Extending the internal/external frame of reference model to early-year cognitive abilities for children from diverse backgrounds

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Abstract: This study extended the internal/external frame of reference (I/E) model to referencing longitudinal data for children from different backgrounds. The extended I/E model was different from the traditional I/E model because early-year verbal and mathematical cognitive abilities offered fewer opportunities for external comparison in school than did later-year school achievement. The extended I/E model was investigated by structural equation modelling using data from the Millennium Cohort Study. The total sample size was 8,731 English children, among whom 1,417 were ethnic minority, 3,327 were disadvantaged and 3,987 were advantaged children. The results revealed that the traditional I/E model prediction was supported only for age 7 cognitive abilities. The results based on age 3 or age 5 cognitive abilities are only consistent with the traditional I/E model prediction in the paths predicting mathematical self-concept. The extended I/E model was typically supported for advantaged, disadvantaged and ethnic minority children, in descending order.

Keywords: achievement; cognitive ability; disadvantaged; domain comparison; early years; ethnic minority; the I/E model; self-concept; structural equation modelling; verbal and mathematical abilities.

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1 Introduction

Marsh (1986) created the internal/external frame of reference (I/E) model to explain how achievements establish self-concepts in diverse domains through two mechanisms: external and internal comparisons (Parker et al., 2013). A typical example is that a high

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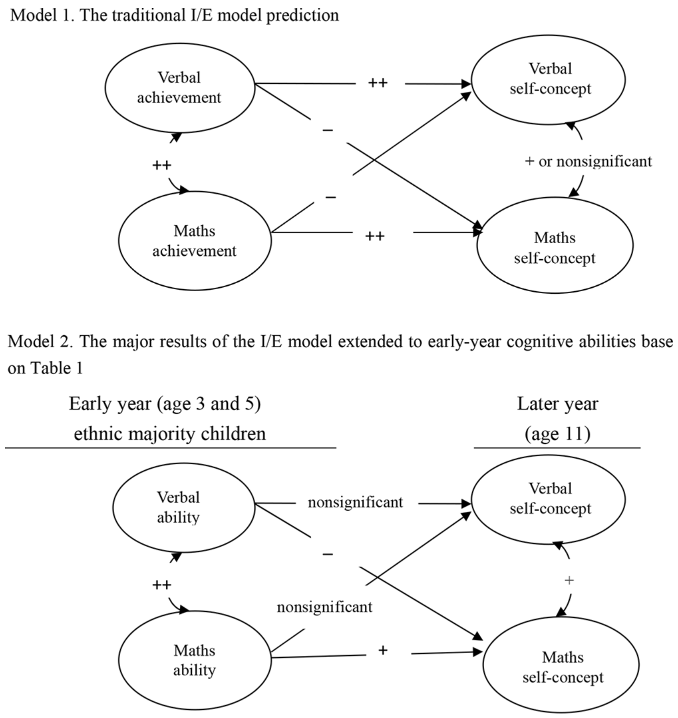
verbal achievement leads to a high verbal self-concept and a high mathematical achievement leads to a high mathematical self-concept through external (or social) comparison with peers; a high verbal achievement leads to a low mathematical self-concept and a high mathematical achievement leads to low verbal self-concept through internal (or dimensional) comparison between domains. The I/E model can also be used for explaining the reasons why a high correlation in achievements between domains leads to a low correlation in self-concepts between domains (Marsh and Hau, 2004), as indicated by Model 1 (the traditional I/E model) in Figure 1.

Figure 1 The traditional I/E model predictions and the major results of the extended I/E model. "+"=weak positive parameter; "++"=strong positive parameter; "–"=weak negative parameter



The traditional I/E model, however, is typically used to explain the phenomenon in the school setting, where external comparison is likely to saliently exist and the two mechanisms (internal and external comparisons) may interact strongly and become hard to be separated. A way to separate external comparison from internal comparison may be to extend the I/E model to early-year cognitive abilities (i.e. the extended I/E model in this study; cf. Model 2 in Figure 1). Early-year ability test results offer fewer opportunities for social comparison compared with later-year school achievements (grades or standardised achievement test results), which are typically used in I/E model research. In addition, parents, peers or even teachers generally do not know early-year ability test results.

Furthermore, the proposed extended I/E model was examined for children from diverse cultural backgrounds to validate the proposed model. If the extended I/E model fit the longitudinal data for children from different cultural backgrounds, then the extended

I/E model could be validated further. Validation of the proposal may advance knowledge on whether self-concept development is rooted in self-comparison in abilities between domains from the early years and diverse backgrounds. In summary, the purposes of this study are to extend the I/E model to early-year cognitive abilities using longitudinal data and to validate the extended I/E model with children from diverse backgrounds.

2 Theories in relation to the I/E model

Four theories in relation to the I/E model assume the likely mechanisms underlying the I/E model. A deeper understanding of the mechanisms may help explain the results obtained by using early-year cognitive abilities to examine the I/E model.

Multidimensional self-concepts. The I/E model addresses the relationships between achievements and self-concepts by considering at least two academic domains. This builds on theoretical and empirical work suggesting that self-concepts can be divided into different domains. Marsh and Shavelson (1985) indicated that self-concept had a hierarchical and multifaceted structure, with a general self-concept comprising academic and non-academic self-concepts, each of which comprised several self-concepts, which could be further divided into different self-concepts. For example, academic self-concept can comprise verbal, mathematical and science self-concepts; verbal self-concept can comprise listening, speaking, reading and writing self-concepts. The multidimensional nature of self-concept has been generally supported by later research (Chiu, 2013; Marsh, 1990).

External or social comparison. Social comparison theory posited by Festinger (1954) indicates that people evaluate their abilities by comparison with others' when no objective or non-social measures can be accessed (p. 118). Based on the social comparison theory, the I/E model assumes that people compare themselves and others in the context of a certain domain through external or social comparisons (i.e. the same-domain path in the I/E model; e.g. verbal achievement leading to increased verbal self-concept) (Möller, Streblow and Pohlmann, 2006).

2.1 Internal or dimensional comparison

In the earlier version of I/E model (e.g. Marsh and Hau, 2004), the internal or dimensional comparison mechanism solely occurs in the cross-domain path. In other words, people compare their own achievements between different domains through internal comparisons (e.g. high verbal achievement leading to decreased mathematical self-concept). The I/E model has gradually assumed that the I/E model may be mainly based on internal comparison with the matching domain paths formally renamed as the 'horizontal paths' from the previously assumed 'external comparison' mechanism and the non-matching domain paths named as the 'cross paths' from 'internal comparison' (Chiu, 2012; Marsh and Hau, 2004; Marsh, Abduljabbar, et al., 2015).

2.2 Dimensional comparison theory (DCT)

DCT is recently posited to elaborate the I/E model mainly by clarifying the issue of domain distances with the far domains (e.g. verbal and mathematics) having more contrasting effects and with the near domains (e.g. mathematics and physics) having less contrasting (or assimilation) effects in the cross paths (Jansen et al., 2015; Marsh, Lüdtke, et al., 2015; Möller and Marsh, 2013). DCT also highlights the likely interaction between external comparison and internal comparison; in other words, both the horizontal and cross paths in the I/E model can involve both the mechanisms of social comparison and dimensional comparison (Marsh et al., 2014). DCT views verbal skills and mathematics as far domains and the I/E model predictions should be fully supported (Model 1 in Figure 1). Extending the I/E model to verbal and mathematical cognitive abilities in early years may extend the DCT to consider domain distances not only from the perspective of school subject designs (or domains of knowledge) but also from that of human cognitive development starting from early years.

3 Extending the I/E model to early-year cognitive abilities

The mechanism of internal or dimensional comparison implies that self-concepts develop based on an intrapersonal metacognitive awareness of different cognitive abilities or performances in different tasks, which may begin at a young age (Bryce and Whitebread, 2012). After the early years, children begin attending school, where knowledge domains are formally separated and personal achievements are public and tested or compared against those of peers. In the later years of schooling, self-concepts develop based on both internal and external comparisons, which are difficult to separate. One reason for proposing two mechanisms for the I/E model is that model studies typically focus on a school's academic achievements, even with an extension to cognitive abilities (Chen et al., 2012). Thus, the traditional I/E model prediction (Model 1 in Figure 1) may be changed if early-year verbal and mathematical abilities (with fewer opportunities for social comparison) replace the role of school verbal and mathematical achievements (with more opportunities for social comparison).

Domain-related constructs such as self-concept, affect, achievement, ability and intelligence can be examined as overall or multiple factors (Arens et al., 2011; Brunner et al., 2009; Mandelman et al., 2010). The I/E model supports domain specificity but also consider intelligence as a common factor in achievements of different domains, as indicated by the close relationship between verbal and mathematical achievements (Brunner et al., 2008; Model 1 in Figure 1). Cognitive abilities including working memory and general intelligence can explain 18% of school language achievement, 36% of school mathematical achievement (Lu et al., 2011) and 23–67% of school achievements as a whole (Frey and Detterman, 2004). General intelligence tends to be the strongest predictor of student science, mathematical and language achievements (Spinath et al., 2006). Verbal and mathematical cognitive abilities and their respective school achievements have positive correlations (r = around 0.22 to 0.32) (Trautwein et al., 2009). The generally positive relationships between cognitive abilities and school achievements suggest cognitive abilities may replace the role of school achievements in the I/E model.

Overall intelligence or early-year cognitive ability is more affected by nature (Sternberg, 2014) and school achievements have more confounding influences from nurture or social comparison, as traditionally examined in I/E model research. Including considerations of early-year cognitive abilities extend the I/E model (Model 1) from short-term achievement influences (Goetz et al., 2008; Möller et al., 2011) to long-term cognitive ability influences.

4 Generalising the extended I/E model for students from diverse backgrounds

DCT indicates that dimensional comparison and social comparison are two major mechanisms involving in the relationship patterns described in the I/E model (Marsh et al., 2014). Extending the I/E model to early-year cognitive abilities may provide more opportunities to examine an informal, less salient feedback system in families such as parental appraisals (Gniewosz, Eccles and Noack, 2012), compared with a formal, more salient one in schools such as teacher assessments. Past research on the I/E model has been validated for students with learning disabilities (Möller, Streblow and Pohlmann, 2009) and talent (Plucker and Stocking, 2001), which, however, does not consider mechanisms of cultural contexts. Examining the extended I/E model for children from diverse cultural backgrounds may help address the issue of how other mechanisms (e.g. culture) may involve in the I/E model.

The I/E model for verbal and mathematical achievements and self-concepts has been examined and validated for students from various countries (Marsh and Yeung, 2001; Möller and Köller, 2001; Möller et al., 2009; Xu et al., 2013). Most cultural generalisation studies for the I/E model use data retrieved from international databases such as the Program of International Student Assessment (Marsh and Hau, 2004) and the Trends in International Mathematics and Science Study (Chiu, 2008), which comprise data from different cultures at the national level. The I/E model is typically stable and robust for students from different countries.

Relatively few I/E model studies focus on students from different backgrounds within a society, such as ethnic minorities and socio-economically disadvantaged students. One study indicated that ethnic minority students have lower cognitive abilities, which may result from cultural deprivation, compared with native students (Martin et al., 2012). Disadvantaged students may exhibit lower achievements compared with advantaged students because socio-economic status is moderately related to achievements and resource availability (Lee and Wu, 2012). The manner in which ethnic minority and disadvantaged students within a society formulate their self-concepts based on achievements or abilities in diverse domains does not appear to have been researched.

5 Research questions

A literature review suggested that the mechanism underlying the traditional formation of the I/E model (Marsh, 1986) might be slightly different if the I/E model is extended to early-year cognitive abilities (Figure 1). The rationale was that early-year children had fewer opportunities to perform social comparisons in verbal and mathematical cognitive abilities compared with later-year school children in verbal and mathematical achievements. Moreover, the generalisation of I/E model extended to early-year cognitive abilities might be examined by comparing children from different cultural backgrounds, such as ethnic minority, advantaged and disadvantaged children. This study thus examines the following two research questions:

Research Question 1. Are the traditional I/E model predictions supported if extended to child early-year cognitive abilities?

Research Question 2. Are the traditional I/E model predictions supported if extended to child early-year cognitive abilities for children from different backgrounds (e.g. ethnic minority, disadvantaged and advantaged children)?

6 Method

6.1 Data source and sample

Longitudinal data were obtained from the Millennium Cohort Study (MCS) compiled by the UK Data Service (https://www.ukdataservice.ac.uk). The MCS followed the lives of approximately 19,000 children born in the UK from 2000 to 2001, and five waves of data until 2012 have been collected and released. The MCS collected data on topics such as a child's health and cognitive as well as psychosocial development; parenting, parents' health, employment and education; family housing, neighbourhood and residential mobility; and social capital and ethnicity from cognitive assessments as well as child and parental reports.

This study used five data sets from the MCS: the child assessment data for verbal and mathematical cognitive abilities from Waves 2 (Age of 3 years), 3 (Age of 5 years) and 4 (Age of 7 years); the child self-completion data for verbal and mathematical self-concepts from Wave 5 (Age of 11 years); and the longitudinal family file data for the child background of residents in England and the ethnic minority, disadvantaged or advantaged status. The five data sets were combined using the identifier 'mcsid', which resulted in a total sample size of 8,731 English children, among whom 1,417 were 'ethnic' minorities, 3,327 were 'disadvantaged' (the poorest 25%) and 3,987 were 'advantaged' (neither ethnic minority nor disadvantaged) children, terms as used in the MCS.

6.2 Measures

Wave 2 verbal ability: a score measuring the ability to name vocabulary words obtained from the British Ability Scales (BAS) assessment (variable name 'bdbasa00' in the MCS data set), representing a child's ability to use expressive language.

Wave 2 mathematical ability: scores measuring three variables related to mathematics from the Bracken School Readiness Assessment: numbers/counting ('bdnosc00'), sizes ('bdszsc00') and shapes ('bdshsc00').

Wave 3 verbal ability: a score measuring the ability to name BAS vocabulary words ('cdnvabil').

Wave 3 mathematical ability: scores measuring the ability regarding picture similarity ('cdnvabil') and pattern construction ('cdpcabil') according to the BAS.

Wave 4 verbal ability: a score measuring the word-reading ability according to the BAS ('dcwrab00').

Wave 4 mathematical ability: scores measuring the ability in pattern construction ('dcpcab00') according to the BAS, and the raw score of number skills according to the adapted version of the NFER Progress Test in Maths ('mtotscor').

Wave 5 verbal self-concept: student responses to the item, 'I am good at English' ('ECQ46A00').

Wave 5 mathematical self-concept: student responses to the item, 'I am good at maths' ('ECQ46B00').

Children assessed the self-concept items on a 4-point Likert scale ranging from 1 (*strongly agree*) to 4 (*strongly disagree*). Their responses were reverse coded to allow higher scores to represent higher self-concepts.

6.3 Statistical analysis

The hypotheses were examined through SEM by using R software (version 3.1.3; R Core Team, http://www.R-project.org/) and the R lavaan package (Rosseel, 2012). Full information maximum likelihood (FIML) estimation was used to manage missing data because FIML was recommended for the use with SEM (Enders and Bandalos, 2001) and tended to generate more desirable fit index values compared with listwise deletion. Weights were not used in this study, because adding weights generated improper solutions, which would prevent our solutions from being generalised to the population. Raw or ability scores (not standardised ones) of the measures were used because this study focused on longitudinal development, and certain standardised scores provided by the MCS were adjusted for age; the raw scores or ability scores, however, were standardised before being used in SEM analysis to facilitate data processing.

The model formation for examining the research questions was constrained by data availability and software use. First, the MCS provided cognitive ability data that were measured in children at the ages of 3, 5 and 7 but self-concept data were measured only at the age of 11. In addition, the models setting earlier cognitive abilities (e.g. age 3 verbal abilities) leading to later ones (e.g. age 5 and then age 7 verbal abilities) generated bad fit results perhaps because of the diversity of cognitive ability measures used in children at the ages of 3, 5 and 7. As such, the models examined in this study could not be formulated like those in the reciprocal I/E model with several waves of data on both achievements and self-concepts (Niepel, Brunner and Preckel, 2014).

Second, the MCS provided only one observed variable for the constructs of verbal cognitive abilities and both verbal and mathematical self-concepts. Thus, two principles were used to formulate the model.

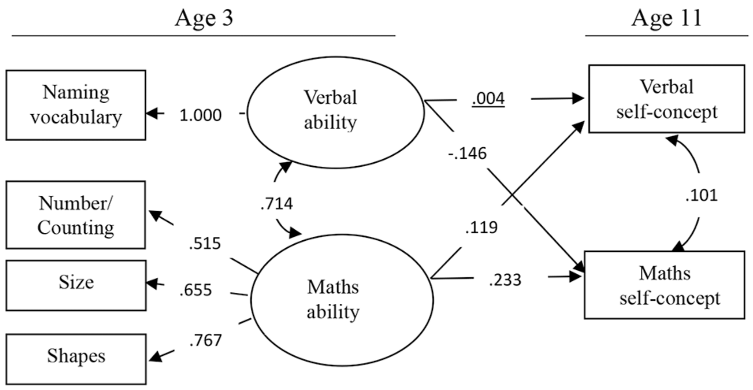
1 When there was only one observed variable, used the observed variable to simplify the model (or to reduce the numbers of free parameters to be estimated).

2 If problems happened or when there were more than one observed variables for a construct, used latent variables.

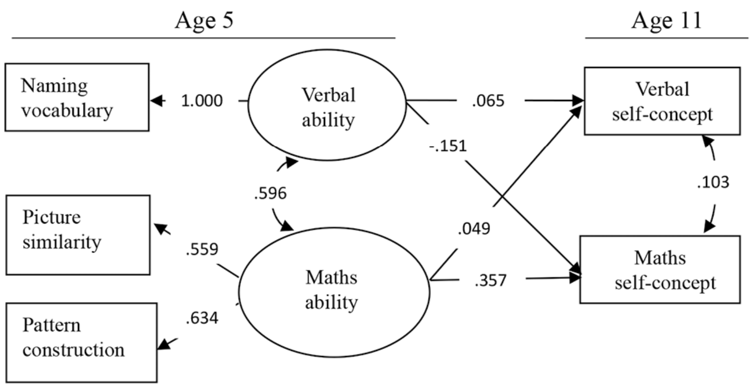
The R lavaan software generated poor fit results when the only one observed variable was used as the verbal cognitive ability, which further could not be resolved by setting a reliability coefficient for the latent variable of verbal ability, as suggested by Marsh and Hau (2004, p. 61). As such, the final models included only one observed variable for the latent variable of verbal ability without setting additional coefficient (i.e. setting 1 by default). Based on the research questions and the two constraints, four models were formulated in this study, as presented in Figure 2.

Figure 2 The longitudinal I/E model with verbal and mathematical self-concepts at age 11 having regressed at ages 3 (Model A), 5 (Model B) and 7 (Model C) for verbal and mathematical abilities. In Model D, the ability constructs are set being correlated with each other and having the observed variables as presented in Models A-C. The parameters were SEM results for all children as a single group. The parameters underlined were non-significant at $p = 0.05$ (see online version for colours)

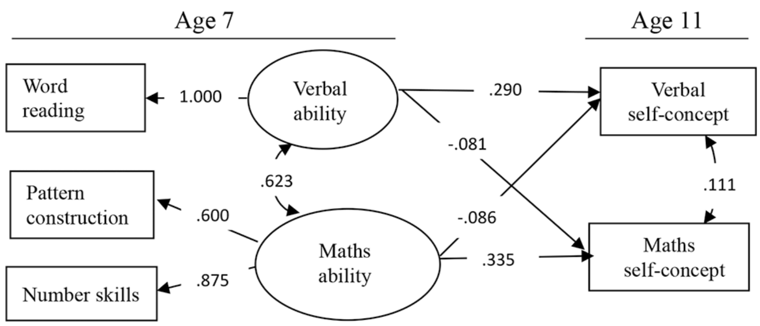
Model A.



Model B.



Model C.



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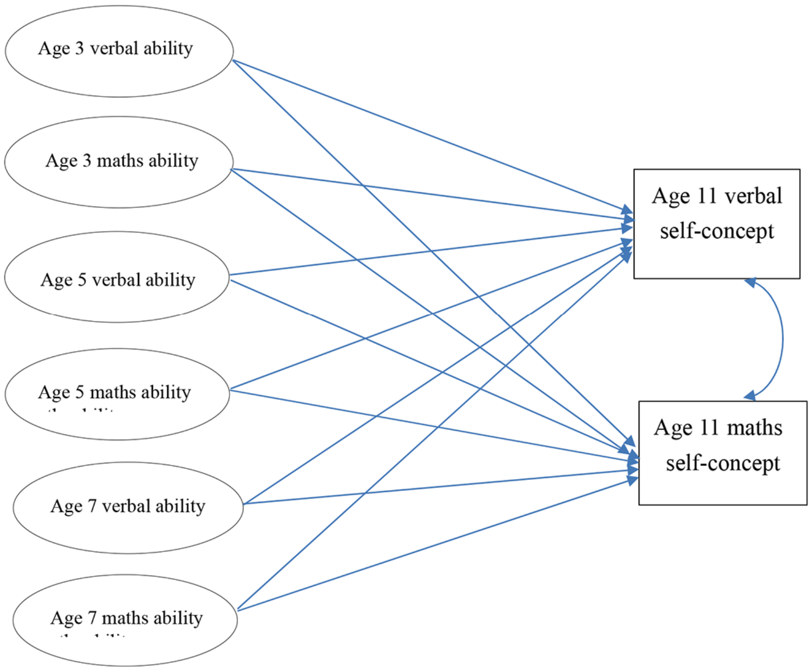
Model D.



Three fit indices were used to determine the degree of capacity of a model to reproduce the variance-covariance matrix of the data: the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and Tucker–Lewis index (TLI). The criteria were an RMSEA lower than 0.100, and a CFI and TLI higher than 0.900 (Hair et al., 2006). The traditional criterion, a non-significant chi-square value (χ^2), was unsuitable for this study because of the large sample (Bollen and Long, 1993). The degrees of freedom (*df*) (i.e. the difference between the number of elements in the covariance matrix and the number of free parameters) provided by SEM can provide information of model specification accuracy (Rigdon, 1994). The *df* would be small because few numbers of observed measures were used relative to the numbers of free parameters to be estimated in the models specified in this study (Figure 2). CFI is normed and its largest value is 1.000, when χ^2 is smaller than *df* and when RMSEA is equal to 0.000; TLI is not normed and can be larger than 1.000, which indicates an overfitting or 'more complex than needed' model (Van de Schoot, Lugtig and Hox, 2012, p. 487). Competing (nested or non-nested) models were compared using information criteria with lower values indicating more properly fitting the data (Lewis, Butler and Gilbert, 2011). Information criteria are developed on the basis of maximum likelihood estimation, which is adjusted for unbiased estimation to form the Akaike information criterion (AIC), adjusted for parameter numbers to form the Bayesian information criterion (BIC) and adjusted for parameter numbers and sample sizes to form the sample size-adjusted BIC (aBIC). The three information criteria are popularly used with the AIC favouring complex models and the aBIC performing higher in model selection when there are large sample sizes (Kim, Yoon, Wen, Luo and Kwok, 2015; Patarapichayatham, Kamata and Kanjanawasee, 2012).

Group differences (Research Question 2) were examined by using multigroup SEM, SEM for the separate groups, and the confidence intervals (CIs) of the path parameter estimates for the separate groups. If the CIs differed between the different groups, the I/E model assumptions could be assumed not to apply equally to the different groups.

7 Results

7.1 The extended I/E model for the total sample

The traditional I/E model predicted that verbal and mathematical achievements would affect the same domain self-concepts positively, but different domain self-concepts negatively (Model 1 in Figure 1). SEM analysis results for the total sample of English children as a single group (i.e. the three models, Models A-C, for ages 3, 5 and 7, respectively, in Figure 1) fit the data properly, as indicated by the fit index values (all RMSEAs below 0.100, and CFIs and TLIs higher than 0.900). However, the regression (path) parameters partially supported the prediction of traditional I/E model extended to early-year cognitive abilities (Table 1; Models A-C in Figure 2).

Among the 12 path coefficients (4 paths for each of the Models A-C) predicted by the traditional I/E model (Model 1 in Figure 1), nine path coefficients supported the traditional I/E model prediction. Mathematical self-concepts could be positively predicted by mathematical abilities and negatively by verbal abilities; Model C (using age 7 abilities to predict age 11 self-concepts) completely supports the prediction of traditional I/E model. Model C tended to support the traditional I/E model prediction more properly than Model A or Model B, as indicated by the lower AIC, BIC and aBIC values of Model C than those of Models A or B. The results suggested that the extended I/E model fitted the data from age 7 children; for age 3 or 5 children, only the paths predicting mathematical self-concepts supported the prediction of traditional I/E model (Model 2 in Figure 1).

Table 1 Path parameter estimates and fit index values for Models A-C

Regressed on	*Vsc*		*Msc*									
	Vab	*Mab*	*Vab*	*Mab*	*χ2*	*df*	*RMSEA*	*CFI*	*TLI*	*AIC*	*BIC*	*aBIC*
All children (single-group analysis)												
Model A: age 3 → age 11	***0.004***	***0.119***	−0.146	0.233	179.568	6	0.058	0.977	0.943	131251.659	131400.152	131333.418
Model B: age 5 → age 11	0.065	***0.049***	−0.151	0.357	10.530	2	0.022	0.997	0.987	117974.617	118101.921	118044.721
Model C: age 7 → age 11	0.290	−0.086	−0.081	0.335	34.145	2	0.043	0.995	0.977	114227.650	114354.944	114297.743
Model D: age 3 → age 11	***0.023***	***0.032***	−0.132	0.096	1235.495	31	0.067	0.955	0.905	259663.627	260080.963	259893.472
Age 5 → age 11	***0.025***	***0.425***	−0.122	***−0.288***								
Age 7 → age 11	0.394	−0.614	−0.184	0.766								
All children (multigroup analysis)												
Model A: age 3 → age 11	0.049	***0.106***	−0.121	0.223	220.778	26	0.051	0.973	0.954	131593.293	131982.202	131807.422
Model B: age 5 → age 11	0.110	***0.024***	−0.122	0.345	63.344	14	0.035	0.986	0.969	118014.767	118340.100	118193.920
Model C: age 7 → age 11	0.280	−0.073	−0.098	0.356	72.319	14	0.038	0.991	0.982	114438.249	114763.556	114617.376
Model D: age 3 → age 11	0.045	***0.035***	−0.112	.100	1446.776	117	0.063	0.948	0.912	261138.885	262221.129	261734.922
Age 5 → age 11	0.046	***0.132***	−0.084	***−0.184***								
Age 7 → age 11	0.311	−0.290	−0.173	0.632								

Table 1 Path parameter estimates and fit index values for Models A-C (continued)

	Vsc		*Msc*									
Regressed on	*Vab*	*Mab*	*Vab*	*Mab*	*χ2*	*df*	*RMSEA*	*CFI*	*TLI*	*AIC*	*BIC*	*aBIC*
Ethnic minority children												
Model A: age 3 → age 11	***−0.035***	***0.088***	***−0.110***	0.199	62.779	6	0.082	0.954	0.886	19116.148	19226.381	19159.672
Model B: age 5 → age 11	0.141	−0.093	***−0.054***	0.162	0.558	2	0.000	1.000	1.012	19036.808	19131.333	19074.153
Model C: age 7 → age 11	0.178	**−0.037**	−0.186	0.386	6.887	2	0.042	0.995	0.975	18493.226	18587.750	18530.571
Model D: age 3 → age 11	**−0.022**	0.046	−0.031	−0.051	277.907	31	0.075	0.944	0.881	39706.007	40015.962	39828.540
Age 5 → age 11	***0.088***	***−0.163***	−0.110	***−0.343***								
Age 7 → age 11	0.167	***0.021***	−0.298	0.865								
Disadvantaged children												
Model A: age 3 → age 11	***0.027***	***0.153***	−0.112	0.210	33.961	6	0.037	0.990	0.976	50338.241	50466.485	50399.758
Model B: age 5 → age 11	0.085	**0.067**	−0.182	0.458	0.157	2	0.000	1.000	1.006	44377.068	44487.023	44429.829
Model C: age 7 → age 11	0.306	−0.061	−0.063	0.352	6.600	2	0.026	0.998	0.992	43151.973	43261.918	43204.724
Model D: age 3 → age 11	***−0.132***	***0.399***	***−0.087***	***−0.013***	499.195	31	0.067	0.957	0.908	98756.742	99117.186	98929.717
Age 5 → age 11	***0.254***	***−3.184***	***−0.117***	***0.289***								
Age 7 → age 11	***−0.385***	***3.199***	***−0.034***	***0.189***								

Table 1 Path parameter estimates and fit index values for Models A-C (continued)

	Vsc		*Msc*									
Regressed on	*Vab*	*Mab*	*Vab*	*Mab*	$\chi 2$	*df*	*RMSEA*	*CFI*	*TLI*	*AIC*	*BIC*	*aBIC*
Advantaged children												
Model A: age 3 → age 11	0.091	***0.076***	−0.133	0.245	106.836	6	0.065	0.968	0.921	62137.702	62269.750	62203.022
Model B: age 5 → age 11	0.105	***0.057***	−0.121	0.346	26.565	2	0.056	0.979	0.897	54580.827	54694.025	54636.829
Model C: age 7 → age 11	0.290	−0.089	−0.098	0.353	36.936	2	0.066	0.988	0.939	52787.154	52900.338	52843.143
Model D: age 3 → age 11	***0.071***	***−0.125***	−0.109	0.195	606.972	31	0.068	0.945	0.882	122661.434	123032.531	122845.056
Age 5 → age 11	***−0.023***	***1.492***	***−0.049***	***−0.692***								
Age 7 → age 11	***0.679***	***1.725***	***−0.328***	***1.149***								

Note: The underlined path parameters and χ^2 values were non-significant at $p = 0.05$ and the ***italicised bold ones*** violated the predictions of traditional I/E model. The path parameters were completely standardised solutions, setting the variances of both observed and latent variables to unity. An exception occurred for multigroup analysis, where it only set the variances of latent variables to unity because the three groups had slightly different completely standardised solutions. Vsc = verbal self-concept; Vab = verbal ability; Msc = mathematical self-concept; Mab = mathematical ability; χ^2 = chi-square (or minimum function test) statistic; df = degree of freedom; RMSEA = root mean square error of approximation; CFI = comparative fit index; TLI = Tucker-Lewis Index; AIC = Akaike information criterion; BIC = Bayesian information criterion; aBIC = sample size-adjusted Bayesian information criterion.

Model D with four waves of data altogether fitted data, as indicated by the RMSEA, CFI and TLI values. However, Model D fitted the data less than Models A-C did, as indicated by larger AIC, BIC and aBIC values of Model D than those of Models A-C. Among the 12 path coefficients predicted by traditional I/E model, seven path coefficients supported the traditional I/E model prediction; only the paths relating age 7 cognitive abilities supported the traditional I/E model predictions. The results obtained by using Model D were worse in later analysis results based on data of children from diverse backgrounds (Table 1). The results suggested that Model D was not a proper model. As such, Model D was not discussed further.

7.2 The extended I/E model for children from diverse backgrounds

Multigroup SEM was performed for ethnic minority, disadvantaged and advantaged children in combination to examine whether the three groups had the same path parameter estimates, while setting the other parameters to be freely estimated for the three groups. The results of multigroup SEM revealed that the three groups generally could be viewed as having the same path parameters with all RMSEAs lower than 0.100 and CFIs and TLIs higher than 0.900 for Modes A-C (all children [multigroup analysis] in Table 1). The path parameters generally supported the traditional I/E model prediction (Model 1), except for the two cross-domain paths from mathematical ability to verbal self-concept for Models A-B.

The analysis results of the CIs of the path parameter estimates revealed one path showing differences between the three groups of children (Table 2). The CIs differed between the ethnic minority children and both the disadvantaged and advantaged children for the path of mathematical ability leading to mathematical self-concept in Model B. The results implied that the I/E model assumptions could not be assumed to be completely equal between the ethnic minority children and the other children.

Additionally, SEM was performed for ethnic minority, disadvantaged and advantaged children in England as separate groups. All of the Models A-C for each sample fitted the data properly with all RMSEAs lower than 0.100 and both CFIs and TLIs higher than 0.900 (Table 1). However, for ethnic minority children, among the total 12 path (regression) parameters (4 paths × 3 models), seven path parameters supported the traditional I/E model prediction. For disadvantaged children, nine path parameters supported the traditional I/E model prediction. For advantaged children, 10 path parameters supported the traditional I/E model prediction. Model C (age 7 abilities) fitted the data more properly than did Models A (age 3) and B (age 5), as revealed by the lower AIC, BIC and aBIC values of Model C than those of Models A or B.

Table 2 Path parameter estimates (PPE), standard errors (SE) and confidence intervals (CI) for Models A-C × diverse background children

	Vsc regressed on Vab			*Vsc regressed on Mab*			*Msc regressed on Vab*			*Msc regressed on Mab*		
	PPE	*SE*	*CI*	*PPE*	*SE*	*CI*	*PPE*	*SE*	*CI*	*PPE*	*SE*	*CI*
Model A: age 3 → age 11												
Ethnic minority students	−0.035	0.059	−0.151~0.081	0.088	0.065	−0.040~0.216	−0.110	0.059	−0.226~0.005	0.199	0.064	0.073~0.325
Disadvantaged students	0.027	0.029	−0.030~0.083	0.153	0.033	0.089~0.217	−0.112	0.029	−0.169~−0.055	0.210	0.033	0.145~0.274
Advantaged students	0.091	0.027	0.037~0.144	0.076	0.031	0.015~0.138	−0.133	0.028	−0.187~−0.078	0.245	0.032	0.183~0.308
Model B: age 5 → age 11												
Ethnic minority students	0.141	0.039	0.066~0.217	−0.093	0.047	−0.185~−0.001	−0.054	0.039	−0.130~0.021	0.162	0.047	***0.070~0.254***
Disadvantaged students	0.085	0.030	0.026~0.145	0.067	0.038	−0.006~0.141	−0.182	0.035	−0.250~−0.114	0.459	0.041	***0.379~0.539***
Advantaged students	0.105	0.023	0.059~0.151	0.057	0.032	−0.005~0.119	−0.121	0.026	−0.171~−0.071	0.346	0.033	***0.282~0.410***
Model C: age 7 → age 11												
Ethnic minority students	0.178	0.043	0.093~0.263	−0.037	0.049	−0.134~0.059	−0.186	0.046	−0.276~−0.097	0.386	0.052	0.285~0.487
Disadvantaged students	0.306	0.024	0.259~0.353	−0.061	0.026	−0.112~−0.009	−0.063	0.026	−0.114~−0.013	0.353	0.029	0.296~0.409
Advantaged students	0.290	0.021	0.248~0.332	−0.089	0.024	−0.136~−0.042	−0.099	0.023	−0.143~−0.054	0.353	0.026	0.303~0.404

Note: The PPEs are unstandardised solutions. The **bold** CIs are different, with the two underlined ones and the two *italicised* ones being different from each other. Vsc = verbal self-concept; Vab = verbal ability; Msc = mathematical self-concept; Mab = mathematical ability.

8 Discussion

8.1 Partially supporting the I/E model extended to early-year cognitive abilities

The first research question or purpose of this study is to extend the I/E model to the relationship between early-year cognitive abilities and self-concepts, drawing on a longitudinal study design. The extended I/E model is partially supported by SEM results, as revealed by fit index values and directions of path parameters for the total sample of English children (Table 1 and Model 2 in Figure 1). The paths supporting the traditional I/E model prediction include all the paths leading to mathematical self-concepts and those obtained by using age 7 data. The results based on age 7 cognitive abilities are generally consistent with the I/E model prediction and past findings of stable longitudinal effects of school achievement on self-concept (Guay, Marsh and Boivin, 2003) and the longitudinal I/E model (Brunner et al., 2010; Möller et al., 2011), with a slight exception (Chen et al., 2013). The most innovative contribution of this study may be that the empirical support for the extended I/E model successfully extends the I/E model from the short-term effects of school achievement on academic self-concepts to the long-term effects of early-year cognitive abilities on academic self-concept. The traditional I/E model prediction, however, is not fully supported until age 7, when is year 3 in primary education, around 2 years after most children start their full-time, compulsory education since age 5 (year 1) in England (http://www.educationuk.org/global/articles/16-and-under-education-path/). The result implies that cognitive abilities play the same roles as school achievements in the I/E model at least starting from age 7.

The results based on age 3 or 5 cognitive abilities are only consistent with the traditional I/E model prediction in the paths predicting mathematical self-concept. The result is consistent with McInerney et al. (2012) study on the I/E model based on standardised test achievement for secondary students from Hong Kong. One reason for this may be that mathematical self-concepts are more highly related to achievements than the verbal self-concepts (Bong et al., 2012), as revealed in this study (Figure 2; Models A-C in Table 1). Measurement use may be another reason, but the path that does not adhere to the traditional I/E model prediction is worth further researching.

For educational practice, the results suggest that based on the I/E model, individuals have a tendency to differentiate their self-concepts between domains gradually from the ages of 3, 5 to 7. This is also supported by the finding that the correlations between different domains of self-concepts decrease from primary to secondary education stages (Abu-Hilal and Bahri, 2000). The next question is whether or when education must focus on developing domain-specific professionals. The results appear to imply that individuals seem to differentiate self-concepts between different domains at least starting from the age of 7, when the full I/E model prediction is supported although mathematical self-concept may emerge slightly earlier starting from the age of 3 (Figure 2). The psychological reasons for this early self-concept differentiation need further speculations such as values and interests (Eliot and Turns, 2011) and need to be examined by future research.

8.2 Partially supporting the extended I/E model for children from diverse backgrounds in society

The second research question or purpose of this study is to extend the I/E model to children from diverse backgrounds. Multigroup SEM and CI analysis results reveal that ethnic minority, disadvantaged and advantaged children generally have similar path parameter patterns, which are similar to the path parameter patterns obtained for the sample as a whole (Table 1). Further, the traditional I/E model also fits the data from the three groups of children separately, as indicated by the fit index values obtained by the single group SEM analysis. However, some of the path coefficients violate the traditional I/E model prediction and reveal differences between the ethnic minority and the other two groups of children. As such, the generalisability of the extended I/E model for children from different backgrounds (Hypothesis 2) is partially supported.

The significance levels of the path parameters obtained by the single group SEM analysis for the three groups separately, however, reveal slight differences in the degrees of support with the traditional I/E model predictions (Model 1 in Figure 1). Among the 12 path parameter (4 paths × 3 models) predictions proposed by the traditional I/E model, the data from ethnic minority children support seven predictions, data from disadvantaged children support nine predictions and data from advantaged children support 10 predictions. The results suggest that cultural backgrounds appear to play a role in the extended I/E model, which is supported by the results of advantaged, disadvantaged and ethnic minority children in England, in descending order. No past studies on the I/E model to date appear to focus on comparing children from diverse cultural backgrounds. This finding is consistent with a minor notion of the DCT that the I/E model mainly evolves on the basis of dimensional and social comparison but may still slightly interact with the other forms of mechanisms or diverse kinds of comparisons (Marsh et al., 2014).

The verbal abilities of ethnic minority children lose most of their predictive capacity for later-year verbal and mathematical self-concepts in the I/E model prediction, compared with disadvantaged and advantaged children, in descending order. Children who belong to an ethnic minority group tend to have low degrees of official language abilities (Martin et al., 2012), which may explain ethnic minority children’s difficulty in transforming verbal abilities into positive verbal and negative mathematical self-concepts for age 3 or 5 verbal abilities, but not for age 7 verbal abilities, when schooling may play more roles than cultural backgrounds do. Advantaged children in society face the opposite situation: they have few reasons to attribute their verbal abilities to nurture or culture, so rather, they attribute them to nature (or abilities). As such, data from advantaged children support the traditional I/E model prediction more than those from ethnic minority children or disadvantaged children do. These speculations, however, need validation by future research.

The link from mathematical ability to mathematical self-concept appears to be weaker for ethnic minority children than those for both disadvantaged and advantaged children when children are 5 years old. Immigrant children have lower problem-solving skills than non-immigrant children do, which may result from contextual factors such as age, gender, age of arrival, socio-economic status and language backgrounds (Martin et al., 2012). The weak link from mathematical ability to self-concept for ethnic minority children may also be a part of the reasons for their low problem-solving skills. It is also interesting to know why the phenomenon occurs when children are 5 years old but not when they are 3 or 7 years old. Is it likely that age 5 is the start of full-time, compulsory education in England? All these speculations need to be examined by future research.

8.3 Conclusion, limitations and suggestions for future research

The traditional I/E model prediction extended to early-year cognitive abilities was partially supported. The extended I/E model may indicate interactions between dimensional and social comparisons in the pattern that the full I/E model prediction starts from age 7, that age 3 or 5 cognitive abilities are only consistent with the I/E model prediction in the paths predicting mathematical self-concepts, and that the early-year verbal abilities of ethnic minority children aged 3 and 5 lose most predictive capacity for later-year self-concepts.

Future research may necessitate using data from other cultures to examine the findings and proposal. This study has two limitations. First, different measures for verbal and mathematical abilities were used for different ages. This problem may be difficult to resolve because children's cognitive development increases rapidly, both qualitatively and quantitatively. It is difficult to use a single measure to accurately assess children's verbal and mathematical abilities during the early years (ages of 3, 5 and 7 in this study). Second, using one item to measure self-concept may not meet the theoretical standard for a psychological construct, but may be practical for data collection, with little method bias in examining predictive models (Bergkvist and Rossiter, 2007). Large-scale studies normally comprise many items for diverse topics; as such constructs represented by one or two items have become a practice.

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