they went to. The results are illustrated in Figure 1. Out of the 2001 students, 392 (19.6%) received their elementary schooling in Port Moresby (POM), 234 (11.7%) in Western Highlands Province (WHP), 177 (8.8%) in Morobe, 137 (6.8%) in Enga, 134 (6.7%) in Eastern Highlands Province (EHP), 121 (6.0%) in Southern Highlands Province (SHP), and 104 (5.2%) - in East Sepik Province (ESP). A few students received their elementary schooling outside of PNG: 13 schooled in the Solomon Islands (SI), 12 in Samoa, 7 in Australia (AUS), 5 in Indonesia and one in the USA. They represent only 1.9% of our sample population.

Home Language (L1) distribution:

The 2001 students were distributed according to their home language (L1). L1 for 958 (47.9%) students was Tok Pisin (TP); Vernacular was L1 for 538 (26.9%) students; both Tok Pisin and English (TPENG) were home languages for 188 (9.4%) students; L1 for 35 (1.7%) students was English (ENG); 30 (1.5%) students spoke both Vernacular and English (VENG) at home. 142 (7.1%) used both Vernacular and Tok Pisin (VTP), and 110 (5.5%) used a mix of all three languages (TPVENG).

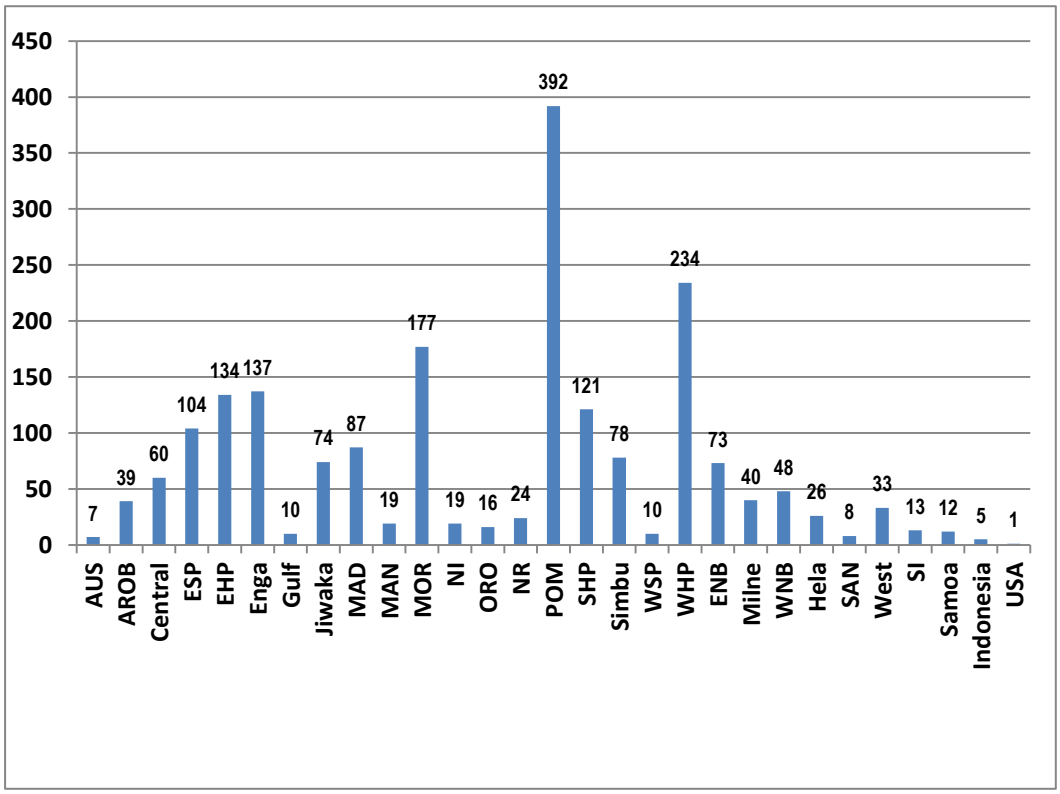

Fig. 1. Locations of students' elementary schooling
AROB = Autonomous Republic of Bougainville; MAD = Madang; MAN = Manus; MOR = Morobe; NI = New Ireland; NR = No Response; WSP = West Sepik; ENB = East New Britain; Milne = Milne Bay; WNB = West New Britain; SAN = Sandaun; West = Western.

Early Learning Language (ELL) distribution:

The frequency of language use in early childhood education changes dramatically, despite the predominantly Vernacular Education practiced in PNG at the time. The 2001 students were distributed according to their ELL. The results show that the ELL for 704 (35.2%) students was English; 835 (41.7%) were taught in both Tok Pisin and English (TPENG); the ELL for 219 (10.9%) was Tok Pisin (TP); for 163 (8.1%) students, the ELL was Vernacular (V); both Vernacular and English (VENG) were used as ELL for 73 (3.6%) students; only 7 (0.3%) of all the students in our sample reported combinations of Vernacular and Tok Pisin (VTP) or Tok Pisin, Vernacular and English (TPVENG) as their ELLs.

Thus, in the present study of the 2001 students, a total of 1539 (76.9%) listed ENG (704) and TPENG (835) as their Early Learning Language (ELL) in the first two years of their formal education.

Age of Onset of learning English (AO):

According to Shapiro-Wilks tests of normality, our AO data for all the students and for the female and male students were not normally distributed (p = 0.000). This was further confirmed by the Box-plots (Fig 2) of the AO data for the female and male students.

Thus, bootstrapping was used for the descriptive statistics presented in Table 1. The Mean AO for all the students was 6.88 years and the 95% Confidence interval was 6.79 – 6.98 years.

Table 1 Descriptive statistics of the Age of Onset (AO) of learning English for the female and male students

Parameters	Females	Males	All
N	798	1203	2001
Mean (years)	6.29	7.27	6.88
Standard Deviation (SD)	1.89	2.08	2.07
95% Confidence Interval (95% CI) (Bootstrapping)	6.16 – 6.43	7.16 – 7.39	6.79 – 6.98
Range	1.0 – 14.0	1.0 – 21.0	1.0 – 21.0
Median	6.0	7.0	7.00

Fig. 2. Box-plots of the distribution of the data for Age of Onset of learning English (AO) for Female (N=798) and Male (N=1203) students.

For the female students, the mean AO was 6.29 years and 95% CI was 6.16 – 6.43 years.

For the males, the mean AO was 7.27 years and the 95% CI was 7.16 – 7.39 years.

The Mann-Whitney U test and Kruskal-Wallis test indicated statistically significant difference (p = 0.001) in the mean and median AO values between the female and male students.

Another interesting observation was made with regard to general AO distribution across four schools of UPNG (SHSS, SNPS, SBPP and SOL) with mean AO of 6.90 years, compared to the School of Medicine and Health Sciences (SMHS), where the MBBS students' mean AO was 5.66 years (p = 0.01). This may be attributed to the rigorous selection criteria for admission into the MBBS program (after their Foundation Year in the School of Natural and Physical Sciences (SNPS), students with younger AO were more successful in meeting the GPA 3.00 selection requirement for the MBBS program).

GPA variable

The Shapiro-Wilk test for normality also indicated that the GPA data were not normally distributed (p = 0.000). The descriptive statistics of the GPA for all the students is presented in Table 3. The Mean GPA was 2.51 and 95% CI (bootstrapping) was 2.48 – 2.54.

Table 3: Descriptive statistics of the GPA for all students

N	2001
Mean	2.51
SD	0.73
95% CI (Bootstrapping)	2.48 – 2.54
Range	0.0 – 4.8
Median	2.50

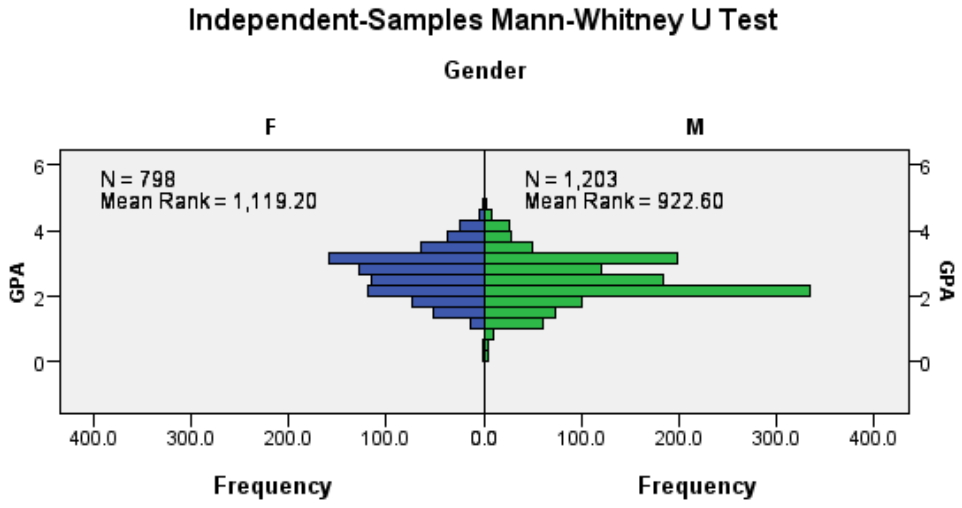

Fig. 3 GPA Frequency distribution of the GPA for the female and male students.

A statistically significant difference was observed when the distribution of the GPA data for the female and male students was compared using Mann-Whitney U Test (Fig 3). The results show that both data were not normally distributed. The GPA data were analysed statistically, using bootstrapping. For the female students, the mean GPA (±STD) was 2.657 ± 0.713 and the 95% CI (Bootstrapping) was 2.61 - 2.71; the median was 2.75. For the male students, the mean GPA was 2.416 ± .726 and the 95% CI (Bootstrapping) was 2.375-2.459, the median was 2.40. These results were confirmed by the independent samples Mann-Whitney U and Wilcoxon tests (p = 0.01, 2-tailed).

A significant association (η^2 = 0.423) was observed between the mean AO and the mean GPA for all the students.

Comparison of Means of the ELL and GPA:

Our data were not normally distributed; thus, we used bootstrapping to assess the Mean GPA in all seven ELL groups. The results are presented in Table 4.

Table 4. Descriptive statistics of the GPA for the students in the different ELL* groups

ELL groups	N	Mean	SD	95% CI (Bootstrapping)	ANOVA F value	p-value	η2
English	704	2.72	0.78	2.67-2.79	95.296	0.000	0.046
Tok Pisin (TP)	219	2.38	0.72	2.29-2.48	7.994	0.005	0.004
Vernacular (V)	163	2.20	0.58	2.11-2.89	33. 087	0.000	0.016
TP + English (TPENG)	835	2.43	0.68	2.38-2.47	20.105	0.000	0.010
V + English (VENG)	73	2.55	0.58	2.43-2.67	0.199	0.656	0.000
TP + V (TPV)	3	2.13	0.32	1.90-2.50	0.808	0.368	0.000
TP + V + Eng (TPVENG)	4	2.83	0.56	2.20-2.50	0.735	0.391	0.000

Comparison of Means revealed highest performance amongst students with ELL English, followed by those with ELL TPENG. The Mean GPA for ELL V students, despite the Vernacular Education policy then in place, was significantly lower (2.20). At first glance, ELL VENG students seemed to have done well, even better than ELL TPENG students - but their numbers were insufficient to yield statistically significant results. ELL TP students, however, consistently show statistically significant low performance (Mean = 2.38). ELL TPV and ELL TPVENG results were not statistically significant due to insufficient representation in the student population (this fact in itself is remarkable, as Vernacular Education policy was law at the time of these students' elementary education).

For further statistical analysis of the data, Correlation, Ordinary Least Squares (OLS) and multiple regression analyses were performed.

The results for the correlation analyses are presented in Table 5. A strong negative

statistically significant correlation (rho = –0.626, p = 0.000) was observed between the AO and GPA. A direct statistically significant correlation (rho = 0.222, p = 0.000) was obtained between the GPA and ELL English. Negative statistically significant correlations were also obtained between GPA and TPENG, V, and TP.

Table 5. Relationship between GPA and Age of Onset (AO) and between GPA and ELL

	GPA	AO	English	TPENG	V	TP
Correlation Coefficient (rho)	1.00	-0.626	0.222	-0.108	-0.131	-0.061
Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.006
N	2001	2001	2001	2001	2001	2001

* The sample size for ELL VENG, ELL TPV and ELL TPVENG were too low to yield statistically significant results

A statistically significant negative correlation (rho = -0.167, p = 0.000) was also observed between male gender and GPA, compared to female gender and GPA (rho = 0.167, p = 0.000). This result further indicates better performance by female students, compared to that of their male counterparts.

Linear Regression analyses: Various linear regression (OLS and Multiple) models were used to examine the relationship between several factors (AO, ELLs) and students' academic performance.

OLS linear regression AO and GPA:

The R Squared regression coefficient was 0.346 (R^2 = 0.35; SE = 0.59081). This means that AO explains 35% of the variation in GPA, the dependent variable in our sample.

The F-Statistic measures the effectiveness of the regression model in assessing the variation between the predictor (AO) and the outcome variable (GPA); F = 1057.036 (p = 0.000) indicates very high variation in mean GPA values between the two gender groups.

The results in Table 6 show that the relationship between AO and GPA was negative and statistically highly significant:

- The unstandardized beta coefficient of -0.208 (p = 0.000) means that a year's increase in AO reduces the GPA by 0.208 grade points.
- The standardized beta coefficient of -0.588 indicates a higher-than-medium effect size of AO on GPA, according to Cohen's (1988) classification.

Table 6. OLS Regression Coefficients a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.943	0.046		85.809	0.000
	AO	-0.208	0.006	-0.588	-32.512	0.000

a. Dependent Variable: GPA

To assess the combined effects of AO and gender on students' academic performance, we ran a multiple linear regression model which includes student level control variable (i.e. gender). The model below was used for the analysis of the data. The results obtained are presented in Table 7.

$GPA = \beta_1(AO) + \beta_2(X') + ei,$
where β is the constant, X' is the student level control variable, and e_i the error term.

Table 7. Estimated coefficients from AO+GENDER*GPA regression model

R	0.589	
R^2	0.347	
Adj. R^2	0.346	(SE = 0.5906797)
F value	529.69787	Sig. 0.000
Bootstrap for Coefficients (95% confidence interval)		
	B	Sig (2-tailed)
(Constant)	-3.952	0.001
AO	-0.206	0.001
GENDER	-0.038	0.171
Pearson's correlation coefficient (r)		Sig (1-tailed)
AO	r = -0.588	0.000
GENDER	r = -0.162	0.000

The relationship between AO and GPA was negative and statistically significant for AO, even after controlling for gender. Adjusted R^2 = 0.346 explains 35% of the outcome variable (GPA), the F statistic indicates significant variation in mean GPA values between the two gender groups. Each year's delay in AO causes a drop in GPA by 0.206 points - which may account for the lower academic performance observed amongst male students (their median AO was 7, as opposed to AO = 6 for female students). Pearson's correlation coefficients confirmed these findings (Table 8).

Multiple Regression: assessing the relationship between ELL variables and GPA

To assess any additional effects of the various ELLs on students' academic performance, we ran a multiple linear regression model, using the equation below:

$$GPA = \delta_1(TPENG) + \delta_2(TP) + \delta_3(V) + \delta_4(VENG) + \delta_5(TPV) + \delta_6(TPVENG) + ei,$$

where δ is the constant and e_i is an error term.

Since our data are not normally distributed, bootstrapping was used to satisfy the assumptions, associated with a linear regression model (i.e., normalcy of distribution, homoscedasticity, absence of outliers, linearity, etc.).

ELL is a categorical variable with 7 ELL subcategories (ENG, TP, V, TPENG, VENG, VTP and TPVENG). Therefore, in order for our ELL variable to be usable in a multiple linear regression prediction model, it was re-coded into 7 dichotomous "dummy" variables. English (ENG) was taken as the reference level, followed by all other "dummy" variables – TPENG, VENG, V, TPV, and TPVENG. Each one of the "dummy" variables has its level in relation to the one that is taken as the reference level (in this case, ENG), and the model was adjusted, taking into account all reference levels. Our results are presented in Table 8.

Table 8. Estimated coefficients from linear regression models ELL*GPA

R	0.234			
R^2	0.055			
Adj. R^2	0.052	(SE = 0 .71114)		
F value	19.218	Sig. 0.000		
Bootstrap for Coefficients			Collinearity statistics	
	B	Sig (2-tailed)	Tolerance	VIF
(Constant)	-2.724	0.001		
TP	-0.343	0.001	0.856	1.168
V	-0.524	0.001	0.884	1.131
TPENG	-0.297	0.001	0.785	1.274
VENG	-0.174	0.017	0.940	1.063
VTP	-0.590	0.001	0.997	1.003
TPVENG	0.101	0.625	0.996	1.004

These results indicate that students' Early Learning Language (ELL) contributed significantly to the AO impact on their 2018 GPAs, even though the coefficient of determination, R^2 and Adjusted R^2 values are relatively low at 0.055 and 0.052, respectively.

The high F coefficient (19.218, p=0.000) indicates considerable variation between sample means. Thus, as can be seen from Table 7, the academic achievement of students with ELL TP, ELL V, and ELL TPENG was significantly lower, in comparison to that of students with ELL ENG. Notably, as can also be seen from Table 8, there was no collinearity between ELL variables, which further strengthens the validity of our results.

Thus, the correlation analyses, nonparametric tests and regression models in this study have provided clear evidence that students' AO and ELLs have a significant effect on their academic performance, measured by their GPAs. Based on this evidence, we reject our null hypotheses (that there was no significant AO/ELL effect on UPNG students' 2018 GPAs), and accept the alternative hypotheses, listed below:

1st H_1 = AO has a significant effect on UPNG students' GPAs.
2nd H_1 = ELL has a significant effect on UPNG students' GPAs.

DISCUSSION:

The results obtained in the present study established a robust negative (inverse) statistically significant correlation between students' AO and their academic achievement. While academic performance is, undoubtedly, a function of the totality of one's biology and socio-cultural experience, this complexity was beyond the scope of our study. However, the understanding of the mechanisms of neurobiological development and the advantages of using the "windows of opportunity" it provides for effective learning may help in developing optimal strategies for quality education. During development, brain structures are formed over time, in 4 waves of myelination progressing from the bottom up, and from the caudal to anterior areas. "In the first few years of life, more than one million new neural connections are formed every second. After this period of rapid proliferation, connections are reduced through pruning, so that brain circuits become more efficient. Sensory pathways like those for basic vision and hearing are the first to develop, followed by early language skills and higher cognitive functions. Connections proliferate and prune in a prescribed order, with later, more complex brain circuits built upon earlier, simpler circuits" [24]. Early childhood education (ECE) captures these windows of opportunity while they are open, allowing for most effective learning and laying stronger foundations for later learning. Practical, factual evidence of the negative impact of any increase in students' age of onset of learning English (AO) on their academic performance in Papua New Guinea should be factored into government education policy.

Here, as in several other multiethnic and multicultural developing nations, English is the medium of formal education; therefore, students' ability to learn in all post-elementary education is predicated on their English proficiency. We contend that preserving linguistic and cultural diversity, on the one hand, and pursuing government objectives of developing quality human resources (HR) to advance sustainable socio-economic development, are not mutually exclusive propositions. Both goals are achievable, if strategy, grounded in science, makes use of the biologically 'sensitive' periods in early childhood development.

Disparity in access to early education not only accelerates social class division, but also prevents the development of human resources - that is why governments around the world increasingly turn their attention to maximizing the benefits of ECE. Many publications have come out in recent times on studies in this area [27; 28; 29]. For example, Chen et al. [25] describe the remarkable success of one such intervention, launched in 2009 by the China Development Research Foundation (CDRF) - the One Village One Pre-school (OVOP) project. This government-supported public intervention established over 2300 centers in central and western rural China, providing over 170,000 disadvantaged rural and minority 3–6-year olds with access to ECE, free of charge for all.

OVOP uses the “windows of opportunity” in children's cognitive development, addressing a range of biological, public health and socio-cultural issues. OVOP provided every village with a pre-school, trained and employed high school leavers/ local volunteers to deliver a standardized curriculum, and dispensed nutritional supplements to needy children. Chen et al. [25] present a comprehensive analysis of the impact these measures have had on the children's long-term academic achievement, providing convincing evidence of the value of using those critical "windows of opportunity" while they are still open in early childhood. Their analysis of longitudinal data on the academic achievement of 1962 “OVOP” children over the first five years of their primary school and compared their performance with that of those who had had no ECE. Their results revealed that children who had attended OVOP centers scored much better than those who had not, and even better than others who had attended private centers. The OVOP study has demonstrated the remarkable efficacy of ECE intervention; it provides empirical support for the value of investing in low-cost ECE, which benefits the entire society long-term. Our earlier studies [19; 20; 21; 22; 23] also lead to the same conclusions, providing evidence of better performance amongst those high school and university students who started their education earlier, particularly with regard to learning English (which is the medium of

instruction in all post-elementary education in Papua New Guinea).

CONCLUSIONS AND RECOMMENDATIONS:

To conclude, our results show that students' AO and ELLs have a significant effect on their academic performance, measured by their GPAs. Increase in AO correlated with lower GPAs, as did ELLs other than English. This highlights the need for children to be sufficiently proficient in English before they embark on their educational journey.

To move the quality of education forward, efforts must be made to utilize the "critical periods" in children's cognitive development, and provide them with the tool they need for learning at later stages of their education - English proficiency.

To achieve sustainable national development, a comprehensive multifaceted strategy must be developed - a strategy, based on language education policy grounded in the science of human brain development and understanding of socio-economic needs of the country, ensuring effective teacher training, and addressing public health and infrastructure development issues.

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