Personality and Individual Differences 55 (2013) 406–410

Contents lists available at SciVerse ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

Spearman's Law of Diminishing Returns and national ability

Thomas R. Coyle [a,*], Heiner Rindermann [b]

[a] Department of Psychology, University of Texas at San Antonio, United States
[b] Department of Psychology, Chemnitz University of Technology, Germany

ARTICLE INFO

Article history:
Received 18 February 2013
Received in revised form 5 March 2013
Accepted 29 March 2013
Available online 29 April 2013

Keywords:
General intelligence (*g*)
National *G* factor
SLODR
PISA
TIMSS
PIRLS
Lynn & Vanhanen

ABSTRACT

This research examined Spearman's Law of Diminishing Returns (SLODR) using national ability as the unit of analysis. National ability was estimated using international standardized tests such as the Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS). Factor analysis estimated the national *G* loadings of tests for high and low ability nations. Consistent with SLODR, the *G* loadings of tests were lower for higher ability nations. The pattern was confirmed after correcting for school attendance and age biases. Because a test's *g* loading is directly related to its predictive validity (correlation with outcomes), our results imply that the predictive validity of tests may be lower for higher ability nations.

1. Introduction

This research examines international differences in general intelligence (*g*, big "*G*" at the national level), defined as variance common to diverse mental tests. *g* arises from positive manifold, a reference to positive correlations among different tests. Positive manifold indicates that people who do well on one test generally do well on all others, a finding repeatedly confirmed (Jensen, 1998).

A concept related to *g* is Spearman's Law of Diminishing Returns (SLODR; Jensen, 1998, pp. 585–588). SLODR predicts that correlations and *g* loadings of tests should decline with increases in the ability level of subjects. SLODR is based on Spearman's (1932) observation that correlations among tests are lower for higher ability subjects. In Spearman's (1932, p. 219) words, "The correlations always become smaller—showing the influence of *g* on any ability to grow less—in just the classes of person which, on the whole, possess this *g* more abundantly." One theory of SLODR is the differentiation hypothesis, which states that increases in the ability level of subjects are associated with increases in cognitive specialization, which reduces *g* variance among tests (Deary et al., 1996).

SLODR has been tested using various indicators of *g*, including correlations among tests, *g* loadings of tests, and variance in tests accounted for by *g* (Jensen, 1998, pp. 585–588). Consistent with SLODR, these indicators of *g* typically decline with increases in the ability level of subjects. The size of the decline, based on *g* loadings, is small but consistent over a range of two standard deviations in ability (effect ≈.10; te Nijenhuis & Hartmann, 2006, p. 438). The decline (in *g* loadings) has implications for predictive validity: Because a test's predictive validity is directly related to its *g* loading, the predictive validity of tests (correlation of tests with cognitive variables) should be lower for higher ability groups, a prediction that has received support (Detterman & Daniel, 1989, Table 1, p. 352).

Much of the evidence supporting SLODR comes from studies comparing high and low ability groups *within* countries (Jensen, 1998, pp. 585–588). These studies have compared different races, ethnicities, and ability groups in standardization samples (e.g., Wechsler IQ Tests; Detterman & Daniel, 1989). Consistent with SLODR, correlations and *g* loadings of tests have generally been lower for higher ability groups.

The current research is the first to examine SLODR at the level of nations. National ability was measured as a nation's performance on international standardized tests. The tests included the Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS).

International standardized tests have revealed substantial differences in national ability. In Greenwich IQ units (UK $M = 100$, $SD = 15$), national ability ranges from 60–62 in Saint Lucia, Gambia, and Malawi (Rindermann, 2012a) to 103–105 in Taiwan, Korea,

* Corresponding author. Address: University of Texas at San Antonio, Department of Psychology, One UTSA Circle, San Antonio, TX 78249, United States. Tel.: +1 210 458 7407; fax: +1 210 458 5728.
E-mail address: thomas.coyle@utsa.edu (T.R. Coyle).

0191-8869/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.paid.2013.03.023

Hong Kong, Japan, and Singapore (Lynn & Vanhanen, 2012; Meisenberg & Lynn, 2011; Rindermann, 2007a). This variation in national ability predicts differences in economic growth, rule of law, liberty and democracy, and health (Rindermann, 2012b; Rindermann & Meisenberg, 2009). Such differences may be caused by cross-country variation in culture, genes, wealth, modernization, and education (e.g., Hunt, 2012; Rindermann, Woodley, & Stratford, 2012).

The current research examined SLODR at the national level using international standardized tests as measures of national ability. Nations were divided into high and low ability groups based on their performance on international tests. Because nations are merely groups of people with different levels of ability, SLODR (which applies to groups) was expected to apply to nations. Thus, it was predicted that the national *G* loadings of tests would be lower for higher ability nations.

2. Method

2.1. Tests and assessments

Data from international standardized tests were obtained from public surveys. Because preliminary factor analyses with all surveys would not converge to a solution, older surveys with smaller country samples (e.g., IEA-Reading from 1990/91) and surveys covering only single regions (e.g., SACMEQ in Africa) had to be excluded. Within PISA and TIMSS, the newer and larger surveys were chosen (with TIMSS covering both grade 4 and 8). The following tests provided uncorrected and corrected country means and could be used in all analyses: PISA-Reading 2006, PISA-Math 2006, PISA-Science 2006, PISA-Reading 2009, PISA-Math 2009, PISA-Science 2009, TIMSS-Math 8th grade 2003, TIMSS-Science 8th grade 2003, TIMSS-Math 4th grade 2007, TIMSS-Science 4th grade 2007, TIMSS-Math 8th grade 2007, TIMSS-Science 8th grade 2007, PIRLS-Reading 2001, PIRLS-Reading 2006, and psychometric IQ tests (Supplement 1a and 1b). (Abbreviations are explained below.) Test scores were averaged to estimate the ability level of each nation (Rindermann, 2007a; Rindermann, Sailer, & Thompson, 2009).

In prior research, student assessment studies (SAS) have reported results on a scale of $M = 500$ and $SD = 100$ (for PISA, TIMSS, and PIRLS). The current study retains these values, which roughly represent the mean ability level, and average within country heterogeneity, in well-developed Western countries (e.g., North-West-Middle Europe, North America, Australia, and New Zealand). The psychometric IQ collection of Lynn and Vanhanen (2012) is "Greenwich" scaled using the British sample ($M = 100$, $SD = 15$).

2.1.1. Data

PISA (Programme for International Student Assessment) measures academic competence in reading, mathematics, and science (and problem solving in 2003) for 15-year-old students. The surveys began in 2000 and have been repeated every three years, with increasing participation in each wave. The survey is organized by the OECD (Organisation for Economic Co-operation and Development).

PISA 2006 reports results in reading, mathematics, and science for $N = 56$ to 57 countries (OECD, 2007, Figs. 2.13, 6.8b, 6.20a, pp. 63, 296, 316).

PISA 2009 reports results in reading, mathematics, and science for $N = 73$ countries (OECD, 2010, Tables I.2.3, I.3.3, I.3.6, pp. 197, 224, 228). Results for further countries (e.g., India, Venezuela, and Moldova) were reported by Walker (2011, Tables 2.1, 3.1, 3.3, pp. 10, 42, 53).

TIMSS (Trends in International Mathematics and Science Study) measures competence in mathematics and science for mostly fourth, eighth, and twelfth graders and, depending on school starting age, for third and seventh graders in some countries. TIMSS focuses on core aspects of curricula in different countries, with greater emphasis on the curricula of developed countries. The surveys are repeated every four years (1995ff.), with increasing participation in each wave. The survey is organized by the IEA (International Association for the Evaluation of Educational Achievement).

TIMSS 2003 reports results in mathematics and science for eighth graders in $N = 45$ countries (Mullis, Martin, Gonzalez, & Chrostowski, 2004, Exhibit 1.1, p. 34; Martin, Mullis, Gonzalez, & Chrostowski, 2004, Exhibit 1.1, p. 36).

TIMSS 2007 reports results in mathematics and science for fourth and eighth graders in $N = 36$ and 50 countries, respectively (Mullis et al., 2008, Exhibit 1.1, p. 34f; Martin et al., 2008, Exhibit 1.1, p. 34f).

PIRLS (Progress in International Reading Literacy Study) measures competence in reading for fourth graders and, depending on school starting age, for third graders in some countries. The surveys are repeated every 5 years (2001ff.), with more countries participating in each wave. The survey is organized by the IEA.

PIRLS 2001 reports results in reading for fourth graders in $N = 33$ countries (Mullis, Martin, Gonzalez, & Kennedy, 2003, Exhibit 1.1, p. 26).

PIRLS 2006 reports results in reading for fourth graders in $N = 39$ countries (Mullis, Martin, Kennedy, & Foy, 2007, Exhibit 1.1, p. 37).

Finally, the psychometric IQ collection of Lynn and Vanhanen (2012) was used. The collection includes intelligence tests, notably Raven's Matrices, Culture Fair Intelligence Test, Wechsler Intelligence Scale for Children, and more rarely, the American Otis Test, Kaufman Assessment Battery for Children, and Primary Mental Abilities Test, among others (see Lynn & Vanhanen, 2012, pp. 392ff.). When available, results for a single country were taken from different IQ studies and averaged. Surveys from different test years were corrected for the secular rise of IQ (FLynn-effect), and standardized using the Greenwich norm from the British sample ($M = 100$, $SD = 15$; see also Meisenberg & Lynn, 2011). Mistakes and flaws (see Hunt, 2011; Wicherts, Dolan, Carlson, & Van der Maas, 2010) were corrected (e.g., wrong data for Equatorial Guinea eliminated), and newer data were added (e.g., for Costa Rica). The current study uses only measured (not estimated) psychometric IQs, which were available for $N = 88$ countries also having student assessment data (Supplement 1a and 1b). No corrections were applied to the psychometric IQs.

2.1.2. Single country corrections

The *Kazakhstan* 2007 TIMSS fourth grade results differ widely from those of countries with similar cultural, ethnic, and economic backgrounds (e.g., Armenia, Iran, and Ukraine) and from the Kazakhstan PISA 2009 results. (Mean SAS scores in Kazakhstan for TIMSS 2007 and PISA 2009 are, respectively, 542 and 390, a difference of 152 SAS points, equal to $d = 1.52$ or 22.80 IQ.) Because of these divergences, only the PISA 2009 results were used.

China has not participated in a recent student assessment study. In PISA 2009, only results for the province of Shanghai were reported. Due to selective within-country migration, local economic success, and development status, the Shanghai PISA results are likely positively biased compared to all of China (UNDP China, 2010, Table 1, p. 131). To correct this bias, we assume a 33 SAS overestimation and subtract 33 points (equal to $d = 0.33$ or 5.00 IQ).

India also has not participated in a recent student assessment study, with the exception of the states of Himachal Pradesh and Tamil Nadu. Both states have advanced education and income levels