Social Science & Medicine 165 (2016) 108–118

Contents lists available at ScienceDirect

Social Science & Medicine

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

Do early life cognitive ability and self-regulation skills explain socio-economic inequalities in academic achievement? An effect decomposition analysis in UK and Australian cohorts

Anna Pearce [a, b, *, 1], Alyssa C.P. Sawyer [a], Catherine R. Chittleborough [a], Murthy N. Mittinty [a], Catherine Law [b, 1], John W. Lynch [a, c]

[a] School of Population Health, University of Adelaide, Adelaide, Australia
[b] Population, Policy and Practice, UCL Institute of Child Health, University College London, London, United Kingdom
[c] School of Social and Community Medicine, University of Bristol, United Kingdom

ARTICLE INFO

Article history:
Received 19 April 2016
Received in revised form
28 June 2016
Accepted 17 July 2016
Available online 20 July 2016

Keywords:
Socio-economic inequalities
Early childhood
Early intervention
Academic achievement
UK millennium cohort study
Longitudinal Study of Australian Children
Avon longitudinal study of parents and their children

ABSTRACT

Socio-economic inequalities in academic achievement emerge early in life and are observed across the globe. Cognitive ability and "non-cognitive" attributes (such as self-regulation) are the focus of many early years' interventions. Despite this, little research has compared the contributions of early cognitive and self-regulation abilities as separate pathways to inequalities in academic achievement. We examined this in two nationally representative cohorts in the UK (Millennium Cohort Study, n = 11,168; 61% original cohort) and Australia (LSAC, $n = 3028$; 59% original cohort).

An effect decomposition method was used to examine the pathways from socio-economic disadvantage (in infancy) to two academic outcomes: 'low' maths and literacy scores (based on bottom quintile) at age 7–9 years. Risk ratios (RRs, and bootstrap 95% confidence intervals) were estimated with binary regression for each pathway of interest: the 'direct effect' of socio-economic disadvantage on academic achievement (not acting through self-regulation and cognitive ability in early childhood), and the 'indirect effects' of socio-economic disadvantage acting via self-regulation and cognitive ability (separately). Analyses were adjusted for baseline and intermediate confounding.

Children from less advantaged families were up to twice as likely to be in the lowest quintile of maths and literacy scores. Around two-thirds of this elevated risk was 'direct' and the majority of the remainder was mediated by early cognitive ability and not self-regulation. For example in LSAC: the RR for the direct pathway from socio-economic disadvantage to poor maths scores was 1.46 (95% CI: 1.17–1.79). The indirect effect of socio-economic disadvantage through cognitive ability (RR = 1.13 [1.06–1.22]) was larger than the indirect effect through self-regulation (1.05 [1.01–1.11]). Similar patterns were observed for both outcomes and in both cohorts.

Policies to alleviate social inequality (e.g. child poverty reduction) remain important for closing the academic achievement gap. Early interventions to improve cognitive ability (rather than self-regulation) also hold potential for reducing inequalities in children's academic outcomes.

1. Introduction

Educational qualifications and trajectories of employment, income and health across the life course are all importantly influenced by academic achievement in childhood (Galobardes et al., 2008; Harper et al., 2011). There are large socio-economic inequalities in academic achievement throughout childhood (Brinkman et al., 2012; Sirin, 2005), and these help drive the emergence of health inequalities (Lynch and Davey Smith, 2005). In acknowledgement of the benefits to giving every child a strong start in life and the subsequent contributions to the economic productivity of society (Allen, 2011; Organization for Economic Cooperation and Development, 2011), the focus of government and non-government organizations in many countries has turned

* Corresponding author. 30 Guilford Street, London, WC1N 1EH, United Kingdom.
E-mail address: anna.pearce@ucl.ac.uk (A. Pearce).
[1] For AP's main affiliation see 'b'.

http://dx.doi.org/10.1016/j.socscimed.2016.07.016

to improving overall levels and socio-economic gaps in academic achievement in early childhood (Douglas et al., 2014; HM Government, 2011; Organization for Economic Cooperation and Development, 2011; The Equity and Excellence Commission, 2013).

While cognitive ability is a widely recognised determinant of academic achievement, there is increasing interest in the role of "non-cognitive" characteristics (F Cunha and Heckman, 2007; Heckman et al., 2006; Kautz et al., 2014). Though the term "non-cognitive" has not been consistently defined or measured, the idea of non-cognitive skills encapsulates personality characteristics and social behaviours that can maximise life opportunities (Borghans et al., 2008). In young children an important component of non-cognitive abilities is self-regulation (Barkley, 2011) which refers to the control of attention, emotion and behaviour (Blair and Diamond, 2008). Some research has suggested that early "non-cognitive" skills like self-regulation may be as important (if not more important) than cognitive ability for future outcomes like labour market success, both directly and by supporting later cognitive ability (Flavio Cunha and Heckman, 2008).

Self-regulation is integral to cognitive ability in childhood, through supporting engagement in and persistence with learning tasks (Blair and Diamond, 2008). Cognitive ability and self-regulation have both been linked to better academic achievement (Blair and Diamond, 2008; Oberle et al., 2014; Sawyer et al., 2015) and are generally lower among socially disadvantaged children (C. R. Chittleborough, Mittinty, Lawlor and Lynch, 2014; Dearden et al., 2011; Evans and Rosenbaum, 2008; Feinstein, 2003; Sektnan et al., 2010). Observational studies indicate that self-regulation (Dilworth-Bart, 2012; Evans and Rosenbaum, 2008; Sektnan et al., 2010) and cognitive ability (C. R. Chittleborough et al., 2014) may mediate the association between socio-economic disadvantage (SED) and academic achievement (although none explicitly compared the mediating roles of both). It is therefore plausible that intervening on these components of child development (Bierman et al., 2008; Raver et al., 2011) may reduce socio-economic inequality in academic achievement. Interventions targeting cognitive ability and/or self-regulation in the United States have been shown to improve school readiness and early academic achievement (Kautz et al., 2014), including in disadvantaged families (Bierman et al., 2008; Raver et al., 2011), although effects may fade with time (Burger, 2010; U.S. Department of Health and Human Services & Administration for Children and Families, 2010). A comparison of cognitive and self-regulation skills, as two related mechanisms that can be targeted by interventions, would inform the design of early childhood programs to reduce socio-economic gaps in academic achievement.

Our goal was to decompose the pathways from SED at birth (represented by low maternal education) to children's academic achievement in mid-childhood that were via early-life self-regulation (task attentiveness and persistence) and cognitive ability (verbal and non-verbal skills). Fig. 1 shows the direct pathway from SED to the child academic achievement (in bold), the indirect pathway via cognitive ability (in dashes), and the indirect pathway via self-regulation (including via cognitive ability in dots). We conducted comparative analyses throughout early- to mid-childhood using data from contemporary, nationally representative cohorts from Australia (the Longitudinal Study of Australian Children, LSAC(Australian Institute of Family Studies, 2014)) and the United Kingdom (UK) (the Millennium Cohort Study, MCS(Connelly and Platt, 2014)). As a sensitivity analysis to measurement error in the self-regulation measures, which were based on maternal report in MCS and LSAC (see Methods), we examined these associations in a third cohort - the Avon Longitudinal Study of Parents and Children, ALSPAC(Boyd et al., 2012; Fraser et al., 2013), which collected an objective measure of executive function, a measure of self-regulation in young people.

2. Methods

2.1. Participants

2.1.1. Longitudinal Study of Australian Children

The LSAC is a nationally representative prospective study of two cohorts of children, recruited 2003–2004. The methodology has been previously described (Soloff et al., 2005). We used data on 5107 infants (64% of those invited to take part) from the 'b-cohort', who were first contacted at 0–1 year.

2.1.2. The Millennium Cohort Study

The MCS is a longitudinal study of children born in the UK, 2000–2002. Information on the survey design has been described elsewhere (Hansen, 2010). The first contact with the cohort child was carried out at around age 9 months for 18,818 infants (91% of the 20,646 of the target sample). Data were downloaded from the UK Data Service, University of Essex and University of Manchester, in April 2014.

In both cohorts, interviews were carried out with trained interviewers in the home, with the primary caregiver (usually the mother) and her partner (if relevant); postal questionnaires were also sent to the children's teachers once they reached school age.

2.2. Measures

The counterfactual analytical method used to decompose the mediating pathways of interest (Vanderweele et al., 2014) (see Analysis) favours use of binary exposure, mediator and intermediate confounding variables, because the availability of just one counterfactual state aids interpretability of results. All measures are described in detail in Table 1 and summarised below, including cut-offs for dichotomisation (where relevant).

2.2.1. Exposure: socio-economic disadvantage

Mothers' highest educational qualifications (when the cohort child was an infant) were used as indicators of SED. Low education was defined by educational targets set by the Australian (completion of Year 12(The Commonwealth of Australia and the States and Territories, 2009)) and UK (General Certificate in Secondary Education (GCSE), grades A*-C(HM Government, 2011)) governments.

2.2.2. Outcome: low academic achievement

We analysed two separate measures of academic achievement: maths and literacy scores derived from teacher assessment in LSAC and by tests completed by the MCS children during the interview. 'Low' academic achievement was defined as being in the lowest quintile of scores.

2.2.3. Mediator 1: low self-regulation

We used a number of items representing a component of self-regulation known to influence academic achievement - task attentiveness and persistence (Sawyer et al., 2015) (see Table 1). Responses to the items were summed to create self-regulation scores (Table 1); children in the lowest quintile were defined as having 'low' self-regulation.

2.2.4. Mediator 2: low cognitive ability

Cognitive ability was defined as the non-verbal and verbal abilities of the child (Table 1). Non-verbal abilities were assessed with the Matrix Reasoning subtest in LSAC and pattern construction in the MCS. Verbal abilities were assessed using a test of receptive vocabulary. Verbal and non-verbal scores were