Bilingualism enriches the poor: Enhanced cognitive control in low-income minority children

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Complete List of Authors:	Engel de Abreu, Pascale; University of Luxembourg, EMACS Research Unit Cruz-Santos, Anabela; University of Minho, Tourinho, Carlos; University of Luxembourg, EMACS Research Unit Martin, Romain; University of Luxembourg, EMACS Research Unit Bialystok, Ellen; York University,

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Running head: BILINGUALISM ENRICHES THE POOR

Bilingualism enriches the poor: Enhanced cognitive control in low-income minority children

Pascale M. J. Engel de Abreu[1], Anabela Cruz-Santos[2], Carlos J. Tourinho[1], Romain Martin[1], & Ellen Bialystok[3]

[1] University of Luxembourg - Luxembourg

[2] University of Minho - Portugal

[3] York University – Canada

Address for correspondence:

Pascale M. J. Engel de Abreu

EMACS Research Unit,

University of Luxembourg,

L-7201 Walferdange, G.D. de Luxembourg.

Email: Pascale.Engel@uni.lu

Tel: (+352) 46 66 44 - 9779

Fax: (+352) 46 66 44 - 9556

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Abstract

This study explores whether the cognitive advantage associated with bilingualism in executive functioning extends to young minority-language children challenged by poverty and if so, which specific processes are most affected. Forty Portuguese-Luxembourgish bilingual children from low-income immigrant families in Luxembourg and 40 matched monolingual children from Portugal completed visuo-spatial tests of working memory, abstract reasoning, selective attention, and interference suppression. Two broad cognitive factors of executive functioning labeled representation (abstract reasoning and working memory) and control (selective attention and inhibitory suppression) emerged from principal components analysis. Whereas there were no group differences in representation, the bilinguals performed significantly better than the monolinguals in control. These results demonstrate first, that the bilingual advantage is neither confounded with nor limited by socioeconomic and cultural factors and second, that separable aspects of executive functioning are differentially affected by bilingualism. The bilingual advantage lies in control but not in visuo-spatial representational processes.

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Substantial evidence demonstrates that the regular use of more than one language benefits a variety of executive functions including switching attention, working memory, metalinguistic awareness, creativity, and problem solving (see Adesope, Lavin, Thompson, & Ungerleider, 2010 for a review of research with children and Hilchey & Klein, 2011 for a review of research with adults). One explanation for this bilingual advantage is that the experience of managing several languages on a regular basis *trains* executive functions that are needed to resolve conflict between competing language systems and improves their functioning across other tasks and domains (Bialystok, Craik, Green, & Gollan, 2009). Support for this view comes from fMRI studies of bilinguals showing recruitment of the general executive control system for language switching (Luk, Green, Abutalebi, & Grady, 2011).

Bilingual advantages in executive functioning, however, have not been found in all studies (Bajo, Padilla, & Padilla, 2000; Engel de Abreu, 2011) leading to the suggestion that the observed effects might be related to privileged social backgrounds (i.e., socioeconomic status, SES) rather than bilingualism *per se*. Differences in SES could bias the results in two ways, namely, as a confound or as a limiting condition. Regarding the first possibility, Morton and Harper (2007) argued that previous studies did not properly match SES across groups with the consequence that wealthy bilingual children were being compared to monolingual children from less favorable economical conditions. Bialystok (2009) rejected this claim, explaining that, at least in her research, SES was controlled by sampling the bilingual and monolingual children from the same schools located in economically homogeneous middle-class neighborhoods (Bialystok, 2010).

Second, it may be that the bilingual advantages reported in executive functioning emerge only for children in higher SES brackets, the population most involved in previous research (Oller & Pearson, 2002). This possibility presents a limiting condition in which the constellation of advantages associated with high SES is necessary for children to fully benefit from the opportunity presented by bilingualism. Thus, bilingualism might produce positive effects for children from advantaged social conditions but produce no or even negative effects for children from less favorable backgrounds.

Although it has been reliably shown that children from lower SES backgrounds manifest poorer performance in executive function task than their wealthier peers (Noble, Norman, & Farah, 2005), few studies have explored the effect of bilingualism in children growing up in poverty. Two previous studies reported some benefit of bilingualism for low SES Spanish-English bilingual children (Carlson & Meltzoff, 2008; Mezzacappa, 2004) but both studies compared performance to privileged monolingual children from a different ethnic group and used statistical procedures to control for the substantial initial differences between groups. Thus, no studies to date have examined monolingual and bilingual children in comparable low SES situations from the same cultural group to determine whether the bilingual cognitive advantages previously reported require a specific social context.

In the present study we examine whether the bilingual advantage in executive functioning that is observed in studies targeting middle-class, English-speaking bilinguals in North America can be detected in young minority-language children growing up in low-income immigrant families in Luxembourg. The Grand-Duchy of Luxembourg provides a fruitful linguistic and socio-demographic landscape to explore questions related to SES and multilingualism. The country and educational system are trilingual with Luxembourgish, German, and French being recognized as official languages. Luxembourgish is spoken throughout the country and is the sole language of instruction when children start school at the age of 4. At the age of 6, children are introduced to their first second language, German, and one year later they start to learn their second foreign language, French. The Grand-Duchy's stable, prosperous economy depends heavily on foreign workers; the Portuguese community is by far the largest foreign-born population segment representing 16% of the country's total population (Statec, 2011). The Portuguese living in Luxembourg mostly emigrated from Northern Portugal and tend to be low or unskilled laborers with little education (Alieva, 2009). Despite governmental efforts to reduce social inequalities, the Portuguese students continue to be vastly over-represented in lower educational tracks and special educational programs (MENFP, 2011).

The study focused on first and second generation immigrant children of low-income Portugal-born parents living in Luxembourg who were carefully matched with monolinguals from comparable socio-demographic backgrounds in Northern Portugal – the region from which the families in Luxembourg had emigrated. The matching assured that there was no confound with SES and ethnicity in the group structure, so performance differences between language groups could be clearly attributed to bilingualism. Additionally, the low-income status of the children provides a means for testing the possibility that high SES is an enabling condition for bilingualism to enhance executive functioning. Finally, in contrast to previous studies that generally employ a single measure or type of task to assess executive functioning (e.g. Bialystok, 2010; Engel de Abreu, 2011; Morton & Harper, 2007), the present study included a range of measures that varied in their underlying processes and surface manifestations in order to identify the specific aspect of executive functioning that is impacted by bilingualism.

Bialystok (1991, 2001; Craik & Bialystok, 2006) proposed a theoretical distinction between representation (formally "analysis") and control. Representation is the process of encoding and structuring knowledge in a manner that permits retrieval, logical interference, and access to relational information. The functions contributing to control include selectively attending to relevant aspects of a problem, inhibiting misleading information, and switching between competing responses. In studies with adults and older children, bilingual advantages were found for tasks based on control but no differences were observed for tasks based on representation (for reviews see Bialystok, 1991; 2001). This distinction was incorporated into the present design to validate the dissociation of representation and control processes in young children, determine the effect of bilingualism on each, and establish the applicability of this model for low SES minority-language children. The hypotheses were that bilingualism selectively affects the ability to resolve conflict, an aspect of cognitive control, and that this difference would emerge in carefully matched children from low SES backgrounds.

Method

Participants

Testing was conducted in second grade classrooms across Northern Portugal and the Grand-Duchy of Luxembourg. Portugal and Luxembourg are relatively small countries, both are members of the European Union, and there are no apparent within-country disparities in terms of the quality of public school education. Schools were carefully targeted to be comparable across countries with respect to their number (6 schools in each country), class size (mean of 22 students per class), and demographic region (mean resident population of 8,892). Although the selected children lived in low SES families none of the schools was located in severely disadvantaged neighborhoods, all of the teachers were highly qualified, the curriculum was equivalent across countries (with the exception of foreign language instruction being part of the curriculum in Luxembourg), and none of the schools indicated difficulties with educational resources (additional school and country information is available on-line in Table S1).

In total 121 children were assessed (67 in Luxembourg and 54 in Portugal); they were matched on gender (50% of boys in each group), ethnicity (99% Caucasian), chronological age, and the international socio-economic status index (ISEI-08 based on caregiver occupation; Ganzeboom, 2010). Exclusion criteria included: maternal alcohol or drug use during pregnancy; severe pregnancy or birth complications; history of head injury, epilepsy, or hearing problems; diagnosed special educational needs; bilingualism (for the Northern Portugal group). The final sample consisted of 40 Portuguese children from monolingual homes in Portugal and 40 Portuguese-Luxembourgish bilingual children who lived in Portuguese-speaking homes in Luxembourg.

The first language of all children was Portuguese. In the bilingual group, 25% of the children were first generation immigrants; they were born in Portugal and had immigrated to Luxembourg before the age of three. The remaining children were second-generation immigrants who were born in Luxembourg to Portugal-born parents. All children were exposed to Portuguese at home and had completed their first four years of education in Luxembourgish schools. Parents reported that children used Portuguese and Luxembourgish on a daily basis. The monolingual group had monolingual parents, spoke only Portuguese at home, and attended monolingual schools in Portugal.

Main participants' characteristics are reported in Table 1 (additional sample information is available on-line in Table S2). Socioeconomic status was assessed by a range of indices: the equivalized disposable household income (OECD, 2011); household possessions and size; stimulation in the home (based on Caldwell & Bradley, 1984); caregiver education (ISCED-97 mapped onto years of education, UNESCO, 1997) and occupation (ISCO-08, ILO, 2008); nutritional status of the child (Body Mass Index-for-age, WHO 2009).

Table 1 about here

Despite ISEI matching, the bilingual group was disadvantaged in terms of parental education, household possessions, and household size. Income information showed that all of the bilingual children came from low-income households of which 18% fell below the poverty line[1]. The poverty index frequencies for the monolingual households were as follows: 72% low-income (of which 22% below the poverty line); 15% median-income; 12% wealthy.

Procedure and material

With the exception of the Luxembourgish vocabulary measure (bilinguals only) all of the tests were administered in Portuguese by native Portuguese-speakers. All the measures had been translated and back-translated from the English original and had been used in previous studies with Portuguese-speaking children (Engel, Santos, & Gathercole, 2009). Reliability of instruments was established for the scores produced by the measures in this study. Computerized tasks were administered on Dell Vostro laptops with a 15.4" display.

Language measure

Children completed the *Expressive One Word Picture Vocabulary Test* (EOWPVT, Brownell, 2000) in which they name pictures. The bilingual children completed the task in both languages (counterbalanced across the first and the last testing session) and received a score for each language and a conceptual score indicating the number of unique concepts that could be named. Children who did not know a word in Luxembourgish could use a German or a French word which then counted towards the total conceptual score. As no norms or item statistics were available the same predetermined fixed set of items was administered to all children. The maximum score on the test was 51.

Cognitive measures

Abstract reasoning was assessed with the *Raven Colored Progressive Matrices* (Raven, Court, & Raven, 1986) a nonverbal task in which geometrical figures need to be completed by choosing the missing piece among 6 alternatives. The maximum score was 36.

Two working memory measures from the EU-Portuguese version of the computerized Automated Working Memory Assessment[2] (Alloway, 2007) were administered. Both measures are span tasks in which the number of items to be remembered increases progressively over successive blocks. The number of correctly recalled trials serves as the dependent variable. The *Odd-One-Out* is a complex span task in which visuo-spatial information have to be simultaneously processed and stored. Children are presented with arrays of three boxes with one shape in each. They are asked to identify the shape that does not match with the two others (i.e. processing) and remember its location in each array (i.e. storage). At the end of the trial children are presented with an array of empty boxes and are asked to recall the localization of the odd shape of each array by tapping the empty boxes in the right order. The *Dot Matrix* is a visuo-spatial simple span task involving storage but no explicit processing demands. A red dot appears in different locations of a 4X4 matrix; children are asked to remember the sequence of locations and recall them by tapping the squares of the empty matrix in the right order at the end of each trial.

The *Sky Search* task from the Test of Everyday Attention for Children[2] was administered as a measure of selective attention (Manly, Robertson, Anderson, & Nimmo-Smith, 1998). The test consists of an A3-sheet depicting 128 paired spacecrafts of which 20 pairs are identical. Children have to circle the 20 target items as fast as possible without being distracted by the lures. Subsequently children are administered a motor control version of the task containing only the 20 target items. The sky search time-per-target score is calculated adjusted for motor speed.

Inhibitory suppression was assessed with a *Flanker* task, modified after Rueda and colleagues (2004), that was administered with response buttons on each side of the computer screen. The test consists of displays containing a horizontal row of five equally-spaced yellow fish, and children indicate the direction of the central fish by pressing the corresponding left or right response button as quickly as possible. On congruent trials (50%) the flanking fish are pointing in the same direction as the target and on incongruent trials (50%) the distracters point in the opposite direction. Each trial starts with a 1000 ms fixation cross in the middle of the screen, followed by the fish array for 5000 ms or until a response is made. Responses are followed by a 2000 ms feed-back and a 400 ms blank interval. Children complete 2 blocks of 20 trials each in which presentation of congruent and incongruent trials is randomized. Eight practice trials precede the experimental trials: If more than two errors occur on these trials the instructions and the practice are repeated until the child reaches the criterion level. Response time (RTs) and accuracy are recorded. Incorrect responses, RTs below 200 ms, and RTs above 3 *SD*s of children's individual means were excluded from the analyses (< 3% of trials).

Results

Descriptive statistics for all measures are reported in Table 2. Within-subject comparison showed that the bilinguals named significantly more words in Portuguese than in Luxembourgish [$t(39) = 5.76$, $p < .01$, $d = 1.14$]. Monolingual children performed significantly better than the bilinguals on the Portuguese single vocabulary measure ($p < .01$) and on conceptual vocabulary ($p < .01$). Groups did not differ significantly on abstract reasoning (Raven) or on the working memory measures (odd-one out and dot matrix) with *p*s > .15. Accuracy on the flanker task was at ceiling for both groups in both conditions [mean percent correct = 97.72, *SD* = 4.48]. RTs were significantly lower for the congruent than the incongruent trials [$t(79) = 5.35$, $p < .01$, $d = .37$], and bilinguals were significantly faster than monolinguals in both trial conditions [incongruent: $t(78) = -3.39$, $p < .01$, $d = .76$; congruent: $t(78) = -3.13$, $p < .01$, $d = .69$]. RTs were strongly related across trial conditions ($r = .87$); only RTs for incongruent trials were therefore included in the subsequent principal component analysis. Groups did not differ significantly on motor control ($p > .05$) but bilinguals were significantly faster than monolinguals in the sky search task (controlled for motor speed) [$t(78) = -2.97$, $p < .01$ $d = .67$].

Table 2 about here

Raven, odd-one-out, dot matrix, sky search, and the RTs for incongruent flanker trials were submitted to a principal component analysis with Varimax rotation of the factor structure. Two factors with eigenvalues above 1.00 emerged (accounting for 35% and 25% of the variance), indicating that the measures capture distinct aspects of executive functioning. Factor loadings on the rotated matrix are represented in Table 3. The factor structure was very clear: Abstract reasoning and the working memory measures loaded on factor 1 (factor loadings between .66 and .77) and the selective attention and inhibitory suppression tasks loaded on factor 2 (factor loadings of .83 and .85). Factor 1 is interpreted as representation because the working memory measures and the Raven rely on visuo-spatial encoding and analytical processes without a misleading context. Factor 2 is labeled control because sky search and flanker tasks both involve conflicting information that require selective attention and inhibition to be resolved successfully. Using computed factor scores as the dependent variable, between-group comparisons showed that the bilinguals outperformed the monolinguals on the control factor [bilinguals: mean = -.41, *SD* = .69; monolinguals: mean = .41, *SD* = 1.10; $t(78) = -3.98$, $p < .01$, *d* = .89], but groups performed equivalently on the representation factor [bilinguals: mean = -.14, *SD* = 1.03; monolinguals: mean = .14, *SD* = .96; *t*(78) = -1.29, *p* = .20, *d* = .29].

Table 3 about here

Discussion

There were three major findings from this study. First, the principal component analysis revealed two clear factors that were described as representation (abstract reasoning and working memory) and control (selective attention and inhibitory suppression). This result validates the dissociation account of executive functions (Bialystok, 1991, 2001; Craik & Bialystok, 2006) and extends it to young children from a low SES background.

Second, bilingualism positively affected only one of these processes, namely control, with no group difference in representation (cf., Bialystok, 1991, 2001). Thus, bilingualism does not simply lead to a domain-general increase in cognitive ability that could reflect other environmental factors associated with bilingualism such as SES, but instead selectively influences the ability to deal with conflict. Our findings shed light on inconsistencies in previous research by demonstrating the importance of considering the specific cognitive demands of executive function tasks. The higher the control demand of the task the more likely it is that a bilingual effect will emerge.

Third, and most importantly, the bilingual advantage in control was found in children growing up in economically-disadvantaged families. This bilingual advantage was robust with a large effect size. Because of the detailed matching of children across the monolingual and bilingual groups, these results rule out claims that the bilingual benefits previously reported can be explained by economic or cultural differences (Morton & Harper, 2007; Oh & Lewis, 2008). Instead, the data are consistent with the position that the constant use of executive control to resolve language conflict strengthens these processes and makes bilinguals more proficient than monolinguals in executive function tasks involving directing attention, focusing on relevant aspects of a problem, and filtering misleading information (Bialystok, 1991, 2001).

It is firmly established that early adverse childhood experience can have detrimental effects on children's cognitive development (Noble et al., 2005). Young children growing up in underprivileged conditions are likely to experience environments that impede or even harm healthy brain development (e.g., unresponsive caregiving, stress exposure, economic hardship). In the present study, low-income bilingual children outperformed monolinguals in executive control, despite the presence of environmental conditions that would usually be associated with equivalent or even lower performance. The ability of the brain to sustain normal or improved functioning in the face of significant adverse conditions has been referred to as 'cognitive reserve' (Stern, 2003). Lifelong bilingualism has been found to contribute to cognitive reserve in the elderly by attenuating the negative effects associated with dementia (Craik, Bialystok, & Freedman, 2010). The present study suggests that bilingualism might also provide protection against the adverse cognitive effects that are associated with poverty. From this perspective, regular use of more than one language is a mentally stimulating activity that provides the opportunity to strengthen executive control mechanisms that build a defense to counteract the negative impact of poverty on cognition.

One remarkable feature of our results was that cognitive benefits were detected despite the strikingly low vocabulary scores of the bilingual children. Cognitive advantages are thus possible even with a seemingly low degree of proficiency in both languages. These results clearly show that in spite of facing many linguistic challenges, minority-language children also present important strengths in nonlinguistic cognitive domains that promote academic achievement. (Blair & Razza, 2007; Engel de Abreu, Gathercole, & Martin, 2011; St Clair-Thompson & Gathercole, 2006).

There are a variety of intervention programs designed to improve children's executive control capacities ranging from martial arts to computerized training programs (see Diamond & Lee, 2011 for a review). Unfortunately the majority of these approaches are expensive, so instead of reducing social inequalities they may exacerbate them. Curriculum-based approaches that are accessible to all children might be more appropriate for children from economically-disadvantaged backgrounds. Our findings indicate that intervention programs that are based on foreign language learning are a fruitful avenue for further exploration. Teaching a foreign language does not involve costly equipment, it has the obvious benefit of widening children's linguistic and cultural horizons, and it fosters the healthy development of executive control. Recent research has shown that studying a second language in an immersion school program leads to similar benefits found for bilingual children but in a somewhat reduced form (Bialystok, Peets, & Moreno, in press; Hermanto, Moreno, & Bialystok, in press). Participating in foreign language programs might thus be a promising tool towards reducing the achievement gap between more- and less-advantaged children by contributing to the construction of a sound cognitive foundation that might help children to reach their full potential and improve their educational opportunities.

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Footnotes

[1]This paper employs the OECD (2011) poverty indicator, which is constructed by comparing a household's equivalent income to a relative poverty line that is set at 50% of the median disposable income prevailing in each country. Relative poverty refers to a standard of living or level of income that is high enough to satisfy basic needs but still significantly lower than that of the majority of the population under consideration. A child was considered as *poor* if the household's equivalent income fell below the poverty line; a child was considered as *low-income* if the household income was less than the median of the respective country; a child was considered as *wealthy* when the household's income was above 50% of the median income of the respective country.

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TABLE 1

Mean Scores (and Standard Deviations) of all Background Measures by Group.

	Bilinguals n = 40	Monolinguals n = 40	Significance	
Characteristics	Mean (*SD*)	Mean (*SD*)	*t*(78)	Effect size
Age (months)	99 (3.3)	98 (3.8)	1.25	.28
Schooling (months)	54.9 (4.6)	54.6 (8.4)	.20	.04
Class size (number of students)	22.1 (9.8)	22.4 (2.0)	-.19	.04
Resident population	9,741 (8,540)	8,043 (15,461)	.61	.14
International socioeconomic index[1]	35.3 (6.2)	35.7 (8.7)	-.24	.05
BMI-for-age (z-score)[2]	.72 (1.1)	.81 (1.0)	-.46	.09
Home stimulation[3]	.71 (.15)	.70 (.16)	.23	.06
Caregiver education (years)[1]	9.2 (3.1)	10.8 (3.4)	**-2.17**	**.49**
Household possessions[3]	.53 (.15)	.64 (.14)	**-3.60**	**.76**
Household size	4.4 (.90)	3.8 (.89)	**3.00**	**.67**
Annual household income[4]	\$23,882 (\$7,850) 30% < national median	\$11,095 (\$6,076) 15% < national median	N/A	N/A

Note: p < .05 are marked in boldface. Effect sizes are Cohen's d. [1]Highest level of either caregiver was used. [2]BMI: Body mass index was established following WHO guidelines (2008) with calibrated Plenna MEA 07400 scales, Seca 214 stadiometers, and WHO Anthroplus software. [3]Proportion score: caregivers were asked a series of questions with rating scale format, responses were totaled and divided by the highest possible score. [4]Annual median equivalized disposable household income in USD (OECD, 2011). Data were obtained from caregivers and teacher using the LLBQ-Pt (Luxembourg Language and Background Questionnaire-Portugeuse Version) and the LTQ-Lu and –Pt (Luxembourg Teacher Questionnaires – Luxembourgish and Portuguese Version) designed for the purpose of this study.

TABLE 2

Descriptive Statistics for Task Measures by Language Group.

Measures	Bilinguals $n = 40$		Monolinguals $n = 40$		Significance	
	Mean (*SD*)	Reliability	Mean (*SD*)	Reliability	*t*(78)	Effect size
Language						
EOWPVT Portuguese[a]	23.7 (5.9)	.84	36.0 (3.9)	.72	**-11.01**	**2.46**
EOWPVT Luxembourgish[a]	17.2 (5.3)	.83	N/A	N/A	N/A	N/A
Conceptual vocabulary	27.3 (4.3)	.83	36.0 (3.9)	.72	**-9.32**	**2.08**
Cognitive abilities						
Raven accuracy	26.1 (3.6)	.86	26.4 (4.0)	.92	-.36	.08
Odd-one-out accuracy	15.4 (4.1)	.91	15.7 (3.9)	.91	-.31	.07
Dot matrix accuracy	19.1 (4.3)	.93	20.3 (3.7)	.85	-1.30	.30
Motor control (s)	28.9 (8.9)	N/A	32.3 (8.2)	N/A	-1.77	.40
Sky search: time/target (s)	5.0 (1.5)	N/A	6.2 (1.9)	N/A	**-2.97**	**.67**
Flanker congruent RT (ms)	734 (122)	.82	838 (174)	.89	**-3.13**	**.69**

Flanker incongruent RT (ms)	776 (140)	.84	940 (270)	.89	**-3.39**	**.76**
Flanker congruent accuracy	19.7 (.80)	N/A	19.6 (.83)	N/A	.89	.03
Flanker incongruent accuracy	19.4 (.87)	N/A	19.4 (1.1)	N/A	.00	.01

Note: $p < .05$ are marked in boldface; effect sizes are Cohen's d; reliabilities are Cronbach's alpha coefficients; [a]Expressive One Word Picture Vocabulary Test.

TABLE 3

Factor Loadings From Principal Component Analysis.

Measures	Factor 1	Factor 2
Raven	**.71**	.01
Odd-one-out	**.66**	-.14
Dot matrix	**.77**	-.06
Sky search	-.09	**.83**
Flanker	-.06	**.85**

Note: Factor loadings above .65 are marked in boldface.