An Information Distortion Model of Social Class Differences in Math Self-concept, Intrinsic Value and Utility Value

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Abstract

In this paper we develop an information distortion model (IDM) of social class differences in self-beliefs and values. The IDM combines psychological biases on frame-of-reference effects with sociological foci on ability stratification. This combination is hypothesized to lead to working class children having more positive math self-beliefs and values than equally able salariat children. We further suggest that the same conditions that give rise to the working class benefit in self-beliefs and values are associated with signaling effects, which suppress educational aspirations and attainment. These hypotheses are tested in one cross-sectional multi-national and one longitudinal study. The results in favor of the IDM challenge cultural models of social class differences and have implications for rational action theory.

Educational Impact And Implications Statement

Working class children have higher academic self-concept and task value than equally able, more advantaged, peers in school systems that are stratified by academic ability. However, our cross-national and longitudinal research shows that this advantage does not appear to translate into higher aspirations or attainment. We suggests that the very educational structures that give rise to self-concept and task value advantage for poorer children simultaneously restrict the possibility of their using this advantage to their benefit in terms of educational attainment.

Keywords: assimilation versus contrast, social class, educational aspirations and attainment, academic self-beliefs, academic values

Introduction

There are large gaps in educational achievement, aspirations and attainment by social class that have proven extremely resistant to change (Anders & Micklewright, 2015; Breen, Luijkx, Müller, & Pollak, 2009; Jerrim, Chmielewski, & Parker, 2015; Nash, 2003; OECD, 2011; Reardon, 2011; Van de Werfhorst & Hofstede, 2007). Importantly, gaps in achievement are present at the beginning of schooling and tend to persist or get even larger over the course of schooling (Carneiro & Heckman, 2003; Heckman, 2006). Nevertheless, it is now clear that differences in academic achievement explain only about half the effect of social class on aspirations (Parker, Jerrim, Schoon, & Marsh, 2016) and attainment (Jackson, 2013). As such there has been an increasingly interdisciplinary focus on factors other than academic achievement or ability (or secondary effects in the theoretical framework of Boudon, 1974) as both an explanation for and focus of intervention for closing gaps in outcomes for children from different social backgrounds (Brunello & Schlotter, 2011; Heckman, 2000). This focus has been on what factors predict educational and occupational attainment, and differentiate children from different social classes, for children with similar levels of academic ability. A great deal of focus has been on what Maaz, Trautwein, Lüdtke, and Baumert (2008) suggest are the most important secondary effect mechanisms: academic self-beliefs and task values. This is a sensible choice as considerable research has shown the consistent positive effect of academic self-beliefs and values, particularly those related to math, on various attainment outcomes in university (Guo et al., 2015a, 2015b, 2015c; Marsh, 1991; Parker et al., 2012, 2014a, 2014b) and occupations (Davis, 1966; Marsh, 1991). In the current research we focus on these self-belief and task value factors in the math domain.

In this paper we claim that there is no universal deficit in academic self-beliefs and values for children from less advantaged backgrounds once academic achievement has been taken into account. Rather, such children may have even higher levels depending on the structure of the educational system and the relative importance of school selection. In particular, we hypothesize that educational systems that are tracked, decentralized, private or privatized (e.g., charter or free schools), and/or otherwise stratified by achievement provide working class students with a distorted frame-of-reference that may actually promote higher levels of some self-beliefs and task values than those of their equally able salariat peers (i.e., children of salaried rather than wage earning individuals). Using a series of counterfactual models, we further suggest that, while these factors are associated with educational and occupational attainment in numerous studies, they are relatively poor explanatory variables for social class differences in educational expectations and outcomes. Indeed, while our theory indicates that children from working class backgrounds should have higher academic self-beliefs and values in stratified systems, these are also systems in which disadvantaged children are likely to be furthest behind in terms of aspirations and attainment (Parker et al., 2016). Thus, educational systems that provide contexts for working class children to have more positive self-beliefs and values do not translate those advantages into more equitable educational outcomes. We argue that the reason for this is that the same context that gives rise to systematic differences by social class in academic self-beliefs and values (i.e., school selection and stratification) also has strong counteracting signaling influences that shape aspirations and attainment.

Secondary Effects

Led largely by the research of Heckman (2000), there is a revolutionary focus in educational policy on the influence of factors other than academic ability and achievement on educational and occupational outcomes. Economists, sociologists, and psychologists have taken on this program with gusto. While this multidisciplinary endeavor has been fruitful, it has exposed different theoretical orientations in how social class differences in children of equal ability emerge. Below we review models that hypothesize cultural differences and those that focus on different contexts and constraints at the point of educational transitions.

Cultural Models. Cultural models suggest that social class differences reflect cultural differences in perceptions of the value of education and the way in which positive self-beliefs are encouraged and promoted. For example, Akerlof and Kranton (2000) suggest that working class children perceive real social risks in valuing education too highly. Likewise, Lareau (2003) and Gambetta (2009) suggest that there are distinct orientations to education that define working class versus salariat families. Such models tend to focus on differences in the way education is valued, and indicate that children from working class families tend to have less positive self-beliefs in relation to the academic domain (Sullivan, 2006). Thus, cultural differences not only shape the way education is valued, but also the way in which self-beliefs are constructed and encouraged (Akerlof & Kranton, 2010).

Behind these theories is the assumption that peer effects take the form of *assimilation* (i.e. the values and self-beliefs of children conform to those of their peers in the same social class). Akerlof (1997) uses the metaphor of gravity to suggest that smaller social distance between individuals and peers in the same social class (rather than between social classes) leads to conformity in peer expectations. This can lead to bright working class children holding lower self-beliefs than they should and some less gifted salariat children holding self-beliefs that are too ambitious. Akerlof posits a standard economic model of education where an individual pursues a level of education up to the point when the marginal benefits of more education matches the marginal costs; however, he adds to this an interpretation of costs that includes social elements.

Rational Action Theory. Alternative to the cultural differences models are the rational action theory models of Goldthorpe and colleagues (e.g., Breen and Goldthorpe, 1997; Goldthorpe, 2007). The Breen and Goldthorpe (1997; hereafter BG model) model represents one of the most important attempts at integrating long established traditions in both sociology and economics to provide a rational action theory of educational and occupational attainment. The BG model rejects the suggestion that different social classes value education differently or that social class warps the construction of academic self-beliefs. In response to the cultural model of Akerlof, Goldthorpe (2007) suggests that social class subcultures do not have “the coherence or normative force that [Akerlof’s] position would require” (p.78). A cultural model assumes that parents from salariat backgrounds are better able to instill the value of education or promote positive self-beliefs. Goldthorpe states that this position is ill-equipped to explain two clear features of historical changes in education: 1) *absolute* educational expansion, where a greater proportion of the population from all social classes have entered university; and 2) despite this expansion, the *relative* distance between social classes in educational attainment has remained comparatively stable (Goldthorpe, 2007).

In contrast to cultural models, the BG model focuses on different “opportunities and constraints, and thus the evaluation of different sets of probable costs and benefits” (Goldthorpe, 2007, p. 32). Embedded in this model is the assumption that, on average, children from all backgrounds value education equally and their self-beliefs are, thus, responsive only to their academic performance rather than cultural norms. Goldthorpe suggests that the processes that link achievement and expectations to educational outcomes are the same for everyone but that children from working class backgrounds face greater risks in pursuing more ambitious choices during educational transition. Thus, they require larger amounts of cognitive skill and/or more resources (e.g., economic resources that cover the direct and indirect costs of education) than their advantaged peers. By implication, the threshold at which a working class child will attend university is hypothesized to be higher than that of a richer child of equivalent ability. This double disadvantage (i.e. having fewer resources but requiring a higher level of such resources to make an ambitious educational choice) is sufficient to explain social class differences without resorting to cultural differences in values or warping of academic self-beliefs by social class.

In detail, the theory suggests that, when considering further education, young people have two competing goals: 1) obtaining a social class position *at least* as prominent as their parents (status *maintenance*); and 2) maximizing their social class position (status *maximization*). Assumptions in the BG model are that: a) status maintenance and maximization are often in conflict, and particularly so for working class children; b) when in conflict, children will preference status maintenance over status maximization in a process referred to as relative risk aversion; c) due to lower levels of academic ability on average, children from working class backgrounds will have lower academic self-beliefs; and d) a young person's self-beliefs and level of resources (including financial) are used to evaluate whether the risks of status maximization are manageable. To place this in context, suppose a child is choosing between going to university and taking an apprenticeship. From a BG model perspective, this choice has very little conflict for a child from a salariat background as a university degree is increasingly a basic requirement for status maintenance for such children. In addition, they have more resources and, on average, higher academic achievement and, thus, higher self-belief. For a child from a working class background, who has fewer resources and, on average, lower academic ability, the choice is more risky as an apprenticeship may ensure status maintenance while attending university is risky where non-completion is a realistic concern. Thus, such a child has both fewer resources to draw on and more to gain from making a less ambitious choice.

Information Distortion Model. We are in general agreement with the BG model in relation to a) relative risk aversion, lower resources, and self-beliefs being the primary drivers of differences in social class (though we suggest school signaling effects may help explain country-to-country variation; see below), and b) that in a completely non-stratified education system there are unlikely to be meaningful social class differences in academic self-beliefs or values beyond that which can be explained by academic achievement. Likewise, our view that individuals value domains they feel competent in and self-beliefs of competence depend upon the information one receives about one's position relative to one's peers is not inconsistent with the BG models. Indeed we only diverge from the BG model in one, crucial, aspect. Like the BG model, we view a child's academic self-beliefs (π in the BG model [see below]; Breen & Goldthorpe, 1997, p. 279) as central to the educational decision-making processes. The BG model assumes π does not vary as a function of social class, once conditioned on academic achievement. Our perspective is that this depends on the information input used to form π and whether the educational system in place leads to systematic variance by social class in that information. Thus, the only alteration we make to the BG model (p. 285) is to the equation:

$$\pi_i = g(a_i)$$

where π_i is academic self-belief, which is the production of some function, g, on the academic ability, a , for individual *i*.

Rather, we claim that than an individual's simple level of achievement, a_i , best represents relative achievement within a given frame-of-reference, specifically within an individual's school. As such, a_i is a product of:

$$a_i = \gamma_i + (\psi_i \times \mu)$$

where γ_i is an individual's underlying academic achievement (this is well known to vary by social class [see Heckman, 2006] and is well integrated into the BG model); μ takes only positive values and is the degree to which a country stratifies students by ability; and ψ represents school selection effects for individual *i* such that:

$$\psi_i = pr(UM_i) - pr(OM_i)$$

where $pr(UM_i)$ is the probability that child i is undermatched (i.e. in a school where the school average achievement is lower than the individual's achievement) and $pr(OM_i)$ is the probability that child i is overmatched (i.e. in a school where school average achievement is higher than the individual's achievement and the complement of $pr(UM_i)$, meaning these probabilities must sum to one). If both probabilities are equal for all individuals then $\psi = 0$ and no selection effects are present. Thus, $\psi_i \times \mu$ represents a correction to γ_i due to school placement and the structure of the educational system.

There are several critical implications of this model. First, it is clear that systematic social class bias in the direction of ψ will lead to systematic differences in π by social class, provided that μ is non-zero. Indeed, there is now clear evidence that salariat children tend to be in schools in which there is an overmatch between the ability of the child and that of the school, while, due to choice constraints, the opposite is true for working class children (Jerrim, Parker, Chmielewski, & Anders, 2016; Maaz et al., 2006). As such, on average, $\psi_w > 0$ for working class children and $\psi_s < 0$ for salariat children. Second, in countries in which no stratification occurs (i.e., $\mu = 0$), absolute ability will equal relative ability regardless of the degree of school selection effects and thus the formula for π will revert to that reported in Breen and Goldthorpe (1997). Finally, as with the BG model, our model explicitly rejects additional social class influences that would be consistent with a cultural difference model. As such, social class differences on π conditioned for γ will either be zero ($\mu = 0$ or $\psi = 0$), as implied by the BG model, or in favor of working class children (given $\psi_w > 0$ and $\psi_s < 0$). Importantly, we explicitly exclude an additional parameter in the equation for π that implies class assimilation effects and thus we do not expect there to be circumstances under which able working class children hold, on average, more negative self-beliefs or values compared to their equally able salariat peers. We unpack these implications below.

The formation of self-beliefs and values

While there are a number of theories on the development of academic self-beliefs, a common set of processes have been implicated within empirical research (Marsh, 2006). These are that a) children tend to feel competent in areas in which they get better over time (*temporal* frame-of-reference); b) children tend to have an internal ranking of their competence in different academic domains and to have an upward bias in the subjects they are best in and a downward bias in the subjects they are worst in beyond what can be explained by objective ability (*internal* frame-of-reference); and, most importantly, c) children base their self-beliefs on their position among their peers (*external* frame-of-reference; see Marsh, 2006 for an overview). Given a major driving force in what children value (e.g., intrinsic or interest and instrumental or utility value) are areas in which they believe they are competent, it is unsurprising to find that the frames-of-reference noted above have been found to be in operation for academic values (Guo et al, 2015c; Marsh et al, 2014; 2015). Of particular relevance to educational policy are external frames-of-reference effects. Indeed, there is now considerable evidence that shows that external frames-of-reference are heavily dependent on contextual factors (Marsh, 2006) and that their manipulation is heavily susceptible to educational policy (Espenshade, Hale, & Chung, 2005; Salchegger, 2015).

Contextual Factors. The Big-Fish-Little-Pond Effect model (BFLPE; Marsh, 2006; see also the frog pond effect: Davis, 1966; Espenshade, Hale, & Chung, 2005, and range-frequency theory: Murphy & Weinhardt, 2014) suggests that individuals contrast from the group they are members of when evaluating their position in external frames-of-reference.[1] To illustrate, imagine two children of average academic ability. One child is selected into a high achieving school where they rank among the poorer performing students. The other

[1] Such a model is not just present in psychology and sociology. Indeed models of relative wage rank within a company and its primary role in job satisfaction and well-being have been developed in economics (see Brown et al., 2005; Card et al., 2011).

child is selected into a poor performing school where they rank among the best performing students. The BFLPE hypothesizes that the child in the poorer performing high school will have the higher self-concept despite having the same level of academic ability.[2] There is exceptionally strong support for the BFLPE from a variety of sources for self-concept (Marsh et al., 2001), academic values (Marsh, Kuyper, Morin et al., 2014; Marsh, Abduljabbar et al., 2014; Marsh & Parker, 1984; Marsh, Seaton, et al., 2008; Nagengast & Marsh, 2012; Zell & Alicke, 2009), and even aspirations and attainment, though these effects tend to be much smaller in size (Davis, 1966; Marsh, 1991). It should be noted that these claims about the prevalence of contrast effects over assimilation effects and the role of school stratification in increasing the strength of contrast effects run in direct contrast to cultural models. Indeed, Akerlof and Kranton (2010, p. 80) note that an increase in choice of schools leads to greater 'social gravity' or pressure on students to assimilate to the dominant values of their school and peers. And, similar to reflected glory models in educational psychology, greater achievement. However, empirical research juxtaposing such assimilation processes with contrast processes suggests that the latter are strong and persistent, while the former are weak and ephemeral (Marsh et al., 2000). Importantly, the BFLPE is known to be larger in countries with greater ability stratification (Salchegger, 2016). As such, the BFLPE roughly corresponds to the $\psi_i \times \mu$ identified above.

Identity Distortion Model Assumptions

Building on Marsh (1987) who provided an early information distortion model to explain ethnic divides in academic self-concept, we advance the following claims:

1. Social class is strongly associated with school placement.
2. As a result, children from disadvantaged backgrounds are disproportionately selected into schools with lower average ability. Thus, for children of similar ability, a child

[2] Assimilation and contrast processes are also known in the economics literature as reference-group dependent and rank dependent respectively (Brown et al., 2005).

from a working class background is more likely to enroll in a school where the average ability is lower than a child from a salariat background.

3. From a BFLPE perspective, the child from the working class background should have higher levels of academic self-concept than an equally able child from a salariat background.
4. This relative advantage for working class children should be strongest in countries in which an average child's relative position in the school is most divergent from their absolute position in the country.
5. This divergence will systematically vary by social class, resulting in *undermatching* (attending a poorer performing school than expected based on ability) for working class children and *overmatching* (attending a better performing school than expected based on ability) for salariat children.
6. Social class differences in academic self-beliefs and values (conditioned on attainment) are emergent properties of school selection and educational structure rather than a reflection of different cultural views, practices, or beliefs among social classes.

It could be argued that any impact of relative ability on self-concept would dissipate over time as children glean information about their standing in the wider community (see Goldthorpe, 2007). For example, countrywide standardized testing could provide a natural correction to the information distortion noted above. However, empirical evidence suggests that the BFLPE tends to get larger over the course of schooling rather than smaller (Marsh, Abduljabbar et al., 2014). An explanation for the continual strength of relative performance despite information on absolute standing is the local dominance effect (Alicke, Zell, & Bloom, 2010; Zell & Alicke, 2009). This effect states that children have a strong preference for information about their ability that comes from proximate sources, and that the more proximate the source, the stronger the preference. This finding has been supported in experimental studies (e.g., Alicke et al., 2009) as well large observational studies (Marsh, Kuyper, et al., 2014). The latter is of particular interest as the results showed that children had a tendency to form self-concepts on the basis of within school or class position despite some evidence suggesting they can accurately assess their absolute position within their country.

Signaling and Inequality

Social class differences in self-concept favoring working class children do not necessarily represent an equalizing force but rather indicate the degree to which children are basing their self-beliefs on distorted information (we outline a procedure for quantifying the degree of distortion below). However, supporting our claim that this is not conducive to more equitable outcomes, the degree of ability stratification is associated with a negative relationship between social class and aspirations and attainment and a weaker relationship between self-beliefs and task values and these outcomes (see Parker et al., 2016). This is not to say that BFLPE type processes are not in operation for aspirations and attainment; empirical research suggests they are (e.g., Marsh, 1991). Rather, we suggest that other competing forces which are much more closely tied to social class exist to explain gaps in attainment.

Relative risk aversion and differential resourcing, as outlined in the BG model, are parsimonious explanations for such social class differences. However, it is not clear if they entirely explain significant country-to-country variation in the strength of social class differences in these outcomes. Following from Parker et al. (2016), we suggest that the extent of signaling in a school system relating directly to the extent of ability stratification explains such variation. School placement can send parents, universities, and employers clear signals about a student’s underlying ability and suitability for particular educational or occupational pathways, despite what the student themselves might think (see Bedard, 2001; Checchi, 2006). We further suggest that signaling exerts a unique and powerful influence on aspirations and attainment beyond ability, self-beliefs, and values. Signaling can be explicit, such as in systems like Germany where children are placed into either university or vocational track schools at an early age. Alternatively, signaling can be implicit, such as in stratified countries with selective or private education, where a school's reputation sends salient signals to all parties (Jerrim et al., 2015). Bachmann and Park (2009) note that countries with strong signaling tend to propagate social disadvantage in both aspirations and attainment (see also Chmielewski, Dumont, & Trautwein, 2013; Hanushek & Wößmann, 2005; Parker et al., 2016).

It would be expected that signaling would take on considerable importance in countries in which parents from wealthy backgrounds have greater ability and inclination to choose the school that their child attends. This includes countries in which tracking by academic ability is extensive and undertaken at an early age (e.g., Austria and Germany) and, to a lesser degree, countries in which implicit ability stratification occurs via decentralization, private or privatized schooling, or where high degrees of parental choice exist (e.g., the UK and USA). Countries in which there is little stratification by ability should experience little in the way of signaling effects (e.g., Finland and Norway). This is not to say that no class differences in aspirations would emerge in these countries. Rather, the differences should be smaller as they will relate to resource deficits and relative risk aversion processes rather than to these factors in addition to signaling effects. Taken together, while negative ψ_w and positive ψ_s, as well as strong μ, are anticipated to give rise to conditions that benefit working class children in terms of academic self-beliefs and values, it is those same conditions that will give rise to stronger signaling which benefits salariat children.

Social Class Versus Socioeconomic Status

Before outlining our hypotheses, we wish to make a final note on our use of social class rather than socioeconomic status. Socioeconomic status and social class emerge from two distinct theoretical traditions (Wohlfarth, 1997). The former is based on the economics literature and is concerned primarily with single or linear combinations of continuous measures of income, years of education, and/or occupational prestige (e.g., Ganzeboom & Treiman, 1996). Social class emerged out of neo-Durkheimian (e.g., Grusky, 2005) or neo-Marxist theories (e.g., Sørensen, 2000) and hypothesizes qualitatively distinct groups of individuals who are relatively homogenous across a range of intersecting domains (rather than linear combinations of those domains), including income and education but also culture and similarities in access to and constraints on resources (see Goldthorpe, 2007 for a review).

In this research, we use Goldthorpe's (2007) social class schema, which has become the standard method, particularly in Europe, for exploring the effect of social class on educational outcomes and is used consistently in research on educational and occupational stratification (Ichou & Vallet, 2011). We do not wish to pit economic and sociological traditions against each other in this research, nor do we seek to suggest that social class theoretical models are superior to socioeconomic status ones. Rather, primarily for pragmatic reasons, we focus on social class in this research in order to situate this study in the broader literature and to be consistent with the theories from which we draw.

Hypotheses

We hypothesize that schooling systems with greater ability stratification result in a discrepancy between a child's position within their school (relative position) and their position in the country as a whole (absolute position [3]). In such systems, systematic social class differences in school selection mean that able working class children will tend to end up in schools in which their relative position will be higher than their absolute position while

[3] We use the term absolute here despite the international context due to the country remaining the primary labor market for participants, ignoring international labor mobility.

children from salariat backgrounds will tend to have the inverse relationship. The end results of this are a) higher self-beliefs and values in children from working class backgrounds conditioned on achievement; b) strong signaling effects leading to lower educational aspirations for working class children; and c) the balance between these competing forces strongly favors signaling and other rational action theory mechanisms. We test this in two studies. Study 1 is a comparative study of groups of countries that differ in ability stratification. Here we select countries that fall into three main groups based on Bol, Witschge, Van de Werfhorst, and Dronkers (2013) index of tracking and intra cluster correlations (ICC) of achievement (e.g., Marks, 2006; see Table 3). First, open countries (represented by Finland, Iceland, Norway, and Sweden) are those with low tracking and low ICCs. Second, stratified countries are those with low tracking but high ICCs (represented by Australia, Canada, UK, and USA). Finally, Tracking countries are those with both high tracking and high ICCs (represented by Austria, Czech Republic, Germany, Hungry, Netherlands, and Slovakia). Study 2 utilized longitudinal data from Australia to explore the degree to which working class advantages in self-beliefs and values counteract other factors in educational and occupational attainment.

Study 1. Study 1 consists of three main hypotheses. Hypothesis 1 relates to the relationship between school selection and degree of stratification within a country. Hypothesis 2 relates to social class differences, conditioned on achievement, in academic self-concept and values as a function of country differences in ability stratification. Hypothesis 3 relates to social class differences in university aspirations as a function of country differences in ability stratification; under the assumption that greater stratification implies greater signaling potential. These hypotheses as they relate to different sets of countries are outlined in Table 1.

Study 2. Study 2 represents a longitudinal extension in a single country (Australia). In this study we test the hypothesis that the academic self-beliefs and values advantage for working class children does not translate into a meaningful advantage in educational attainment (measured by university entry by age 19 and university graduation by age 25). In this way Study 2 is an extension of H3 in Study 1 (see Table 1) but with a focus on a single counterfactual question: "how much *bigger* would social class differences in academic attainment be if academic self-beliefs or values did not vary according to class".

Study 1

Method

Participants. To test the relationships identified in the hypotheses, the current research used data from the 2003 cycle of the Programme for International Student Assessment (PISA). We chose this database because a) its focus is on math, which has been shown to be a particularly important domain for assessing long-term educational outcomes (e.g., Parker et al., 2012); b) it is the only PISA cycle to assess long-term educational outcomes (we focus here on aspirations to attend university) in all countries; and c) it forms the first wave for our longitudinal study (Study 2). We select countries in three groups, Open, Stratified, and Tracking, based on differences in degree of ability stratification and signaling as measured by ICCs and Bol et al.'s (2013) index of tracking (see Table 3). Basic demographics are reported in Table 2.

Sample Design. In each country, a minimum of 150 schools were selected to participate with probability proportional to size. Thirty students were then randomly selected from within each school. Average response rates of both schools (90%) and pupils (90%) were high, though this varied moderately between countries. Further details are available in the PISA technical reports (OECD, 2004). The survey organizers provided a set of population weights and these were used in all analyses. The two stage sampling procedure of PISA means the data has a complex structure with students nested within schools. The small amount of missing data was addressed using five multiple imputations (Enders, 2010). A single imputation with each of the plausible values for math achievement (see below) was undertaken so that five imputed datasets were retained, each with one of the five plausible values for mathematics, reading, and science. Models incorporating weights and multiple imputations were estimated using the *survey* and *mitools* packages in R (Lumley, 2010). We used country specific standardization for all predictors.

Measures. The measure *Children's university aspirations* was based on the PISA item that asked "which of the following do you **expect** to complete" (emphasis in original question) in relation to level of education. Country specific options were provided in the questionnaire.[4] The primary outcome of interest was whether the child selected one of the top categories (ISCED level 5a or ISCED level 6), referring to university or postgraduate level education. Response rates to this question were very high (over 95% in all the countries we considered). *Child social class* was based on parents' occupation recoded into the three classes (salariat, intermediate, and working) using the Erickson–Goldthorpe–Portocarero (EGP) schema (Erikson, Goldthorpe, & Portocarero, 1979). As per Erikson (1984) and Morgan, Spiller and Todd (2013), the 'highest' (most prestigious) occupation of the child's mother or father is used. *Children's academic achievement* was measured via performance on a standardized test. The achievement tests used in PISA are specifically designed to enable cross-national comparisons. As part of the PISA 2003 study, children (aged 15) sat a two-hour test. Since the PISA's major domain in 2003 was math ability, the majority of test questions focused on children's skill in mathematics (our focus here) with a smaller number of items testing their ability in reading and science. Answers were summarized by the survey organizers into a single score for each of the three domains using an item-response model; the intuition of such models is that true skill in each subject is unobserved and must be estimated from the answers to the test (see OECD, 2004 for further details). Five plausible values were generated for each pupil, estimating their proficiency in each subject. The survey organizers scaled these scores (across all OECD countries) to have a mean of 500 points and standard deviation of 100. In all analyses we used math achievement which was z-standardized within each country. We ran all analyses for each plausible value separately and combined the results using the formulas defined by Rubin (1987). *Math self-concept, intrinsic value, and utility values* were measured using the summary scores provided by the PISA organizers. Again these were z-standardized within each country.

Information Distortion Index. Testing of several of the hypotheses required a means of quantifying the degree of mismatch between relative and absolute ability positions. In this paper we developed an information distortion index (IDI; see also Murphy & Weinhardt, 2013 for an example of a similar approach). The IDI is defined as the difference in relative percentile rank and absolute percentile rank. Thus, an IDI index of 20 would indicate an undermatched student whose relative percentile rank is 20 points higher that their absolute percentile rank. A score of -10 would indicate an overmatched student whose relative rank was 10 percentile points lower than their absolute rank. Positive scores represent students who are undermatched to a school based on their ability, while negative scores indicate overmatching. Figure 1 shows the difference between relative (i.e., within school) and absolute (i.e., within country) percentile in different countries.

An IDI can be calculated for each individual student provided there is representative data at both the school- and country-level which can be averaged over sub-groups of participants. As a country-level summary statistic, we calculate the median of the absolute IDI scores (AIDI)[4]. This is the L^1_{-Norm} of the distance from the 45° line in Figure 1. This index is naturally related to the intra cluster correlation (ICC) but is a) more easily

[4] The average of the IDI scores theoretically sums to zero and we therefore take the median of the absolute scores. Mean AIDI and IDI scores are reported in supplementary materials but produce very similar results (see Table A1).

interpretable in relation to distortions of frames-of-reference, b) more flexible as each individual gets a unique score and thus AIDI can be easily calculated for different groupings and c) more readily interpretable to lay audiences who are familiar with percentile ranks. We would expect that the BFLPE should be largest in countries with the biggest AIDIs, as with ICCs. Indeed, using the information from Table 1 in Salchegger (2015) this is the case for OECD countries (Spearman $r = -.631$, $p < .001$).

Analysis. Models including country fixed effects are used to test hypothesis H2 and H3:

$$Y_i = \sum_{j=1}^{n-1} EGP_j + \sum_{k=1}^{n-1} CNT_k + \sum_{j=1}^{n-1} EGP_j \times \sum_{k=1}^{n-1} CNT_k \quad (1)$$

$$Y_i = ACH_i + \sum_{j=1}^{n-1} EGP_j + \sum_{k=1}^{n-1} CNT_k + ACH \times \sum_{i=1}^{n-1} CNT_k + \sum_{j=1}^{n-1} EGP_j \times \sum_{i=1}^{n-1} CNT_k \quad (2)$$

Here, *Y* is the outcome of interest (self-beliefs, values, or aspirations), *EGP* is a series of dummy variables representing social class (salariat as the reference category), *CNT* represents a series of dummy variables for country (Australia as the reference category) and *ACH* is the within country standardized math achievement. Equation 1 provides estimates of unconditional social class differences, while Equation 2 provides differences conditioned on academic achievement. Group averages and differences between groups for the Open, Stratified, and Tracking countries were derived using the delta method.

Due to clustering at the school level, standard errors calculated *as if* observations are all independent, would have been smaller than they should be and, thus, significance tests would be more liberal than is appropriate (Stapleton, 2008). To account for this, all models were estimated using replicate and population weights provided by the survey organizers (Lumley, 2010). This ensured that statistical inference accounted for this additional uncertainty.

Link function. In the context of binary outcome models there are issues with the use of either probit or logit link functions when comparing coefficients across countries. In particular, there are potential dangers in comparing coefficients across groups (as is the focus of this research) as any change in parameter estimates could be due to either 'confounding' or 'rescaling' (Allison, 1999; Mood, 2010). Linear probability models (LPM; OLS regression with binary variables) provide unbiased and consistent estimates of the average effect of each variable and thus facilitate group comparison (Mood, 2010). LPMs also have the additional advantage of parameter estimates that are directly interpretable (Mood, 2010). Nevertheless, results from probit regression models are presented in the Appendix (Table A2); we compared countries using differences in predicted probabilities in order to avoid some of these concerns noted by Mood (2010).

Results

Hypothesis 1. Open countries had low tracking, small ICCs and an AIDI of 6. This means that the median individual in an Open country had just 6 percentiles difference between their rank in their school and in their country. Stratified countries also had low tracking but moderate ICCs and a median AIDI of 10. Finally, Tracking countries had high tracking, high ICCs, and a median AIDI of 16. This confirmed the selection of countries as three distinct groups. Thus, we found clear support for H1a. Table 3 also confirms H1c where differences in IDI were largest for Tracking countries and smallest for Open countries. Confirming H1b, all social classes had small IDIs in Open countries while in Stratified and Tracking countries, children from salariat backgrounds tended to be overmatched (negative IDI) and children from working class backgrounds tended to be undermatched (positive IDI). Taken together, these findings are consistent with the overarching premise of Hypothesis 1 that high stratification is associated with more evidence of meaningful social class differences in school selection.

Hypothesis 2. Table 4 provides results for both unconditional and conditional social class differences in math self-beliefs and values. Consistent with both hypothesis H2a and H2b, the lower levels of these variables in working and occasionally intermediate class children compared to salariat children in the unconditioned models were often reversed in Stratified and Tracking countries when conditioned on academic achievement in math. Thus, using Australia and self-concept as an example, the difference favoring salariat over working class children was .144 of a standard deviation. Upon controlling for achievement, this difference flipped, such that working class children were, on average, .137 standard deviation units higher than salariat children. However, there were two surprises in the results. First, we hypothesized that conditioned social class differences in Open countries should be approximately zero and indeed in half of instances this was the case. However, in the other half of cases, small though significant decrements in self-beliefs and values were observed for working and particularly intermediate class children. This is not consistent with either our information distortion model or the BG model. Second, while we hypothesized that Tracking countries would, on average, see higher levels of self-beliefs and values in working class children than salariat children, we were surprised by the size of this effect. Working class children were, on average, higher than .15 of a standard deviation and, for intrinsic value, above .20 of a standard deviation.

Hypothesis 3. Table 5 provides the results for hypothesis 3. Again, using LPMs, we tested social class differences both unconditioned and conditioned on academic achievement. In all countries social class differences were large and significant, favoring salariat children over working and intermediate class children. Further, this pattern of results remained significant in all countries after conditioning on achievement. Consistent with Parker et al.

(2016), conditioning on achievement resulted in much bigger declines in social class differences in Tracking rather than Stratified or Open countries, although social class differences remained significantly larger in Tracking countries. Finally, we conditioned on achievement, self-beliefs and values. Again, working and intermediate class children had significantly lower aspirations for university completion than children from salariat backgrounds. Consistent with our information distortion model, controlling for self-beliefs and values resulted in small, but not statistically significant, increases in social class differences in aspirations in Stratified and Tracking countries, indicating that information distortion may *slightly* attenuate the impact of social class differences on aspirations and attainment. This is a hypothesis we directly address in the following study.

Study 2

Methods

Participants. The Longitudinal Study of Australian Youth (LSAY) is a longitudinal extension of the PISA 2003 used in Study 1. The initial wave consisted of 10,370 15-year-old Australians surveyed over ten years. The sample had approximately equal numbers of females (49.7%) and males, and consisted largely of children born to native-born Australians (78%), with smaller populations of first (11%) and second (9%) generation Australian immigrants. Two percent of the sample identified as being of Aboriginal or Torres Islander decent. Using international classifications, 40% of the participants had at least one parent with a university level of education and 43% had at least one parent with either short cycle or post-secondary non-tertiary level of education. The remaining participants had at least one parent with some high school or lower level of education (17%).

We used the wave collected at age 19 to measure university entry and the wave collected at age 25 to measure university graduation. By the age 19, 64% of the original sample remained in the study. By age 25, only 37% remained in the sample. Given the sample attrition, there is a trade-off between representativeness and time of measurement; however, recording university completion at age 25 provided sufficient time for even late entrants to have entered university, completed at least a bachelor's degree, and to have generally entered the job market. It should be noted that this level of attrition is of a similar magnitude to other large-scale longitudinal studies that cover such a dramatic period of change. We used the combined sampling and attrition weights provided by the survey organizers to account for attirition. Multiple imputation was used to account for the very small amount of remaining missing data, including variable specific missing data (see Study 1 for details). However, it should be noted that there is possible selection by attrition as 41% of the age 19 sample reported attending university and yet 42% of the age 25 sample reported having obtained a bachelors degree. Part of this could have been due to late entrants into university, which is common in Australia (i.e., after gap-years; see Parker et al., 2015). However, after weighting there was no evidence of differential attrition by social class, which remained stable between Study 1 (age 15) and the two age periods in Study 2 (age 19 and 25).

Measures. The measures of social class, achievement, self-beliefs, and values were identical to those used in Study 1. The only difference was that the longitudinal outcomes present for Australian participants of the PISA 2003 cycle were used. For university entry, a derived variable was used which indicated whether the participant had enrolled in a bachelor's degree at any stage from 2003 to 2007. For university graduation, a derived variable was used which summarized information from career interviews from all waves of the LSAY database. In this case, a participant was considered a university graduate if at any time from 2003 to 2013 they indicated they had completed a bachelor's degree or higher. Further information can be found at http://www.lsay.edu.au/publications/2487.html.

Analysis. The analysis approach taken in Study 1 was followed in terms of use of replicate weights, multiple imputations for missing data and use of plausible values for achievement. Again, linear probability models were used (see Appendix Table A3 for probit models). We modeled the hypotheses as:

$$Y_i = ACH_i + SB_i + IV_i + UV_i + \sum_{j=1}^{n-1} EGP_j \quad (3)$$

Here, *Y* is university entry or graduation, *ACH* is math achievement, *SB* is math self-belief, *IV* is the intrinsic value of math, and *UV* is the utility value of math of individual, *i*, evaluated at age 15. *EGP* is a series of dummy variables representing social class.

Using the difference between salariat and working class children in the probability of graduating university as an example, we used the parameter estimates from this model to calculate a set of unconditional probabilities (see Parker, Bodkin-Andrews, Marsh, Jerrim, & Schoon, 2015 for more information):

- *UCP1.* The probability of a working class child completing university based on their own achievement, self-beliefs, values and choice profile.
- UCP2. The probability of a salariat child completing university based on their own achievement, self-beliefs, values and choice profile.
- UCP3. The probability of a working class child completing university based on their own self-beliefs, values, and choice profile but the achievement profile of the salariat children.
- UCP4. The probability of a salariat child completing university based on their own self-beliefs, values, and choice profile but the achievement profile of working class children.

The total gap in attainment between salariat and working class children is thus the difference in probability between UCP1 and UCP2, or:

$$E(Uni\ |Class = S) - E(Uni|Class = W)\ \ (4)$$

UCP1 to UCP4 were then recalculated as conditioned probabilities CP1 to CP4, in which only achievement and choice components were calculated at class specific levels and self-beliefs and values were evaluated at the population means.

The difference in the unconditional and conditional social class differences in the probability of graduating university or obtaining a salariat occupation for these two lots of probabilities provided a counterfactual estimate of the degree to which the working class advantages in math self-beliefs and values meaningfully reduce the gap in attainment that would occur if no such differences were present. A third set of counterfactual probabilities are presented in supplementary materials that provide evidence on the rather speculative assumption that social class achievement gaps would remain constant if gaps in self-beliefs and values were completely erased. Given the results of Study 1, this seems unlikely. Rather, it is more likely that declines in social class gaps for self-beliefs and values would be accompanied by a reduction in achievement gaps (i.e., the whole system would move to be more like a Open country). As such, we provide a counterfactual case where we substitute Australian social class achievement differences with Finnish social class achievement differences (i.e., a reduction in social class gaps of approximately .15 standard deviation units).

Results

Table 6 gives the results of social class differences in university entry (aged 19) and university graduation (age 25) based on social class and predictors at age 15. Results suggested several conclusions. First, there are considerable social class differences in both university graduation and salariat occupational attainment. Second, these differences remain significant after holding achievement, self-belief, and value factors constant. This is consistent with the BG model that relative risk aversion and resource differences account for a considerable difference in social class attainment gaps. Third, holding self-beliefs and values constant across social classes (i.e., removing the effects of the information distortion model) barely changed the size of differences. At its largest, the results suggest that if academic self-beliefs and values were constant across social classes, differences by social class would grow, at most, by half a percentage point. To put this in context, we ran further counterfactual models in which achievement differences in Australia were replaced by the slightly smaller differences in Finland, under the assumption that a reduction in self-belief and value differences by social class would be accompanied by a counteracting reduction in academic achievement differences. Rather than an increase in social class differences in attainment this relatively conservative counterfactual case resulted in a four-percentage point decline in university entry gaps between salariat and working class children and a three-percentage point decline in gaps between these groups in university graduation. Reduction in the gaps between salariat and intermediate class children were much smaller at one-and-a-half to half a percentage point for university entry and graduation respectively.

Discussion

The current research aimed to test the implications of an information distortion model of social class differences in academic self-beliefs and values. In particular, the model proposes that children rely primarily on relative rank in their local environment (e.g., school or class) when forming self-beliefs and values (see also Murphy & Weinhardt, 2013). The information distortion model suggests that a) the degree of ability stratification, and b) the degree to which there is a systematic bias in the tendency for working class children to be undermatched and salariat children to be overmatched, will result in working class children having either equal (as implied by the BG model) or higher academic self-concepts once academic achievement is accounted for. The model further proposes that these same educational conditions send strong signaling messages, overwhelming the possible benefits from self-beliefs and values, which would result in working class children being significantly less likely to aspire to and attain a university level of education.

Study 1. Results for Study 1 were generally supportive of the information distortion model. In particular, there was clear evidence of information distortion (distance between relative and absolute percentile rank) and social class differences in overmatching and undermatching in Tracking and Stratified countries but not in Open countries. Support was also found for the effect of this information distortion on self-beliefs and values. Of particular interest was the size of the mathematic self-beliefs and values advantage for working class children over their similarly able salariat peers in Tracking countries. Indeed, for mathematics self-beliefs and utility values, this difference was as high as one fifth of a standard deviation. To place this in context, this is not much smaller than the oft-reported gender difference in mathematics self-beliefs in OECD countries (OECD, 2013); a gap that is not conditioned on achievement.

While the support for the majority of hypotheses was clear, there were two exceptions. First, we hypothesized that countries with little achievement stratification (i.e., Open countries) would have no social class differences in academic self-beliefs and values once achievement was accounted for. This was almost universally the case when comparing salariat and working class children (notwithstanding a barely significant effect for utility value). However, for math self-concepts and utility values, intermediate class children were significantly lower than salariat children in some cases. This could be taken as evidence in favor of cultural models that implicitly assume an assimilation process (e.g., Akerlof & Kranton, 2000). However, it should be noted that these differences were very small: approximately a twentieth of a standard deviation. As such, it is hard not to rule out concerns over measurement. Further, these differences largely tended to occur between salariat and intermediate class children rather than between salariat and working class children, as might be expected by cultural models.

Such results require further investigation. For example, it may be that both assimilation (cultural models) and contrast (information distortion model) processes are in operation; with the former significantly weaker under most conditions. However, assimilation processes may be more powerful when there is little of either stratification or selection. Alternatively, it could be that working class children struggle more with being overmatched due to fewer social and financial resources and that this is especially the case in countries where under- and overmatching are less tied to social class (i.e., Open countries). Indeed, the differential effects of over- and undermatching represent an important line of future research. Finally, given the local dominance effect, it is possible that these results may be due to treating the school, rather than the more salient classroom, as the context of interest (Marsh et al., 2014). Indeed, given that many of the countries identified in this study as non-tracking did have some form of within-school and/or subject based tracking, testing the hypotheses of the information distortion model at the level of the classroom is another critical area for further research. Within-school tracking has increased in prominence and the combination of between-school differences in within-school tracking processes has important implications for placement by social class (Chmielewski, 2014). This may also have interesting implications for the information distortion model. It is worth noting that out-of-school peer groups, which may be more or less socially homogenous in different countries, represent a largely unknown context in moderating the effects noted here.

The second unexpected finding was of particular relevance to the signaling component of our model. As expected, social class differences in Tracking countries were significantly larger than both Stratified and Open countries, regardless of the set of controls used. Also consistent with our hypotheses, Stratified countries had significantly larger social class gaps in university graduation aspirations than Open countries. However, this difference was only statistically significant when achievement was not accounted for. It is important to note that a) in all countries, aspirations favored salariat children regardless of the controls used, b) consistent with the information distortion model, social class gaps in aspirations in Stratified and Tracking countries got slightly larger rather than smaller once mathematics self-beliefs and values were accounted for, and c) the pattern of results was consistent with the direction hypothesized and significant in the model with no controls. Despite this, the non-expected result deserves attention. One potential explanation is that signaling forces in Stratified countries tend to be implicit and defuse rather than explicit and clear as they are in Tracking countries (Parker et al., 2016). As such, the signaling may become a more powerful influence on aspirations later in Stratified countries than Tracking countries. As noted above, it is also possible that signaling due to classroom placement rather than school placement complicates the results presented here.

Study 2. As noted above, when academic self-beliefs and values were accounted for, social class gaps in aspirations actually increased in size. Study 2 investigated this issue further by asking the question 'how much bigger would social class gaps in university and occupational attainment be if the information distortion model did not hold'. As expected, while the effects of information distortion tended to reduce the potential gaps, this reduction was *extremely* small and was dwarfed by the change that would occur in the context of compensatory changes to the achievement gap. Such results can be interpreted in light of Boudon's (1974) primary and secondary effect model in which social class gaps are a product of academic ability (primary) and factors related to decision making (secondary). Research on this model has typically interpreted secondary effects as the residual direct effect of social class on attainment once achievement has been controlled for (Morgan, 2012). Our research on self-beliefs and values represents an attempt to explore specific, some would contend central (see Maaz et al., 2006), components of secondary effects. In this case, two implications for Boudon's model emerge from our work. First, not all secondary effect mechanisms favor more advantaged children. As such, secondary effects are more accurately the summation of competing mechanisms, the balance of which determines the degree to which secondary effects favor salariat over working class children.

Second, while primary and secondary processes are seen as independent, it would be inaccurate to assume that reducing the overall influence of secondary effects would leave the size of primary effects unchanged. Rather, it is likely that some sort of compensatory process would be in operation. Indeed, a similar argument has been made in relation to the standard model of social mobility. This argument states that there is no guarantee that closing education gaps will not result in other non-educational mechanisms coming to the fore and thus keeping social mobility constant (Brown, 2013). Likewise, as we imply in our set of counterfactual models in Study 2, there is no guarantee that reducing secondary effects can be done in a way that keeps primary effects constant. Countries in our research that had the largest gap in self-beliefs and values favoring working class children also tended to have the largest gap in achievement favoring salariat children and the largest proportion of the total effect of social class on aspirations explained by achievement (based on Parker et al., 2016). The implications of our model then are that educational structures which lead to working class children having higher self-concept than salariat children tend to be systems which are more unequal, favoring salariat children in aspirations and attainment. As such, it is critically important that efforts to increase working class children's self-beliefs and task values aim to account for any potentially unintended consequences.

Implications for Practice and Theory

Educational psychology has long suggested that realistic self-concept (i.e., those that match a child's actual position in the academic achievement hierarchy) is best for children (see Covington & Beery, 1976). We suggest a slight modification in relation to educational systems. That is, educational systems in which relative position within school represents an accurate proxy of absolute position within the country tend to be the most equal. Further, factors like academic self-beliefs and values have a rather limited influence on explaining social class gaps in attainment. As such, it may be more fruitful to focus attention on other mechanisms such as relative risk aversion, academic achievement gaps, and poorer access to resources as outlined in the BG model. This is not to say that self-beliefs and values are not in and of themselves important predictors of educational outcomes (see Guo et al., 2015; Marsh, 1991; Parker et al., 2012), but rather that they do not clearly differentiate between social classes in the way that many in educational psychology might expect. It is possible that our statistical models underestimate the size of these effects due to the use of math-specific factors. However, given other research (see Goldthorpe, 2007) showing the strength of relative risk aversion, resource differences, achievement gaps, and signaling factors, and our findings here on the impact of the structure of the educational system, it is important that macro-level factors and student psychology factors are considered together in policy discussions.

One of the major goals of such educational policy discussion is to ensure that current systems provide students with the human capital (e.g., skill, perceptions, attitudes, and beliefs) they need to join the labor force and make a contribution to society (Becker, 1994). The current research suggests that educational systems that are highly stratified by achievement may be inefficient in obtaining this for everyone. Perhaps paradoxically, children from privileged backgrounds who are typically channeled into the top end of stratified schools systems may be those most directly affected as they come to have lower self-concepts than their objective ability suggests they should. Research dating back 50 years, has highlighted that young people form their self-beliefs in relation to highly local peer comparisons which can lead individuals in competitive educational institutions to make less ambitious career decisions than they might otherwise do (Davis, 1966). Rather than a negative, this could be viewed as an equalizing force as children from lower social classes tend to get channeled into less competitive schools and thus receive, at least as seen in this study, a notable advantage in self-concept and task values. Unfortunately, as our research has shown, such students are largely unable to transform this advantage into more ambitious aspirations or increase their educational attainment. Parker and colleagues (2016) suggest that this is due to the strong signaling that school placement sends students before social comparison processes within those schools can take place. Put simply, it can be hypothesized that school systems that rely on ability stratification neither benefit the rich nor assist the poor and, as indicated in previous research (Parker et al., 2016), tend to suppress the level of aspiration and educational achievement present in the country as a whole.

A further important point to note is that our argument against cultural models as it applies to social class is not that sociocultural influences are unimportant. Rather, we take the BG model position than macro-social class structures do not have the normative power that would be required for such models to hold (Goldthorpe, 2006). This does not suggest that other social grouping do not exert such normative pressure. For example, it may be that Grunsky's (2005) more disaggregated definition of social class at the level of occupational grouping holds more normative power. Likewise, gender, race, and rural living, among other social groupings, may impart much more normative pressure than macro-social class can. Taken together, the information distortion model should only be seen as a macro-model of social class. It remains to be seen whether similar processes exist for other social groupings.

Limitations

The primary aim of the current research was to outline an information distortion model. In order to access the full implications of this model we used the PISA 2003 database in this research. The rationale behind this was that it included a large number of countries with quality social class, achievement, self-beliefs and values, and aspiration measures, and could be linked with the LSAY2003 database, which allowed us to extend our model to predict educational and occupational attainment 10 years later. Notwithstanding its many advantages, there are important limitations of the use of this database. First, it is mathematics focused, with self-beliefs and values measured specifically in this domain. This is not unusual in this sort of research and mathematics is an important domain in explaining long-term attainment (Buchmann & Park, 2009; Hauser, 2010). Nevertheless, self-beliefs are domain specific and, as such, further research should consider the information distortion model in relation to other academic domains and in relation to global academic domain variables. Second, Study 2 relied on strong assumptions in exploring relevant counterfactual questions. While this represents a useful first step, taking advantage of natural experiments, such as changes in the educational system due to policy change, is critical to evaluating whether the assumptions underlying these counterfactuals hold. Finally, it is important to note that we chose to group countries in terms of their educational system. However, these groups of countries also differed from each other in other respects (e.g., geography and culture). The supplementary material provides a table with a range of metrics that may be relevant to the issues at hand (Table A4). As may be seen, when comparing these metrics to our educational ones, or substantive groupings bring together countries that are quite different in other ways, but nevertheless fit our hypotheses. Nevertheless, there are many metrics available beyond those we report and thus it may be that the results we find here are a function of third variable differences between countries.

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Tables and Figures

Table 1
Hypotheses in Study 1

	Hypothesis	Open	Stratified	Tracking
H1a	Average degree of discrepancy between relative and absolute positions in a country.	Low	Moderate	High
H1b	Direction of discrepancy between relative and absolute positions in a country	~0: S,I, & W	- S +W S<I<W	-- S ++ W S<I<W
H1c	Size of discrepancy, within country, between relative and absolute positions.	Small	Moderate	Large
H2a	Social Class differences in self-concept (the amount by which distorted frame-of-reference impact self-beliefs)	~0	W > I >S	W >> I >> S
H2b	Social Class Differences in Values (the amount by which distorted frame-of-reference impact values)	~0	W > I > S	W >> I >> S
H3a	Social Class Differences in University Aspirations (the degree to which signaling leads to larger social class differences).	W < I < S	W << I << S	W<<< I<<< S
H3b	H3a conditioned on academic achievement.	W < I < S	W << I << S	W<<< I<<< S
H3c	H3b conditioned on achievement, academic self-beliefs, and values	W < I < S	W << I << S	W<<< I<<< S

Notes. S = Salariat background, I = Intermediate class background, W = Working class background. ~0 = Approximately zero. + = Positive value (overmatching); - = Negative value (undermatching); > or < = direction of difference. The more symbols the stronger the hypothesized relationship.

Table 2
Demographics

Country	N	EGP Class Percentage: Salariat	Intermediate	Working	Math Achievement	Math self-concept	Math Interest Value	Math Utility Value	University Aspirations
Open									
FIN	5796	.531	.336	.134	544	.011	-.241	.060	.512
ISL	3350	.612	.281	.106	515	.032	-.111	.307	.361
NOR	4064	.646	.270	.084	495	-.180	-.165	.149	.259
SWE	4624	.563	.336	.101	509	.121	.084	.022	.329
Stratified									
AUS	12,551	.618	.261	.121	524	.128	.008	.224	.624
CAN	27,953	.543	.339	.118	532	.171	-.015	.215	.608
GBR	9535	.481	.395	.124	508	.105	.003	.123	.321
USA	5456	.634	.272	.095	483	.243	.040	.172	.638
Tracking									
AUT	4597	.405	.426	.169	506	.061	-.283	-.486	.243
CZE	6320	.516	.382	.102	516	-.100	-.182	.008	.367
DEU	4660	.444	.417	.138	503	.116	.031	-.042	.192
HUN	4765	.429	.444	.127	490	-.151	-.208	-.113	.532
SVK	7346	.426	.436	.138	498	-.047	.033	-.044	.427

Notes. Math achievement is scaled such that it has a mean for OECD countries of approximately 500 and a standard deviation of approximately 100. The total sample size is 101,017.

Table 3
Stratification Indexes

Country	Stratification Measures: Bol	ICC	AIDI(S.E.)	IDI: S	I	W	IDI: Difference: SvI	SvW
Open								
FIN	-.870	.05	5.67(.31)	.41(.54)	1.88(.57)	2.63(.70)	-1.47	-2.21
ISL	-.805	.04	5.24(.12)	.10(.13)	1.96(.30)	3.91(.71)	-1.87	-3.81
NOR	-1.043	.07	7.05(.41)	1.35(.62)	3.90(.71)	3.34(.78)	-2.54	-1.98
SWE	-.870	.11	6.64(.33)	1.02(.50)	2.60(.58)	3.39(.87)	-1.59	-2.37
Average	-.879	.07	6.15	.72(.44)	2.59(.54)	3.32(.77)	-1.86	-2.60
Stratified								
AUS	-1.043	.21	9.46(.46)	-.81(.60)	4.88(.71)	6.98(.74)	-5.70	-7.79
CAN	-1.321	.17	8.36(.31)	-2.76(.52)	.55(.38)	1.35(.69)	-3.30	-4.11
GBR	-1.043	.23	10.34(.51)	1.21(.77)	6.61(.67)	8.87(.28)	-5.39	-7.66
USA	-1.321	.26	9.97(.52)	-1.10(.67)	2.32(.82)	6.01(.34)	-3.42	-7.11
Average	-1.182	.22	9.53	-.86(.64)	3.59(.64)	5.80(.01)	-4.45	-6.67
Tracking								
AUT	1.817	.55	17.76(.65)	-4.68(.51)	7.69(.45)	14.58(.30)	-12.37	-19.27
CZE	1.621	.52	16.38(.65)	3.38(.13)	10.74(.01)	14.46(.30)	-7.35	-11.08
DEU	1.862	.58	17.26(.60)	-6.31(.27)	6.19(.26)	10.68(.72)	-12.50	-16.98
HUN	1.421	.59	15.80(.81)	-8.43(.28)	5.29(.25)	16.45(.82)	-13.73	-24.89
SVK	1.621	.43	14.06(.77)	-2.20(.93)	6.36(.93)	14.19(.95)	-8.56	-16.39
Average	1.668	.53	16.25	-3.65(.22)	7.25(.18)	14.07(.62)	-10.90	-17.72

Notes. Bol = The Bol et al. tracking index. ICC = intra cluster correlation. AIDI = average absolute information distortion index. IDI = information distortion index. S = salariat background, I = intermediate background, W = working class background, v = versus/comparison. Countries represented using ISO 3-letter codes.

Table 4

Marginal Differences in Self-beliefs and Values

Country	Difference in self-concept		Marginal Difference in self-concept		Difference in Intrinsic Motivation		Marginal Difference in Intrinsic Motivation		Difference in Utility Value		Marginal Difference in Utility Value	
	SvI	SvW	SvI	SvW	SvI	SvW	SvI	SvW	SvI	SvW	SvI	SvW
Open												
FIN	-.260(.022)	-.298(.033)	-.033(.028)	-.005(.037)	-.128(.030)	-.136(.046)	.000(.030)	.029(.047)	-.179(.020)	-.186(.054)	-.068(.030)	-.043(.050)
ISL	-.207(.034)	-.321(.056)	-.063(.034)	-.142(.051)	-.108(.036)	-.219(.063)	-.027(.035)	-.116(.062)	-.064(.039)	-.137(.052)	-.009(.039)	-.067(.054)
NOR	-.314(.036)	-.317(.056)	-.057(.033)	-.030(.049)	-.185(.038)	-.131(.059)	.000(.039)	.076(.056)	-.225(.033)	-.305(.052)	-.085(.035)	-.147(.053)
SWE	-.280(.034)	-.224(.054)	-.049(.029)	.064(.052)	-.170(.038)	-.025(.052)	-.034(.034)	.144(.050)	-.181(.036)	-.103(.052)	-.078(.033)	.026(.050)
Average	-.265(.018)	-.290(.025)	-.051(.015)	-.028(.024)	-.148(.019)	-.128(.029)	-.015(.018)	.033(.029)	-.163(.017)	-.183(.027)	-.060(.016)	-.058(.027)
Stratified												
AUS	-.096(.035)	-.144(.048)	.095(.031)	.137(.039)	-.012(.030)	-.024(.041)	.076(.028)	.106(.040)	-.049(.029)	-.078(.038)	.039(.028)	.040(.036)
CAN	-.119(.025)	-.153(.034)	.052(.024)	.095(.035)	-.067(.023)	-.040(.043)	.026(.023)	.095(.047)	-.094(.023)	-.090(.038)	-.004(.023)	.039(.040)
GBR	-.124(.031)	-.147(.053)	.081(.030)	.166(.053)	-.015(.033)	.086(.060)	.065(.034)	.209(.063)	-.001(.034)	.081(.054)	.061(.036)	.176(.059)
USA	-.122(.033)	-.159(.049)	.048(.034)	.134(.048)	.025(.037)	.129(.055)	.070(.040)	.206(.059)	-.033(.035)	.048(.046)	.031(.037)	.157(.050)
Average	-.115(.014)	-.151(.024)	.069(.014)	.133(.023)	-.018(.016)	.038(.028)	.059(.016)	.154(.028)	-.042(.015)	-.010(.022)	.032(.016)	.103(.023)
Tracking												
AUT	-.094(.036)	-.013(.050)	.060(.036)	.197(.051)	.063(.037)	.186(.048)	.121(.040)	.267(.052)	.200(.040)	.274(.051)	.190(.041)	.261(.053)
CZE	-.157(.035)	-.180(.052)	.055(.034)	.174(.053)	-.041(.039)	.042(.064)	.063(.040)	.214(.066)	-.008(.035)	.037(.059)	.049(.037)	.131(.064)
DEU	-.047(.035)	-.055(.035)	.135(.036)	.253(.054)	.015(.037)	.081(.060)	.104(.038)	.232(.062)	.050(.032)	.076(.052)	.071(.034)	.112(.058)
HUN	-.063(.034)	-.004(.062)	.128(.034)	.250(.064)	.054(.037)	.112(.056)	.135(.040)	.219(.058)	.031(.036)	.044(.049)	.092(.036)	.125(.050)
SVK	-.167(.037)	-.218(.064)	.068(.032)	.158(.061)	.064(.035)	.142(.067)	.141(.035)	.264(.065)	.081(.040)	.152(.059)	.127(.039)	.226(.059)
Average	-.106(.015)	-.084(.017)	.089(.014)	.188(.020)	.031(.016)	.097(.024)	.113(.018)	.215(.027)	.071(.017)	.102(.023)	.106(.017)	.151(.025)
Group Comparison	a,b	a,b,c^	a,b	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c^

Notes. S = salariat background, I = intermediate background, W = working class background, v = versus/comparison. Countries represented using ISO 3-letter codes. Standard errors in brackets. All estimates in country-specific standard deviation units. a = Open average significantly difference to Stratified average; b = Open average significantly difference from Tracking average; c = Stratified average significantly different from the Tracking average. ^ indicates significant only at the $p < .10$ level.

Table 5

Differences in University Aspirations

Country	Difference in Aspirations		Marginal Difference in Aspirations[1]		Marginal Difference in Aspirations[2]	
	SvI	SvW	SvI	SvW	SvI	SvW
Open						
FIN	-.141(.013)	-.183(.022)	-.096(.013)	-.125(.021)	-.091(.013)	-.123(.020)
ISL	-.137(.019)	-.197(.026)	-.091(.017)	-.140(.025)	-.089(.017)	-.132(.024)
NOR	-.189(.014)	-.200(.024)	-.137(.014)	-.142(.023)	-.130(.014)	-.132(.022)
SWE	-.200(.016)	-.190(.024)	-.150(.015)	-.128(.023)	-.143(.014)	-.135(.022)
Average	-.166(.007)	-.192(.011)	-.118(.007)	-.134(.011)	-.113(.007)	-.130(.011)
Stratified						
AUS	-.192(.017)	-.256(.023)	-.115(.015)	-.143(.022)	-.120(.015)	-.149(.021)
CAN	-.205(.012)	-.230(.020)	-.150(.011)	-.150(.019)	-.151(.011)	-.156(.019)
GBR	-.200(.015)	-.248(.024)	-.111(.013)	-.111(.020)	-.113(.013)	-.119(.019)
USA	-.162(.018)	-.238(.025)	-.101(.019)	-.134(.023)	-.104(.019)	-.144(.024)
Average	-.190(.008)	-.243(.010)	-.119(.008)	-.134(.009)	-.122(.008)	-.142(.009)
Tracking						
AUT	-.222(.019)	-.268(.023)	-.147(.016)	-.166(.021)	-.146(.016)	-.167(.021)
CZE	-.263(.013)	-.351(.020)	-.156(.012)	-.173(.021)	-.159(.012)	-.183(.021)
DEU	-.194(.015)	-.214(.019)	-.128(.014)	-.103(.018)	-.130(.014)	-.107(.019)
HUN	-.338(.018)	-.478(.023)	-.189(.015)	-.281(.019)	-.188(.015)	-.278(.020)
SVK	-.291(.015)	-.442(.022)	-.164(.012)	-.238(.022)	-.165(.012)	-.241(.022)
Average	-.261(.006)	-.320(.009)	-.157(.006)	-.177(.009)	-.158(.006)	-.180(.009)
Group Comparison	a,b,c	a,b,c	b,c	b,c	b,c	b,c

Notes. S = salariat background, I = intermediate background, W = working class background, v = versus/comparison. Countries represented using ISO 3-letter codes. Standard errors in brackets. All estimates in country specific standard deviation units. a = Open average significantly difference to Stratified average; b = Open average significantly difference from Tracking average; c = Stratified average significantly different from the Tracking average. [1]Controlling for achievement. [2]Controlling for achievement, self-beliefs, and values.

Table 6

Standard and Counterfactual Predicted Probability Differences

	Standard Case		Counterfactual Case[1]			Counterfactual Case[2]		
	Probability	SE	Probability	SE	Difference	Probability	SE	Difference
University entry (age 19)								
SvI	-.187	.016	-.185	.016	.002	-.173	.016	-.014
SvW	-.247	.024	-.243	.024	.004	-.203	.024	-.044
University graduation (age 25)								
SvI	-.129	.022	-.133	.022	.004	-.124	.022	-.005
SvW	-.233	.035	-.234	.035	.001	-.198	.035	-.035

Notes. S = salariat background, I = intermediate background, W = working class background, v = versus/comparison. [1]Class specific achievement and direct effect by population self-beliefs and values. [2] Class specific achievement profile from Finland (taken from Study 1), class specific direct effect, and population self-beliefs and values. Difference = difference to standard case.

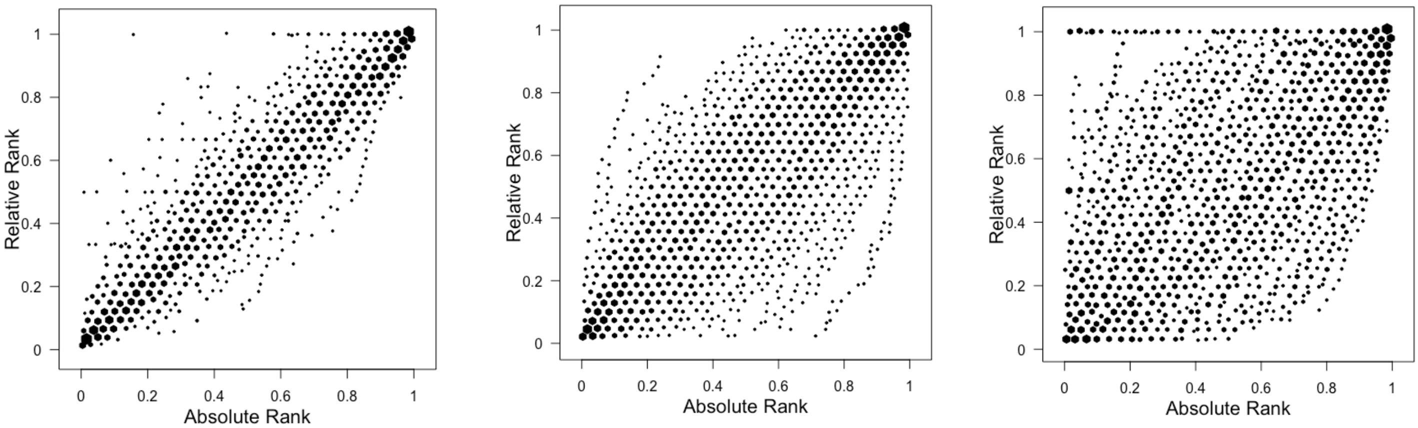

Figure 1. Hexbin plot of relative and absolute percentile rank in Iceland (Open), Australia (Stratified) and Hungry (Tracking). The size of the hexagon indicates the density of participants in that region. A country with no overmatching or undermatching would have all points on the 45° line.

Appendix

Table A1

Mean (rather than Median) IDI

Country	AIDI(S.E.)	S	I	W
Open				
FIN	7.41(.34)	.08(.66)	1.99(.63)	2.71(.74)
ISL	7.45(.09)	.58(.19)	3.11(.32)	5.56(.72)
NOR	9.24(.42)	1.63(.82)	4.48(.78)	3.73(.09)
SWE	9.11(.40)	.45(.86)	3.04(.69)	4.04(.19)
Average	8.30	.68(.63)	3.15(.60)	4.01(.93)
Stratified				
AUS	12.05(.52)	-2.07(.70)	5.01(.69)	7.87(.79)
CAN	11.36(.35)	-4.25(.61)	.20(.51)	1.78(.78)
GBR	13.75(.49)	.23(.10)	7.46(.64)	11.30(.15)
USA	13.59(.55)	-.75(.83)	4.97(.92)	8.91(.49)
Average	12.69	-1.71(.81)	4.41(.69)	7.47(.05)
Tracking				
AUT	20.55(.50)	-3.84(.26)	7.80(.92)	14.06(.20)
CZE	19.71(.56)	1.23(.06)	10.79(.86)	15.79(.27)
DEU	20.82(.46)	-6.19(.05)	6.39(.09)	11.91(.30)
HUN	20.08(.61)	-9.40(.15)	7.59(.05)	17.25(.92)
SVK	17.60(.72)	-3.96(.02)	6.79(.87)	15.16(.60)
Average	19.75	-4.43(.11)	7.87(.96)	14.83(.46)

Table A2
Differences in University Aspirations: Probit Regression

Country	Difference in Aspirations		Marginal Difference in Aspirations[1]		Marginal Difference in Aspirations[2]	
	SvI	SvW	SvI	SvW	SvI	SvW
Open						
FIN	-.141(.013)	-.183(.022)	-.099(.013)	-.128(.022)	-.095(.014)	-.129(.022)
ISL	-.137(.019)	-.197(.026)	-.101(.019)	-.164(.028)	-.099(.019)	-.158(.029)
NOR	-.189(.014)	-.200(.024)	-.154(.016)	-.157(.027)	-.149(.016)	-.151(.028)
SWE	-.200(.016)	-.190(.024)	-.161(.016)	-.138(.026)	-.157(.016)	-.148(.024)
Average	-.166(.007)	-.192(.011)	-.129(.008)	-.147(.013)	-.124(.008)	-.144(.012)
Stratified						
AUS	-.192(.017)	-.256(.023)	-.121(.016)	-.146(.024)	-.131(.016)	-.159(.024)
CAN	-.205(.012)	-.230(.020)	-.156(.012)	-.154(.020)	-.161(.011)	-.165(.021)
GBR	-.200(.015)	-.248(.024)	-.124(.015)	-.137(.024)	-.128(.015)	-.147(.025)
USA	-.162(.018)	-.238(.025)	-.104(.019)	-.133(.024)	-.108(.020)	-.147(.026)
Average	-.190(.008)	-.243(.010)	-.126(.009)	-.143(.010)	-.133(.009)	-.156(.011)
Tracking						
AUT	-.222(.019)	-.268(.023)	-.167(.017)	-.198(.025)	-.164(.017)	-.198(.025)
CZE	-.263(.013)	-.351(.020)	-.186(.016)	-.227(.031)	-.192(.015)	-.239(.031)
DEU	-.194(.015)	-.214(.019)	-.140(.015)	-.118(.026)	-.142(.015)	-.121(.026)
HUN	-.338(.018)	-.478(.023)	-.203(.017)	-.328(.024)	-.201(.017)	-.325(.025)
SVK	-.291(.015)	-.442(.022)	-.189(.014)	-.313(.030)	-.190(.014)	-.317(.031)
Average	-.261(.006)	-.320(.009)	-.177(.006)	-.237(.013)	-.177(.006)	-.239(.013)
Group Comparison	a,b,c	a,b,c	b,c	b,c	b,c	b,c

Notes. S = salariat background, I = intermediate background, W = working class background, v = versus/comparison. Countries represented using ISO 3-letter codes. Standard errors in brackets. All estimates in country specific standard deviation units. a = Open average significantly difference to Stratified average; b = Open average significantly difference from Tracking average; c = Stratified average significantly different from the Tracking average. [1]Controlling for achievement. [2]Controlling for achievement, self-beliefs, and values.

Table A3
Standard and Counterfactual Predicted Probability Differences

	Standard Case		Counterfactual Case[1]			Counterfactual Case[2]		
	Probability	SE	Probability	SE	Difference	Probability	SE	Difference
University entry (age 19)								
	-.220	.018	-.222	.018	.002	-.209	.019	-.011
	-.283	.027	-.286	.027	.003	-.245	.030	-.038
University graduation (age 25)								
SvI	-.143	.024	-.147	.024	.004	-.138	.024	-.005
SvW	-.256	.036	-.258	.036	.002	-.226	.039	-.030

Notes. S = salariat background, I = intermediate background, W = working class background, v = versus/comparison. [1]Class specific achievement and direct effect but population self-beliefs and values. [2] Class specific achievement profile from Finland (taken from Study 1), class specific direct effect, and population self-beliefs and values. Difference = difference to standard case.

Table A4
Country Metrics

Country	PISA Math Rank	Educational Spending as % of GDP	Social Expenditure as % of GDP	Cultural Diversity Index	% Immigrant	High-School Graduation Rate
Open						
FIN	2	7.2	23.8	.132	3.0	87
ISL	14	9.9	17.2	-	6.8	73
NOR	22	8.9	23.7	.098	7.6	82
SWE	17	7.6	28.2	.189	12.0	82
Average	14	8.4	23.2	.140	7.3	81
Stratified						
AUS	11	10.1	17.5	.147	23.5	77
CAN	7	8.8	16.3	.499	18.1	93
GBR	-	8.5	19.0	.184	8.6	79
USA	28	-	19.2	.271	11.6	90
Average	15	9.1	18.0	.275	15.4	85
Tracked						
AUT	18	6.2	26.5	.100	14.1	83
CZE	13	5.8	18.8	.064	4.7	82
DEU	19	6.6	26.6	.090	12.9	87
HUN	25	5.2	21.9	.185	3.0	83
SVK	21	6.1	16.6	.170	3.2	91
Average	19	6.0	22.1	.122	7.6	85

Notes. PISA rankings for math for PISA cycle 2003. Cultural diversity index taken from (Fearon, 2003). Social expenditure taken from the 2003 values from the OECD social expenditure database (https://www.oecd.org/social/expenditure.htm). Percent immigrant taken from the OECD foreign-born database (https://data.oecd.org/migration/foreign-born-population.htm). Graduation rates taken from the OECD better life index which reports percentage of adults aged 25-64 who have completed upper secondary education (http://www.oecdbetterlifeindex.org/topics/education/). Educational expenditure as percentage of GDP taken from the OECD public spending on education database from the 2005 values (https://data.oecd.org/eduresource/public-spending-on-education.htm).