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CP 11

Intelligence quotient, working memory, and reaction time of secondary school students in Jaffna district and the influence of sociodemographic factors

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Abstract

Background and objectives: Intelligence quotient (IQ), working memory (WM), and reaction time (RT) are important cognitive abilities that influence career achievements. The objective of the study was to assess intelligence, working memory, and reaction time of secondary school students in Jaffna district and to determine their association with sociodemographic factors.

Methods: This analytical cross-sectional study was conducted among 765 students across five educational zones in Jaffna. The IQ and WM were assessed by Raven's Standard Progressive Matrices (RSPM) and Digit Span Backward Test (DSBT), respectively. The RTs were assessed by computer software developed locally. Independent sample t-test and one-way ANOVA were used for statistical analysis (significance level 0.05).

Results: The mean simple and choice RTs among students were 690.6±114.5s and 775.8±119.5s, respectively. The mean IQ assessed by RSPM was 47.9±7.4 and the mean DSBT score was 5.6±1.9. There were significant differences in RTs between males and females in simple (663.8s versus 718.5s, $p<0.001$) and choice (753.0s versus 799.6s, $p<0.001$) RTs with males having lower RTs than females. However, there were no significant differences in IQ and WM between males and females. Significant differences in all cognitive parameters were observed by educational zone, school, and parents' educational qualifications ($p\leq0.05$). Both IQ and WM displayed an increasing trend with increasing parental education. A strong positive correlation was observed between WM and IQ ($r=0.37$, $p<0.001$). Both simple and choice RTs had a weak negative correlation with IQ (simple $r=-0.19$, $p<0.001$; choice $r=-0.22$, $p<0.001$) .

Conclusions: Our findings are consistent with studies in other countries. Further research incorporating functional neuroimaging is required to establish the neurobiological basis of sex differences in cognitive abilities and the neurobiological relationship between IQ, WM, and RTs.

Keywords: Reaction times, Intelligent quotient, Working memory, Secondary school students

Introduction

Intelligence, working memory, and reaction time are key features of cognitive ability and are known to have a significant influence on academic success and career path (1).

Intelligence by definition is the ability to utilize information, understand experiences, engage in logical thinking and arrive at conclusions in order to resolve tribulations and acclimatize to new situations (2). Working memory (WM) refers to the system or systems that are assumed to be necessary to keep things in mind while performing complex tasks such as reasoning, comprehension, and learning (3). Reaction time (RT) is the time that elapses between the presentation of a particular sensory stimulus (visual, auditory, tactile, etc.) to an individual and their behavioral response to that stimulus (4). These three cognitive skills provide insight into the ability of a person to acquire, store, process and utilize information for decision-making. Though these processes are interconnected, the intricacies of their relationships with one another remain a mystery.

Research has shown that these cognitive domains are influenced by both genetic and environmental factors. The extent of the influence of sociodemographic factors on cognitive abilities is an area of constant debate. Research in this area is limited in the South Asian region, especially in Sri Lanka. Our study aimed to assess the cognitive abilities of secondary school students in Jaffna district and the influence of sociodemographic factors on cognitive abilities.

Methods

This was an analytical cross-sectional study conducted among 765 students from 10 schools (2 schools each in 5 educational zones) in Jaffna district. Students studying in Grade 10 in the schools with the highest enrollment in each zone were recruited using cluster sampling with consideration to the gender ratio. We intended to recruit an equal number of students from each educational zone, but the unavailability of schools with large student populations in the Theevagam zone led to clusters with unequal populations.

Raven’s standard progressive matrices version 1 (RSPM V1.0) was used to assess the intelligence quotient (IQ). It consists of five sets (A to E) of puzzles with puzzles within a set becoming increasingly difficult. An hour was given for the participants to complete the test. The score was calculated according to the number of correct responses from a range of 0-60.

WM was measured by the digit span backward test (DSBT). The test starts when the examiner reads aloud a sequence of digits starting with a three-digit span. The participants are then required to write the read span in backward order. The length of the sequence is then increased by one digit up to an eight-digit span. Two such sets were read out loud and the scores were calculated based on the highest span of digits correctly recalled in at least one of the two sets. Scores were assigned from a range of 0-8

RT was measured using reaction timer software developed locally and installed on a computer. Simple visual RT and choice visual RT were measured by selecting the best of three attempts each. Although RSPM V1.0 and DSBT have not been validated in Sri Lanka, they have been validated in India and used extensively in studies conducted in Sri Lanka (5,6). The RT software has also been used previously by the Department of Physiology, University of Jaffna.

Data were analyzed using SPSS 23. Independent sample t-tests were used to test differences in IQ, WM, and RT between males and females and one-way ANOVA was used to explore the significance of differences among other sociodemographic categories. Pearson’s correlation coefficient was used to describe the correlation between different cognitive abilities. A correlation coefficient of 0.00 to 0.19, 0.20 to 0.39, 0.40 to 0.59, 0.60 - 0.79, and 0.80 to 1.00

were considered to signify very weak , weak, medium, strong and very strong correlations, respectively.

Ethical clearance was obtained from the Ethics Review Committee, Faculty of Medicine, Jaffna.

Results

Table 1 summarizes the sociodemographic characteristics of the participants. A total of 765 students from 10 schools across five educational zones in Jaffna participated in the study. Of them 391 (51.1%) were males and the remaining 374 (48.9%) were females. Jaffna zone contributed the highest proportion of participants (25.1%), while the Theevagam zone contributed the lowest (13.2%). In the sample, 16.6% and 17% of students, respectively, reported their fathers and mothers were degree holders, while 1% of fathers and 0.7% of mothers had no formal education.

Table 1. Sociodemographic characteristics (n=765)

Characteristic		n	%
Sex	Male	391	51.5
	Female	374	48.9
Zone	Jaffna Zone	192	25.1
	Vadamaradchchy Zone	167	21.8
	Thenmaradchchy Zone	151	19.7
	Valigamam Zone	154	20.1
	Theevagam Zone	101	13.2
School	Vembadi Girls' High School	98	12.8
	Nelliady Central College	96	12.5
	Jaffna Hindu College	95	12.4
	Chavakacheri Hindu College	84	11.0
	Mahajana College, Tellipalai	80	10.5
	Union College, Tellipalai	74	9.7
	Methodist Girls High School	70	9.2
	Meesalai Veerasingam Central College	67	8.8
	Velanai Central College	54	7.1
	Karainagar Hindu College	47	6.1
Father’s educational level	No formal Education	8	1.0
	Primary Education	43	5.6
	Secondary Education	373	48.8
	G.C.E A/L	189	24.7
	Diploma	25	3.3
	Degree and Postgraduate	127	16.6
Mother’s educational level	No Formal Education	5	0.7
	Primary Education	28	3.7
	Secondary Education	316	41.3
	G.C.E A/L	233	30.5
	Diploma	53	6.9
	Degree and Postgraduate	130	17.0
Total		765	100.0

Table 2 presents the mean scores of the sample obtained for the three facets of cognitive abilities assessed. The choice RTs were higher than simple RTs obtained.

Table 2. Cognitive abilities of the participants (n=765)

Cognitive ability		Mean	Standard deviation	Median	IQR
Reaction time	Simple visual reaction time(s)	690.6	114.5	674.0	153.0
	Choice visual reaction time(s)	775.8	119.5	768.0	149.5
Intelligence quotient	RSPM V1.0[a]	47.9	7.4	49.0	8.0
Working memory	Digit span backward test	5.6	1.9	6.0	3.0

[a] Raven's Standard Progressive Matrices Version 1.0

Table 3 depicts the differences between the males and females in the cognitive abilities. The mean simple RT of males was lower than that of females ($p<0.001$). Males also had a better mean choice reaction time compared to females ($p<0.001$). The mean IQ score for females (48.4±6.2) was slightly higher than that of males (47.4±8.4), although the difference was not statistically significant ($p=0.06$). Similarly, the difference in WM assessed by DSBT was also statistically not significant ($p=0.33$), although females again had a higher mean score. The variability of IQ and WM scores was higher in males compared to females (Table 3).

Table 3. Sex differences in cognitive abilities (n=765)

	Sex	**Mean**		**t-test**	
		Mean	Standard deviation	t value, df	p value
Simple visual reaction time (s)	Male	663.8	108.1	6.79	<0.001
	Female	718.5	114.4		
Choice visual reaction time (s)	Male	753.0	114.7	-5.49	<0.001
	Female	799.6	120.0		
Intelligence quotient	Male	47.4	8.4	-1.96	0.060
	Female	48.4	6.2		
Working memory	Male	5.5	2.0	-.97	0.330
	Female	5.6	1.8		

Table 4 summarizes the differences among different zones in cognitive abilities. The results showed that there were significant differences in cognitive abilities among education zones.

Table 4. Cognitive abilities in different zones (n=765)

	Educational Zone	Mean	Standard deviation	F	p value
Simple visual reaction time	Jaffna Zone	655.4	112.8		
	Vadamaradchchy Zone	705.7	119.4		
	Thenmaradchchy Zone	701.0	121.5	7.40	<0.001
	Valigamam Zone	689.0	98.4		
	Theevagam Zone	719.2	107.3		
Choice visual reaction time	Jaffna Zone	744.5	124.2		
	Vadamaradchchy Zone	784.0	110.7		
	Thenmaradchchy Zone	793.2	129.5	7.77	<0.001
	Valigamam Zone	763.0	103.3		
	Theevagam Zone	815.4	116.4		
Intelligence quotient	Jaffna Zone	52.7	3.6		
	Vadamaradchchy Zone	48.1	6.2		
	Thenmaradchchy Zone	45.5	8.9	40.47	<0.001
	Valigamam Zone	47.1	6.9		
	Theevagam Zone	43.5	8.2		
Working memory	Jaffna Zone	6.5	1.4		
	Vadamaradchchy Zone	5.5	1.9		
	Thenmaradchchy Zone	5.7	2.0	23.66	<0.001
	Valigamam Zone	4.9	1.9		
	Theevagam Zone	4.71	1.9		

Table 5. Cognitive abilities and father's education level (n=765)

	Father's education level	Mean	Standard deviation	F	p value
Simple visual reaction time	No formal education	652.6	97.4		
	Primary education	723.8	109.6		
	Secondary education	701.2	110.2	3.05	0.010
	G.C.E A/L	681.9	114.4		
	Diploma	657.4	127.2		
	Degree/ postgraduate	669.9	122.3		
Choice visual reaction time	No formal education	743.6	105.5		
	Primary education	807.4	109.1		
	Secondary education	783.6	113.5	2.50	0.030
	G.C.E A/L	775.5	1274		
	Diploma	745.8	137.7		
	Degree/ postgraduate	750.7	121.6		
Intelligence quotient	No formal education	48.0	5.5		
	Primary education	43.6	9.0		
	Secondary education	46.5	7.7	13.52	<0.001
	G.C.E A/L	48.9	7.2		
	Diploma	51.0	4.6		
	Degree/ postgraduate	51.3	4.6		
Working memory	No formal education	5.9	1.8		
	Primary education	4.7	1.7		
	Secondary education	5.3	2.0	11.46	<0.001
	G.C.E A/L	5.7	2.0		
	Diploma	6.2	1.5		
	Degree/ postgraduate	6.5	1.3		

There were significant differences in cognitive abilities among schools as well.

The differences in cognitive abilities between groups categorized according to the father's and mother's educational levels are summarized in Tables 5 and 6. The results reveal statistically significant differences based on both the father's and mother's educational qualifications in all four cognitive domains assessed. The mean scores for IQ and WM show an increasing trend with increasing educational qualifications of the parents apart from the group with no formal education, which departs from the trend. However, it must be noted that the sample size of the subgroup with no formal education was too small to draw any conclusions.

Table 6 - Cognitive abilities and mother's education level (n=765)

	Mother's education level	Mean	Standard deviation	F	p value
Simple visual reaction time	No formal education	715.2	45.1		
	Primary education	715.4	97.7		
	Secondary education	708.9	112.8	3.98	0.001
	G.C.E A/L	679.8	109.5		
	Diploma	679.6	111.4		
	Degree/ postgraduate	663.4	126.5		
Choice visual reaction time	No formal education	814.0	56.6		
	Primary education	778.7	139.9		
	Secondary education	788.2	112.6	2.53	0.028
	G.C.E A/L	778.0	113.5		
	Diploma	756.2	138.4		
	Degree/ postgraduate	747.9	131.0		
Intelligence quotient	No formal education	45.0	3.3		
	Primary education	43.5	11.2		
	Secondary education	46.2	7.6	13.56	<0.001
	G.C.E A/L	48.2	7.5		
	Diploma	51.2	4.8		
	Degree/ postgraduate	51.2	4.4		
Working memory	No formal education	4.4	2.7		
	Primary education	4.4	2.5		
	Secondary education	5.3	1.9	10.55	<0.001
	G.C.E A/L	5.6	1.9		
	Diploma	6.0	1.6		
	Degree/ postgraduate	6.4	1.5		

Table 7 shows the correlation coefficients relevant to each variable. There was a very high positive correlation between simple and choice RTs (r=0.6). Simple visual reaction time had a very low negative correlation with IQ (r=-0.19) and WM (r=-0.16). IQ had a low positive correlation with WM (r=0.37). The corresponding p values for all the correlations was 0.01.

Table 7 – The correlation between cognitive abilities (n=765)

	Simple visual reaction time	Choice visual reaction time	Intelligence quotient	Working memory
Simple visual reaction time(s)	*	0.60	-0.19	-0.16
Choice visual reaction time(s)	0.60	*	-0.22	-0.13
Intelligence quotient	-0.19	-0.22	*	0.37
Working memory	-0.16	-0.13	0.37	*

Discussion

We found that simple visual RT was significantly lower than the choice visual RT among the school students. Males had faster simple and choice visual RTs compared to females, which is consistent with other studies (7). The choice RTs were higher than simple RTs, obviously due to the increased complexity of the tasks.

Our results did not show any significant differences in IQ and WM between the genders. Several other studies have also demonstrated similar findings. Wendy showed that although there were no significant differences in the mean IQ score, the IQ score of males showed greater variability (8), a finding demonstrated in our study too. Buczyłowska *et al* reported that there were differences between males and females in different domains of intelligence, although general intelligence was similar (9). A study that used neuroimaging and functional connectivity analysis of the brain attributes these sex differences to differences in neurobiological correlates underpinned by differences in brain network patterns (10)

A systemic review found no sex differences in serial recall and span tasks despite evidence of differences in various aspects of WM (11). Another key finding of this review was that women had similar scores to men in the absence of distraction although their performance declined significantly when distractions were present (12). Our study was conducted in a distraction-free environment, and the findings are consistent with prior findings reported.

Although studies exploring the influence of sociodemographic factors on RT and WM are limited, several studies have explored their relationship with IQ. Studies have demonstrated that parental education correlates significantly with IQ (13,14). Given the correlation between WM and intelligence, it is possible that parental education can have a significant correlation with WM.

The observation of higher cognitive scores in students with parents of higher educational backgrounds raises the question of whether this trend is explained by genetic or environmental influences. The genetic influence hypothesis stems from the possibility that parents with better educational qualifications might have better cognitive abilities and in turn have children with superior cognitive abilities given the strong association between genetics and cognitive abilities. On the other hand, the quality of living of children of educated parents might be higher than that of those with parents from poor educational backgrounds and the environmental factors associated with quality of living such as nutrition, psychosocial support, etc. could be the explanation for the differences. Further research is required to establish the reasons for this interesting observation.

We found an association between schools and educational zones, and cognitive abilities. Differences in cognitive abilities between schools and zones have not been explored previously. However, studies have found that place of residence can influence IQ (15).

Differences in cognitive abilities among students from different zones and schools may in fact be due to differences in place of residence, which, in turn, may be influenced by other social factors.

Our findings of the positive correlation between WM and IQ and the negative correlation between RT and IQ are consistent with earlier findings (16,17). An explanation for these findings may be that although IQ, WM and RT are distinct domains, there could be much overlap in the basic cognitive processes underlying them. This raises a possibility that improvements in one cognitive ability might have positive changes in other cognitive abilities as well. However, further studies using brain imaging and connectivity are required to establish this.

Conclusion

The findings of our study are consistent with studies conducted in other settings. Though we have established associations and correlations between cognitive domains and some sociodemographic factors, neuroscientific studies incorporating functional neuroimaging are required to establish the neurobiological mechanisms that underlie these findings.

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Conflict of interests

There are no conflicts of interest.

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CP 12

Antenatal care service utilization in public and private sectors among women delivering at a public tertiary care centre in Northern Sri Lanka

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Background and objective: Maternity care is provided free-of-charge through Sri Lanka's public healthcare system. However, pregnant women who rely on the public system also access private antenatal care (ANC) on a fee-levying basis. This study describes ANC service utilization in public and private sectors among pregnant women awaiting delivery at a public tertiary hospital in Jaffna.

Methods: This descriptive cross-sectional study was conducted at Teaching Hospital Jaffna (THJ). Pregnant women ≥18 years awaiting delivery after 33 weeks of gestation were recruited over a 12-week period (20/06/2022 to 09/09/2022). An interviewer-administered questionnaire was administered at the bedside and medical records reviewed to elicit sociodemographic data and details of ANC use. Data were analysed with SPSS (v21). Standard descriptive statistics and chi-square test were used in the analysis (significance level 0.05).

Results: In total, 251 pregnant women participated (response rate 97.6%). The majority (80.5%, n=202) combined public ANC with private services. All participants accessed public ANC at medical officer of health clinics and 96.8% were visited at home by a public health midwife. The majority had visited public hospital clinics (76.9%) and used public laboratory services (64.9%); 35.5% had used inpatient ANC. The use of private sector services was comparatively lower; most accessed private pharmacies (60.6%), followed by channeling centres (48.2%) and laboratories (45%); only two participants reporting using private inpatient care. Median number of contacts with skilled ANC providers was 20 [IQR 17-23; public 17 (IQR 14-21); private 1 (IQR 0-5)]. Women with O/L qualifications (or higher) and those employed were 1.4 and 1.2 times more likely, respectively, to use private ANC. Both these associations were significant at the 0.05 level.