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How to Easily Construct a Very Brief Practical Measure of IQ:
The Pernambuco Adult Intelligence Mini Test

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Abstract

The present paper demonstrates the use of a small set of school-like questions to create a very brief, practical, and accurate measure of general intelligence. This is done through the Pernambuco Adult Intelligence Mini Test (PAIMT), a one-to-one, face-to-face instrument applicable in outdoor settings in five minutes or less by non-experts with minimal training. It is comprised of items from two previous tests and standardized into an IQ through a sample of 1,254 individuals from 46 municipalities in the state of Pernambuco, Brazil, in 2011, and construct-validated and evaluated for Flynn Effect through data from 4,201 adults collected between 2011 and 2019. The PAIMT IQ was found to be a Gaussian and unidimensional construct associated with multiple other variables similar to IQ. This approach can produce flexible, reliable, and valid measures of intelligence that are easily adapted and normed for use in various contexts.

Keywords: Intelligence, IQ, Testing, Psychometrics, Brief Measure

Resumo

O presente artigo demonstra o uso de um pequeno conjunto de perguntas escolares para criar uma medida muito breve, prática e precisa da inteligência geral. Isso é feito por meio do Miniteste de Inteligência do Adulto de Pernambuco (PAIMT), um instrumento aplicado face a face, em ambientes externos e em cinco minutos ou menos por não especialistas com treinamento mínimo. É composto por itens de dois testes anteriores e padronizados em um QI por meio de uma amostra de 1.254 indivíduos de 46 municípios do estado de Pernambuco, Brasil, em 2011, sendo validado por construto e avaliado para o Efeito Flynn por meio de dados de 4.201 adultos coletados entre 2011 e 2019. O QI PAIMT foi considerado um construto gaussiano e unidimensional associado a várias outras variáveis semelhantes ao QI. Essa abordagem pode produzir medidas de inteligência flexíveis, confiáveis e válidas que são facilmente adaptadas e normatizadas para uso em vários contextos.

Palavras-chave: Inteligência, QI, Testes, Psicometria, Medida Breve

Intelligence, as measured by an IQ test, can be roughly defined as the set of cognitive abilities encompassing linguistic, logical-mathematical, and abstract thinking, as well as pattern-recognition, learning and problem-solving in linguistic, logical-mathematical, and abstract contexts (Hermstein & Murray, 1994; Ulrich et al., 1996; Anastasi & Urbina, 1997; Kaufman, 2009; Mackintosh, 2011; Lynn & Vanhanen, 2012). In spite of criticism (Sternberg & Wagner, 1993; Borsboom, 2006; Gould, 1996; Schönemann, 1997; Cronshaw et al., 2006; Mackintosh, 2011) it is a construct of unparalleled scientific success (Jensen, 1982; Ulrich et al., 1996; Eysenck, 1998; Hunt, 2011; Lynn & Vanhanen, 2012; Ganuthula & Sinha, 2019).

Rapid ways of measuring intelligence include short forms (selected items from a larger test) and brief tests (a small set of original items), however, they still take 15-30 minutes to apply and require a secluded space with desks, chairs and writing material (See Kaufman & Kaufman, 2001; Homack & Reynolds, 2007; Pierson et al., 2011). An instrument that could be applied by individuals with little training, in street-like settings and in only a few minutes, would allow more representative samples, with less recruitment bias, in shorter time and at a lower cost than traditional tests. It would also allow one to measure more variables in the same project.

The successful acquisition of the type of scientific and mathematical concepts generally included in school curricula involves the internalization of complex abstract ideas through processes involving logical reasoning and linguistic thinking (Piaget & Inhelder, 1941; Tolmin, 1961; Bachelard, 1968; Solomon, 1983; Mortimer, 1995; Sirotic & Zazkis, 2007; Oliveira, Brando & Caldeira, 2017). Indeed, there is evidence that schooling can boost IQ scores causally (Ritchie & Tucker-Drob, 2018).

Therefore, general intellectual ability should be measurable through an assessment of scholastic performance, as some have already found (Frey & Detterman, 2004; de Vent et al., 2018).

In Brazil, intelligence testing is characterized by multiple psychometric issues including inadequate norming and extrapolated use, with the cost of standardization being one of the likely causes (Noronha, Freitas & Ottati, 2002; Noronha et al., 2003; Noronha & Primi, 2004; Vendramini & Lopes, 2008; Primi, 2010; Reppold et al., 2017; Wechsler, Hutz & Primi, 2019). Also, most efforts have focused on children or adolescents rather than adults (Campos & Nakano, 2012; Alves et al., 2016). Practical short instruments would help to overcome such challenges, but little or nothing has been done in that regard (Coutinho, 2010; Hutz & Primi, 2019).

The Academic Thinking Test and the Knowledge Test are two instruments developed for the rapid assessment of general cognitive ability and scholastic knowledge of adults in street-like conditions, having been used in multiple studies in Brazil (Souza, Silva & Roazzi, 2010; Souza et al., 2012; Taissun et al., 2012; Souza et al., 2012; Souza et al., 2017; Souza & Roazzi, 2017; Paula & Souza, 2019; Souza et al., 2019). Given the first is comprised of a series of abstract logical-mathematical and linguistic problem-solving taks and the second of questions assessing the understanding of concepts that require that same type of thinking, the current paper explores the use of the sum of the two to create a valid and coherent measure of intelligence that can be applied in under five minutes in a wide variety of informal settings: the Pernambuco Adult Intelligence Mini Test (PAIMT).

It is expected that the PAIMT will not only show itself a new and practical instrument that can potentially help to bridge a significant gap in intelligence testing in Brazil, but also, more importantly, validate a new approach to the development of intelligence tests.

Some known associations between IQ and other variables

IQ tests were originally created for the purpose of predicting educational attainment based on the measurement a trait, something in which they were quite successful (Anastasi & Urbina, 1997). Unsurprisingly, a positive association between IQ and level of education is the most consistent finding in the specialized literature (ex: Sternberg, Grigorenko & Bundy, 2001; Deary et al., 2007; Lynn & Mikk, 2007, 2009), including in Brazil (Colom, R. & Flores-Mendoza, 2007).

Another ubiquitous finding regarding IQ is a relevant positive association to occupational attainment and personal income even when controlling for level of education and family income (Jensen, 1982; Hermstein & Murray, 1994; Ulrich et al., 1996; Anastasi & Urbina, 1997; Eysenck, 1998; Scullin et al., 2000; Sternberg, Grigorenko & Bundy, 2001; Firkowska-Mankiewicz, 2011; Hunt, 2011; Lynn & Vanhanen, 2012; Meisenberg, 2012; Ganuthula & Sinha, 2019).

There is substantial evidence that individuals tend to be fairly aware of their level of general intelligence, with multiple studies finding a positive correlation between IQ and self-appraisal of intellectual capacity (Paulhus, Lysy & Yik, 1998; Furnham, Moutafi & Chamorro-Premuzic, 2004; 2005; Kornilova & Novikova, 2012).

Some researchers suggest that the sexes have no difference regarding average IQ but men tend to present a greater variance (Deary et al., 2003; Strand, Deary & Smith, 2006; Johnson, Carothers & Deary, 2008; Dykiert, Gale & Deary, 2009). However, there are far more studies showing women to have a slightly lower mean IQ (Jensen & Reynolds, 1983; Ankney, 1992; Hedges & Nowell, 1995; Alexopoulos, 1996; Halpern & LaMay, 2000; Lynn, 2002; Irwing & Lynn, 2004; Lynn, Pullmann & Laidra, 2004; Jackson, 2006; Lynn & Kawazana, 2011; Nyborg, 2012; Flores-Mendonza et al., 2013; Liu & Lynn, 2015). Such

discrepancy is likely due to girls generally entering puberty at a younger age than boys, so that investigations where this is controlled for or research with adults tend to find a consistent small male advantage in the mean, translating into a much higher proportion of men at the upper tail of the distribution (Colom & Lynn, 2004).

Various studies found a negative correlation between age and IQ which would be indicative of a cognitive decline due to the neurophysiological effects of aging (ex: Bigler *et al*., 1995; Garde *et al*., 2000). Nevertheless, most such studies on the matter are cross-sectional rather than longitudinal, and there is evidence to suggest a mitigating role played by the level of education (Ardila *et al*., 2000) and initial intelligence (Deary *et al*., 2009).

The Flynn Effect

The Flynn Effect is the name given to relevant gains in intelligence over time worldwide, at a rate of approximately three points per decade (Flynn, 2013; Pietschnig & Voracek, 2015). But there is also more recent evidence for what might be a "Negative" Flynn Effect, especially after the turn of the 21st century, when raw scores stopped growing and even began to drop (Trahan et al., 2014; Dutton, van der Linden & Lynn, 2016; Flynn, 2020). Regardless of the cause and direction of such an effect, it is a concern for the scoring of intelligence tests.

The only two known studies of the Flynn Effect in Brazil both involve only children and show conflicting results, one finding a positive effect (Colom, Flores-Mendoza & Abad, 2007) and the other none (Bandeira, Costa & Arteche, 2012).

The PAIMT

Overview

Souza, Silva and Roazzi (2010) created a pair of instruments, called the

Academic Thinking Test and the Knowledge Test, for the measurement of general cognitive ability and scholastic content learned. Each was designed to be orally applied in street-like settings and to be answered in two minutes or less.

The Academic Thinking Test is comprised of five verbal and logical-mathematical problems where a correct response is considered the right answer given within 10 seconds or less. The five questions, translated from the original in Portuguese, are:

1. If my watch is on my left hand, what happens with it in a mirror image? (Correct Answer: It appears as being in my right hand)
2. If I have a set of tiles each with five equal-sized sides, can I fully cover at least the central portion of a wall by fitting them side-by-side? (Correct Answer: No)
3. Cold is to Freezing as Tired is to...? (Correct Answer: Exhausted)
4. Considering that a car rides at a speed of 80 km/hour, how long will it take to cover a distance of 60 km? (Correct Answer: 45 minutes);
5. What is the next number in the following sequence? 1, 2, 5, 10, 17, 26... ? (Correct Answer: 37)

The Knowledge Test is comprised of 10 school-content statements to be classified as "true" or "false" within 10 seconds or less. The questions, translated from the original in Portuguese, are:

1. The experiences individuals go through are genetically transmitted to the new generations. (Correct Answer: No)
2. All things that exist are just different mixtures of the same basic ingredients. (Correct Answer: Yes)
3. There are some things that come out of nothing. (Correct Answer: No)

4. The speed with which a body free falls in a vacuum depends on its weight. (Correct Answer: No)
5. Matter can be transformed into energy and vice-versa. (Correct Answer: Yes)
6. Any number can be produced by the division of two integers. (Correct Answer: No)
7. The capital of Denmark is Stockholm. (Correct Answer: No)
8. Was Plato an important Roman philosopher? (Correct Answer: No)
9. Does the English word "work" mean "*trabalho*"? (Correct Answer: Yes)
10. In the Portuguese language, is it correct to say that "250 years HAS passed since Mozart was born"? (Correct Answer: No)

In multiple studies, the scores on both tests were found to be statistically reliable and correlated to each other, as well as to formal education, academic performance, socioeconomic success, personality, and other variables (Souza, Silva & Roazzi, 2010; Souza et al., 2012; Taissun et al., 2012; Souza et al., 2017; Souza & Roazzi, 2017; Paula & Souza, 2019; Souza et al., 2019).

Cognitive Elements of the Knowledge Test

The Knowledge Test covers five items involving the understanding of Science, one involving Mathematics and four the awareness of facts regarding Language, History and Geography.

The understanding of scientific ideas requires the internalization of complex concepts (Piaget & Inhelder, 1941; Tolmin, 1961; Bachelard, 1968; Solomon, 1983; Chi, 1991; Galili & Bar, 1992; Scott, 1991; Mortimer, 1995), and the same can be said of mathematical notions (Shinno, 2007; Sirotic & Zazkis, 2007).

The concept of Darwinian Biological Heredity addressed in Question 1 is a cross-sectional axis that runs through practically all the different branches of knowledge (Tidon & Vieira, 2009), condensing a substantiated knowledge of Biology (Oliveira & Bizzo, 2011). Though revisited by modern science through the notion of Epigenetics, most would not hesitate to indicate that there is no genetic transmission of individual experiences, as the violation of this through molecular means is a complex and detailed nuance that does not represent a direct contradiction of the Darwinian model (Oliveira, Brando & Caldeira, 2017).

Specific knowledge regarding geographical and historical facts that are not part of everyday life or greatly emphasized in school curricula, require scope and depth of learning, as well as recall. Foreign language vocabulary and native language grammar, on the other hand, refer to the verbal and linguistic ability.

Given the scholastic nature of the contents of the Knowledge Test, which can be seen as both causing developmental gains in intelligence through cognitive engagement and reflecting intellectual abilities, this instrument may be considered as a fair measure of something akin to an IQ, specially considering that it is applied with a strict time constraint.

Study Goals

The present paper seeks to investigate the viability of combining problem-solving taks and scholastic knowledge questions as an approach to produce a very brief and practical instrument to measure general intelligence that can be rapidly normed at a relatively low cost, thereby having the potential to help overcome the shortcomings of developing countries in psychometric assessment. For that purpose, data on the application of the Academic Thinking Test and the Knowledge Test to a total of n=4,201 adults from the state of Pernambuco between the years of 2011 and 2019 is to be used to norm and calculate a single

intelligence score, the PAIMT IQ, from the combination of both instruments, so as to perform analyses to determine its psychometric properties, as well as associations with education, income, sex, age and self-evaluation of intellectual ability, along with the evaluation of the need for corrections of the norming due to an eventual Flynn Effect that may have occurred for the period during which the database was collected.

Method

Sample

The norming of the PAIMT IQ used data from a group of n=1,254 Brazilian adults aged 18-84 years, collected by a total of 43 students from an online undergraduate course in Informatics of the Federal Rural University of Pernambuco from a total of 46 municipalities in the State of Pernambuco, Brazil, between August 27th and September 15th, 2011.

For the assessment of the associations between the score on the PAIMT and sociodemographic, sociocultural and psychological variables, the standardization sample was merged with nine other databases collected between the years of 2011 and 2019 also through multiple students on the streets collecting samples of convenience.

Table 01 shows the sex, age and education for each of the 10 datasets.

The combined dataset was comprised of 4,201individuals, with the basic sociodemographics being:

- Total of 4,201 adults from Pernambuco, Brazil, 3,088 from the Metropolitan Region of Recife (74.5%) and 1,066 from other Meso-regions (25.7%);
- Total of 2,096 women (50.5%) and 2,058 men (49.5%), with a mean age of 33.0 years (SD=12.67), ranging from 18.0 to 84.3 years;

- About 20.5% had Basic Education, 45.9% High School Education, 26.3% Higher Education, 3.1% a Master's Degree and 4.2% a Doctorate Degree;
- Roughly 22.6% had a Public Job, 21.8% a Private Job, 7.8% were Autonomous, 2.7% had their own company, 1.4% were Rural Producers, 4.0% other occupations and 4.8% were unemployed, while 11.8% were Students and 1.1% Home Keepers.

Table 01. Descriptions of the databases obtained from the Metropolitan Region of Recife (MRR), the Federal University of Pernambuco (UFPE) and multiple municipalities in the State of Pernambuco, Brazil, with summary statistics for sex, age and level of education.

Database				Sex		Age		Education		
Code	***Description***	***Year***	***N***	**Men**	**Women**	**Mean**	**SD**	**Basic-**	**Interm.**	**Higher+**
A	*Adults from 46 municipalities in the state of Pernambuco.*	*2011*	*1254*	48.4%	51.6%	34.3	12.09	32.1%	41.1%	26.8%
B	*Adults from 11 municipalities in the state of Pernambuco.*	*2012*	*523*	49.5%	50.5%	30.9	9.06	18.0%	62.7%	19.3%
C	*Adults from the MRR, Pernambuco.*	*2012*	*213*	49.3%	50.7%	33.8	12.31	43.2%	21.1%	35.7%
D	*Undergraduate students majoring in Management at UFPE.*	*2014*	*344*	49.6%	50.4%	22.7	2.65	0.0%	100.0%	0.0%
E	*Adults from the MRR, Pernambuco.*	*2014*	*212*	46.2%	53.8%	36.1	14.30	39.2%	17.9%	42.9%
F	*A representative set of undergraduate students at the UFPE.*	*2017*	*231*	50.6%	49.4%	23.2	4.09	0.0%	100.0%	0.0%
G	*Adults from the MRR, Pernambuco.*	*2018*	*434*	52.8%	47.2%	34.4	13.73	4.4%	34.3%	61.3%
H	*Adults from the MRR, Pernambuco.*	*2018*	*577*	46.6%	53.4%	34.9	14.69	26.3%	27.6%	46.1%
I	*Professors in various fields at the UFPE.*	*2019*	*150*	62.7%	37.3%	46.6	10.89	0.0%	0.0%	100.0%

J	*Adults employed in the private or public sector in the MRR, Pernambuco.*	*2019*	*263*	50.7%	49.3%	36.8	13.07	4.7%	45.1%	50.2%

Instruments

The Adult Intelligence Mini-Test (AIMT), comprised of a combination of the Knowledge Test with 10 items and the Academic Thinking Test with 5 items (Souza et al., 2010; Souza et al., 2012);

- Sociodemographic Questionnaire containing items regarding sex, age, education, marital status, occupation and work life, as well as time spent working, sleeping, exercising and with family;
- The Leadership Scale, comprised of 10 items involving the self-evaluation of charisma, eloquence, conflict management, pragmatism, diligence, support, self-confidence, intellect, intuition and delegation.

Procedures

All the samples were collected by graduate and undergraduate students from the Federal University of Pernambuco, with A and B also including data collected by students from the Rural Federal University of Pernambuco. The students were briefed as to how to apply the test according to the instructions, using a wristwatch or smartphone to measure the time for each question, annotating the responses on preprepared printed answer sheets. They were also directed to be polite, but objective, when addressing the participants, actively making an effort to not manifest any sort of preference during the whole interaction. The responses recorded in the paper answer sheets were later transcribed to electronic spreadsheets and sent to the research coordinator through e-mail.

Samples A, B, C, E, G and H were collected on the streets of their respective municipalities with the participants from each town and city

approached at random convenience in the public venues of their location. Each student was required to collect data on a total of eight individuals divided by sex, age and level of education according to the most recent census for the state of Pernambuco, Brazil. Sample J was collected in similar fashion but included only individuals aged 18 through 65 who were employed in public or private organizations.

Samples D, F and I all referred to the students or faculty of the Federal University of Pernambuco, being collected in the 10 Academic Centers of the Recife Campus, enrolling participants as they were found in such locations, respectful of the proportion of the academic population belonging to each center, as well as to sex and how long they had been at the university.

Results

Representativeness of the Standardization Sample

The geographical distribution of the standardization sample regarding the mesoregions of the state of Pernambuco was of 44.15% Metropolitan, 17.51% Mata, 26.26% Agreste, 7.44% São Francisco and 4.65% Sertão. Sex ratio was 48.1% male and 51.6% female. The ages were 60.2% 18-34 years, 33.0% 35-54 years and 6.8% 55+ years. Education was 32.1% basic, 41.1% high school and 26.7% higher education or more. Income was 63.5% up to two minimum wages, 30.6% more than two and up to five minimum wages and 6.0% more than five minimum wages.

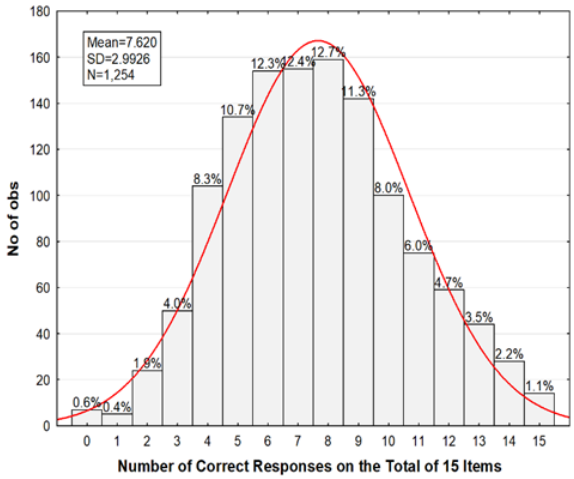
The official data from the National Census for 2010 showed similar proportions for geography (39.51% Metropolitan, 15.1% Mata, 26.24% Agreste, 6.84% São Francisco and 11.79%) and sex (48.1% male and 51.9% female). The population was older (28.4% 18-34 years, 24.5% 35-54 years and 13.4% 55+ years), less educated (72.8% basic, 20.9% high school and 6.35 higher or more) and had a lower income (91.4% up to

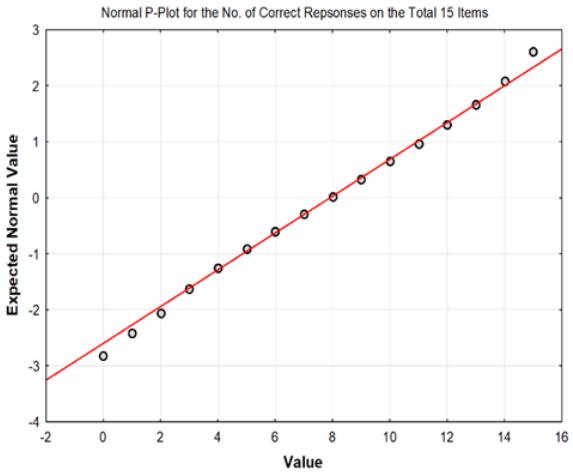
two minimum wages, 5.7% more than two and up to five minimum wages and 2.9% more than five minimum wages).

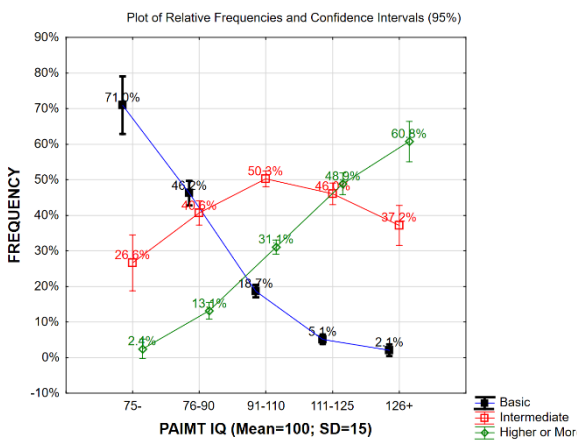
Gaussianity, Realiability and Unidimensionality

The number of correct items on the test had mean of 7.620 and a Standard Deviation of 2.9926. Though the Kolmogorov-Smirnov Test for its distribution indicated a substantial deviation from Normality (d=.08700, p<.01), a Pearson Skewness Score of 0.23 (SD=0.069) and a Kurtosis of -0.36 (SD=0.138) together point to a substantial similarity to the Gaussian Distribution, as did the Histogram and Normal Probability Plot (Figure 01, Elements A and B).

The Reliability Analysis of the 15 items of the Adult Intelligence Mini-Test for the standardization sample of n=1,254 yielded a Cronbach Alpha score of .77. The Item Analysis showed that there was no item that, if removed, would increase the overall value for the rest of the set (Table 2).







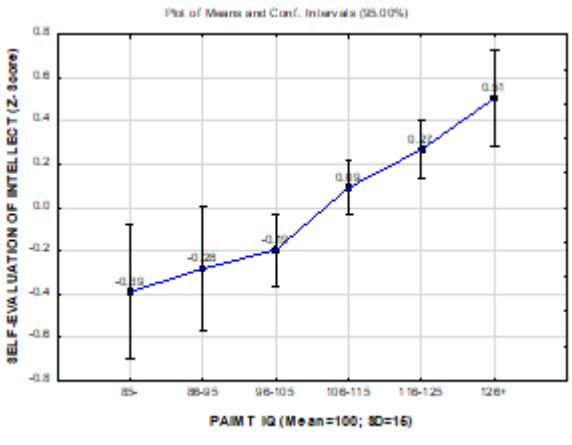


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Figure 01. Distribution (A) and Normal Probability Plot (B) for the number of correct items for the stand-ardization sample, along with the fraction of those with each level of education (C) and self-evaluation of intellect (D) as a function of the PAIMT IQ range for the full sample.

For the larger sample of n=4,201 adults, the proportion of individuals responding to the first item of the Knowledge Test with a “no” was of 61.6%, being 42.4% among those with a fundamental level of education, rising to 63.0% for those with intermediate or high school degrees, to 68.6% for those with a higher education degree and to 80.5% for those with a master´s or doctorate degree.

An Exploratory Factor Analysis of the 15 items of the PAIMT using Varimax Normalized Rotation found five Factors with Eigenvalues above 1.00, their sum explaining some 55.5% of the variance. However, the Scree Test suggests the first Factor as standing out with a value of 3.73, explaining 24.8% of the variance (g factor Loading), with the remaining four having the values of 1.37, 1.13, 1.06 and 1.04.

Table 02. Item-Total Statistics for the combined items of the Academic Thinking Test and the Knowledge Test for the standardization sample.

Test	Item	Answered Correctly	Mean if Deleted	Var. if Deleted	SD if Deleetd	Item-Total Correlation	Alpha if Deleted
Academic Thinking Test	1	69.1%	6.93	11.12	3.33	0.33	0.76
	2	46.5%	7.15	11.38	3.37	0.22	0.77
	3	49.8%	7.12	10.86	3.30	0.38	0.75
	4	27.6%	7.34	10.65	3.26	0.52	0.74
	5	20.4%	7.42	10.89	3.30	0.49	0.75
Knowledge Test	1	55.8%	7.06	10.72	3.27	0.43	0.75
	2	58.9%	7.03	11.57	3.40	0.16	0.77

3	56.2%	7.06	11.02	3.32	0.33	0.76
4	46.3%	7.16	10.60	3.26	0.47	0.75
5	64.6%	6.97	11.23	3.35	0.28	0.76
6	43.5%	7.18	11.12	3.34	0.30	0.76
7	52.2%	7.10	10.90	3.30	0.37	0.76
8	50.3%	7.12	10.45	3.23	0.51	0.74
9	63.4%	6.99	10.88	3.30	0.39	0.75
10	57.3%	7.05	10.79	3.28	0.41	0.75

In a Confirmatory Factor Analysis for a one-Factor model, the Steiger-Lind Root-Mean Square Error of Approximation was 0.040 (90% confidence 0.037-0.042) and the Adjusted Population Gamma Index 0.975 (90% confidence 0.972-0.979), indicating an adequate fit (Hu & Bentfler, 1999; Brown, 2015).

Flynn Effect

For the full sample of n=4,201individuals collected between the years of 2011 and 2019, a Multiple Linear Regression of the number of correct items on the PAIMT controlling for sex, age, level of education, corrected per capita income and the year when the test was applied produced a model with an Adjusted R^2=25%, F(5,3832)=257.98, p<.01, n=3,838, where Year of Test Application showed no independent predictive power (Beta=-0.02, p=.20). This indicates that, once controlled for sociodemographic variables, there is no statistical change in the number of correct items on the PIMT as a function of time.

Deviation IQs

Using Classical Test Theory (CTT), an individual's performance on an intelligence test can be transformed into an IQ score with a Mean of 100 and a Standard Deviation of 15 through the following formula (Anasati & Urbina, 1997; Kaufman, 2009):

$$IQ = 100 + \frac{(X_i - \bar{X}) * 15}{\delta}$$

Where:

- X_i is the number of test items correctly answered by the individual;
- $\bar{X}$ is the Mean number of test items correctly answered by the general population;
- δ is the Standard Deviation of the Mean number of test items correctly answered by the general population.

The average number of correct items on the PAIMT for the standardization sample was M=7.620 with SD=2.9926, with a minimum of 0 and a maximum of 15, yielding scores from 62 to 137, which is the range of the test, encompassing approximately 98.8% of the general population.

g Factor

According to CTT, the g Factor is the Latent Trait responsible for performance in an IQ test, and it is estimated through the first Factor in an Exploratory Factor Analysis (Walrath et al., 2020). The overall g loading found for the PAIMT using the standardization sample was of 24.8%, with the Factor having a mean of 1.859 (SD=0.9239), ranging from -0.181 to 3.787.

Rasch Model True Ability

According to Item Response Theory (Carlson & von Davier, 2017), particularly the 1PL or Rasch Model (Smith & Smith, 2004), the True Ability of a test taker on a test with dichotomous outcomes is dependent on characteristics of both the test itself and of the individual, and can be inferred from the Difficulty of the items on the test through the following formula:

$$\theta = \bar{\beta} + Log\ (\frac{S}{L - S})$$

Where:

- q is True Ability
- $\bar{\beta}$ is the mean Difficulty of the test items;
- L is the total number of items on the test;
- S is the number of items correctly answered.

The mean Difficulty of the test items, in turn, can be very accurately estimated from the Natural Logarithm of the ratio between the percentage of items that were correctly answered and the percentage of items that were not (Wauters, Desmet & Van Den Noorgate, 2011).

Thus, in the present study it was possible to estimate the True Ability (q) of each test taker of the PAIMT, obtaining a Logit score with Mean=0.033 (SD=0.9251), ranging from -2.748 to 2.530.

Correlations Between Scores

Using the IQ, g Factor and q scores calculated for the full sample of n=4,201 individuals based on the standardization data (excluding a total of 59 individuals whose answers on the PAIMT where either all wrong or all correct in the case of q), it was found that IQ was highly correlated to the g Factor (Pearson r=.86, p<.01) and even more so to q (Pearson r=.99, p<.01), the latter two also being strongly correlated to each other (Pearson r =. 85, p<.01). This indicates that an association between one of those three scores to any other variables of interest is very likely to be mirrored in the remaining two.

PAIMT IQ and Educational Attainment

The Spearman correlation between the PAIMT IQ scores and the level of education for the full n=4,201 sample was Rho=.45, with p<.01. The relationship between ranges of scores and the probability of attaining different levels of education is shown in Figure 1, Element C.

Higher levels of the PAIMT IQ were monotonously associated to an increased probability of having a higher education degree and a

reduced probability of having only basic education. Those with a median level of the score where more likely to have an intermediate or high school level of education.

PAIMT IQ and Individual Income

For the n=2,413 in the labor market (excluding full time students, retirees or homemakers), the Spearman correlation between the PAIMT IQ and individual inflation-adjusted income was Rho=.41 (p<.01). A Multiple Linear Regression of the Natural Logarithm of individual inflation-adjusted income as a function of sex, age, level of education, per capita inflation-adjusted family income and PAIMT IQ produced a model with an Adjusted R^2=51%, F (5,2406) = 507.27, p<.01, n=2,412, where the PAIMT IQ showed an independent positive association to the dependent variable (Beta=0.13, p<.01). Given that the Natural Logarithm is a monotonic function, this shows that the PAIMT IQ has a positive association with inflation-adjusted individual income independently of sex, age, education and inflation-adjusted familial income.

PAMIT IQ and Self-Evaluation of Intellect

The Spearman correlation between the PAIMT IQ scores and the self-evaluation of one's intellect ("knowledge, intelligence and rationality") on a 0-4 Likert scale was Rho=.26 with p<.01 for n=607 adults (sum of subsamples "D" and "J" in Table 1). Figure 1, Element D, shows the graph for the association between PAIMT IQ ranges and the self-evaluation of intellect expressed as Z-Scores.

The findings indicate that the AIMT IQ's have a positive association to the self-evaluations of one's intellectual capacity, with those with scores of 106+ tending to rate themselves as above average and those 105- to rating themselves as below average.

PAMIT IQ and Sex

In the total sample of n=4,201, the men (n=2,082) had a mean PAIMT IQ of 103.5 (SD=15.47) and the women (n=2,119) a mean of 100.0 (SD=14.48), a statistically significant difference with p<.01 on the Mann-Whitney U Test. Men were 42.8% of those in the lower range of the score (up to 90), 47.1% in the median range (91-110), 56.1% in the higher range (111-125) and 64.4% in the gifted range (126 or more).

PAIMT IQ and Age

Figure 02 shows the PAIMT IQ per age group according to overall level of intelligence and having a higher education degree or not.

Overall, there was a negative correlation found between the PAIMT IQ and age (Spearman Rho=-.14, p<.01, n=4.154). Controlling for level of education, such a negative correlation occurred only among those with a middle school degree or less (Spearman Rho=-.34, p<.01, n=2,760) and not for those with a higher education degree or more (Spearman Rho=.00, p=.92, n=1,394). Likewise, only among those with an IQ of 110 or less was there a negative association between age and intelligence (Spearman Rho=-.14, p<.01, n=1,819), the same not happening among those with an IQ in the range of 111 or more (Spearman Rho=.01, p=.55, n=2,335).

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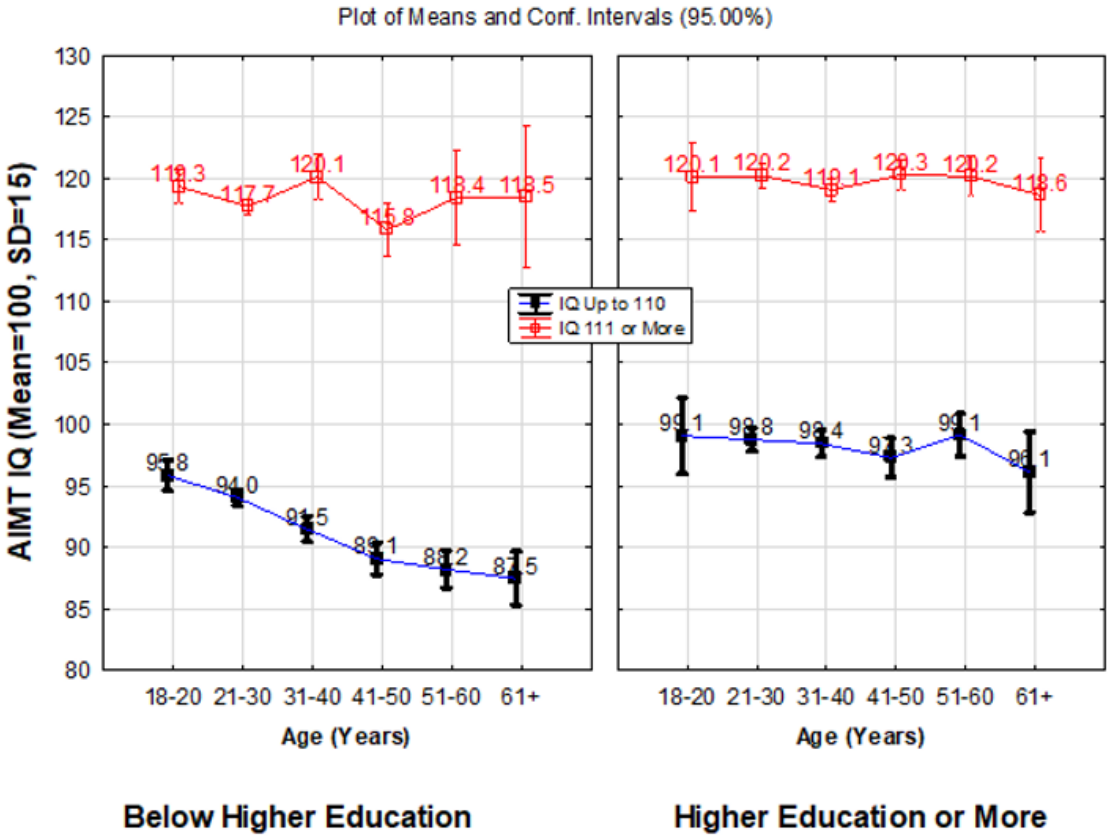

Figure 02. The PAIMT IQ as a function of age, education and range of intelligence.

Discussion

Contents and Psychometric Properties of the PAIMT

The elements of the Academic Thinking Test and of the Knowledge Test are comprised of items that involve identification, recall, understanding and problem-solving in the domain of abstract logical-mathematical, scientific and linguistic contents, all of which under time constraints. This corresponds to what is measured by an IQ test (Hermstein & Murray, 1994; Ulrich et al., 1996; Anastasi & Urbina, 1997; Kaufman, 2009; Mackintosh, 2011; Lynn & Vanhanen, 2012).

The combination of the Knowledge Test and the Academic Thinking Test, which forms the PAIMT, was found to be a fairly consistent

or reliable set of items that, taken together, measure a single trait, with the total number of correct answers having an approximately Gaussian distribution. The g Factor loading was within the lower -but acceptable- range observed for intelligence tests in general.

The first question of the Knowledge Test on the hereditability of individual experiences, arguably controversial due to Epigenetics as a confounding factor, behaved as a valid item with a correct answer of “no”. Not only did more than half of the standardization sample give that response, but in the total sample the proportion was even higher, as well as rising substantially with the level of education. Additionally, it showed a reasonable Item-Total correlation in the standardization sample, with its removal not having a substantial impact on the statistics of the total number of correct items and slightly reducing internal consistency. Therefore, it can be considered a legitimate scientific question with a correct answer of “no”, as suggested by Oliveira, Brando and Caldeira (2017), with its inclusion adding to the precision of the test.

Norming of the PAIMT

The PAIMT was applied to a fairly representative sample of the population of the state of Pernambuco, with only some deviations that approach the profile of those that an intelligence test would most likely be applied to (more schooling and income), while also being closer to the general demographics than the majority of the tests approved for clinical use in Brazil in general and Pernambuco in particular (Noronha, Freitas & Ottati, 2002; Noronha et al., 2003; Noronha & Primi, 2004; Reppold et al., 2017), particularly regarding adults (Campos & Nakano, 2012; Alves et al., 2016). In that regard, it is better than most, if not all, available alternatives.

The mean number of correct items on the PAIMT for the broader sample of adults from the state of Pernambuco from 2011 to 2019

showed no significant changes as a function of time once one controlled for sex, age, income and education, indicating the absence of a positive or negative Flynn Effect. This is consistent with the findings from Bandeira and Arteche (2012), though not with those from Colom, Flores-Mendoza and Abad (2007), perhaps due to the latter relying solely on the relatively imprecise Draw-a-Man Test, whereas the former added the use of the much better Raven's Colored Progressive Matrices. Also, Colom, Flores-Mendoza and Abad (2007) studied samples separated by a very large time gap of 72 years, which would not detect any stagnation or even a drop in recent decades, whereas Bandeira and Arteche (2012) compared samples from the 1980´s, 1990´s and 2000´s. In any case, the findings of the present investigation indicate that deviation PAIMT IQ's based on a representative sample from 2011 would not require any significant corrections at least up to 2019.

Convergent Validity of the PAIMT

The PAIMT IQ showed a strong positive association with educational attainment, the probability of having a higher education degree or more rising substantially with increasing levels of the score in question. This corroborates nearly every study that has ever been made regarding the relationship between intelligence and scholastic performance (Sternberg, Grigorenko & Bundy, 2001; Deary et al., 2007; Lynn & Mikk, 2007, 2009).

There was a positive correlation between the PAIMT IQ and individual income, which remained even when controlling for sex, age, level of education and per capita family income, just as also universally found (Jensen, 1982; Hermstein & Murray, 1994; Ulrich et al., 1996; Eysenck, 1998; Scullin et al., 2000; Sternberg, Grigorenko & Bundy, 2001; Firkowska-Mankiewicz, 2011; Hunt, 2011; Lynn & Vanhanen, 2012; Meisenberg, 2012; Ganuthula & Sinha, 2019).

The PAIMT IQ also showed a clear positive association to self-evaluation of intellectual capacity, similar to what is reported in multiple studies (Paulhus, Lysy & Yik, 1998; Furnham, Moutafi & Chamorro-Premuzic, 2004; 2005; Kornilova & Novikova, 2012).

Men were found to have a slightly higher mean AIMT IQ, even after controlling for age, education, income and year of testing. Albeit the difference in means for the sexes was of only 3.5 points, it did translate into a substantially higher proportion of men in the higher IQ ranges. Regardless of cause, such results reproduce the best literature and are well within the 1.8-5.0 difference reported in the various studies (Jensen & Reynolds, 1983; Ankney, 1992; Hedges & Nowell, 1995; Alexopoulos, 1996; Halpern & LaMay, 2000; Lynn, 2002; Irwing & Lynn, 2004; Lynn, Pullmann & Laidra, 2004; Jackson, 2006; Lynn & Kawazana, 2011; Nyborg, 2012; Flores-Mendonza et al., 2013; Liu & Lynn, 2015).

Age had a negative association with the PAIMT IQ, except for those with higher levels of IQ and/or education. In spite of the limitations of a cross-sectional analysis, it is nonetheless in agreement with studies showing the existence of an overall tendency towards cognitive decline with age (Bigler et al., 1995; Garde et al., 2000) but also with those indicating protective effects for education (Ardila et al., 2000) and level of intelligence (Deary et al., 2009).

Robustness of the PAIMT

The relatively simple deviation IQ scores calculated for the broader sample of adults from Pernambuco were highly correlated to g Factor estimates for the same sample and even more so to True Ability estimates from an ITR Rasch model. This suggests a significant robustness for the PAIMT regarding the trait being measured, with different approaches leading to scores with very similar associations to other variables. Given the relative ease with which one can calculate a

deviation IQ, this is, by far, the most practical score to use for research and screening purposes.

Conclusion

Analyses of data from a combination of 10 samples of adults from the state of Pernambuco, Brazil, collected between the years of 2011 and 2019, showed that the 15 items of the PAIMT produced a reliable, Gaussian and robust measure of a unidimensional latent trait. Norming was based on reasonably representative data collected in 2011, with later datasets indicating that there was no need to correct for a positive or negative Flynn Effect at least until 2019, allowing for the calculation of a deviation-based score called the PAIMT IQ, which was shown to be associated to sex, age, level of education, income and self-evaluation of intellectual ability as reported in the literature, even when controlling for selection bias and known mediating variables.

Given that the PAIMT was artificially pieced together from two preexisting tests, one must ponder the possibility that it might not measure actual intelligence, but something else, albeit correlated to it. However, it is clear that the test is measuring something in a fairly reliable way through the answers to questions involving abstract knowledge and problem-solving. It is also clear that that something is a Gaussian, unidimensional, construct that would have to be highly correlated to IQ in order to be associated to multiple other variables in the same way. Thus, one is hard pressed to think of anything else with all of these properties other than an IQ test and, even if one does manage to conceive such an alternate construct, it would still be a very good proxy for intelligence, i.e., for all practical purposes, a distinction without a difference.

Considering all the results of the present study, there appears to be substantial empirical evidence that the PAIMT IQ is a valid measure of general intellectual ability in adults, with the advantage of being a very

practical tool that can be applied in less than five minutes under informal, street-like, settings by non-psychologists with very little training. It corresponds to a deviation IQ with Mean=100 and SD=15, ranging from 62 to 137, applicable to adults 18 years or older, for research purposes or perhaps even as a screening tool, in the context of the state of Pernambuco. Also, there is no reason to expect that this test cannot be readily normed for other states in Brazil, the country as a whole or even to other Portuguese-speaking nations. Likewise, with adequate translation, customization and/or adaptation, a similar instrument can be made for use in essentially any part of the world.

The findings presented here constitute a demonstration of the possibility of using simple tasks and questions of a scholastic nature, under a strict control of time, for the construction of practical tests for a very rapid, yet accurate, measurement of general intelligence in street-like conditions. This allows for the easy creation of instruments that can be applied to a large number of individuals in very little time, with great flexibility of settings and requiring far fewer resources, allowing for the quick and cheap establishment of representative samples with less recruitment bias. The implication is that, with this approach, one can, rapidly and at a low cost, develop, norm and deploy sound measures of IQ that, at least for research and screening purposes, are valid for a given region or country.

As a caveat, further studies are needed to better determine the accuracy of the new score in question and its potential, if any, for individual clinical assessments, particularly through concurrent validity with one or more well-established measures of intelligence.

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