Height and Cognition at Older Ages: Irish Evidence

by

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Abstract: Previous research suggests that taller individuals have greater cognitive ability. The aim of this paper is to empirically investigate whether the relationship between height and cognition holds in later-life using data from the first wave of The Irish Longitudinal Study on Ageing (TILDA). Seven measures of cognition are used. These measures capture aspects of cognition which are more likely to decline in old age, such as cognitive flexibility, processing speed, concentration and attention. It is found that height is positively and significantly associated with cognition in later-life also when education and early-life indicators are controlled for. The finding that adult height is a marker for nutrition and health environment experienced in early-life is widely accepted in the literature. The findings of this paper suggest that height might have a greater value added, as it appears to be a useful measure of unobserved childhood experiences.

Key words:	cognition, height, ageing, early-life
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1. Introduction

A small but growing body of research suggests that taller individuals earn more than their shorter counterparts (Persico et al., 2008; Heineck, 2009; Lundborg et al., 2014). This "height premium" has been attributed to factors such as self-esteem, social dominance and discrimination against shorter people. Case and Paxon (2008a) offer a different explanation: taller individuals earn more because they have greater cognitive ability. The authors argue that gestation and childhood are crucial periods for height growth. If foetuses and children are well-nourished and in good health, they will eventually reach the adult height set by their genetic potential. Children from taller families will be taller, and children from shorter families will be shorter, but there will be no effect of height on adult outcomes. Children who are, however, exposed to poor nutrition, disease or adversity in utero or early childhood, will not attain their full potential height. There is evidence that physical and cognitive function develop together, suggesting that children who do not reach their potential height will also not reach their full cognitive potential (Deaton and Arora, 2009).

If it is the case that taller individuals have greater cognitive ability, do they also exhibit greater cognitive ability as they age? Do the (dis-)advantages experienced in early-life follow adults into old age? To our knowledge, there are only three economics-based studies that have tested this hypothesis: Case and Paxon (2008b) and Guven and Lee (2013, 2015). These studies use data from the *Health and Retirement Study* in the US *(HRS)*, the *English Longitudinal Study on Ageing (ELSA)*, and the *Survey of Health*, *Ageing and Retirement* in Europe *(SHARE)*. They all find a positive and significant association between height and cognition in later-life. In particular, Guven and Lee (2013, 2015) find that this association remains even after controlling for education and childhood circumstances.

The paper contributes to the existing literature in several ways. First, it provides evidence on the height-cognition relationship in later-life using data from older Irish adults. Historically, Ireland suffered relatively poor economic conditions and high level of infectious diseases in comparison to other European countries, suggesting considerable variation in early-life socioeconomic conditions. Second, it employs several measures of cognition which have three main advantages: i) they are novel in the context of other longitudinal studies on ageing; ii) they capture aspects of cognition which are more likely to decline in old age, such as cognitive flexibility, processing speed, concentration and attention; and iii) they are administered and scored by trained nurses. Due to data limitation, the previous three studies employed mostly measures of word recall, verbal fluency or numeracy in face-to-face or telephone interviews. Third, it uses accurate anthropometric data to capture height. Evidence suggests that self-reported height, employed by Case and Paxon (2008b) and Guven and Lee (2015), is subject to over-reporting, which is often systematically related to age and socioeconomic status, and may lead to biased estimates of the height/cognition relationship (Maurer, 2010, p. 169).

2. Data

The dataset used is the first wave of *The Irish Longitudinal Survey of Aging* (TILDA), which was collected between October 2009 and July 2011. As detailed by Kearney et al. (2011), Cronin et al. (2013) and Whelan and Savva (2013), TILDA collects information on the economic, health and social aspects for a nationally representative sample of individuals aged 50 years and older. TILDA is based on a two-stage clustered sampling design with stratification. In the first-stage, sampling units are geographical clusters. In the second-stage, sampling units are households. Sampling weights are also applied. The method used for variance estimation is Taylor linearization. Both sampling stages provide a component to the variance estimator and have their finite population correction.

At wave 1, a total of 8,175 respondents completed a face-to-face interview in their own home. Each respondent was also invited to undertake an extensive health assessment, either in a dedicated centre or in their own home. All assessments were carried out by trained and qualified nurses. A total of 5,897 respondents underwent a health assessment.

3. Empirical Strategy

3.1 Model

The regression model is:

$$\ln(Cog_i) = \beta_0 + \beta_1 \ln(Height_i) + \sum_j \beta_j X_{ij} + u_i \quad (1)$$

Where: "*Cog*" is a measure of cognition of individual "i" (i = 1,2,.., N); "*Height*" is the individual's height; "X_j" is a set of other variables thought to impact on cognition; and "u" is an error term.

3.2 Variables

A large component of the TILDA health assessment is devoted to assessing cognition using pen-and-paper and computer-based tasks. Seven measures of cognition are collected: (1) *Montreal Cognitive Assessment* (*MoCA*); (2) *Colour Trail Task 1* (*CTT1*); (3) *Colour Trail Task 2* (*CTT2*); (4) *Choice Reaction Time (CRT*); (5) *Choice Reaction Time Variability* (*VAR_CRT*); (6) *Sustained Attention to Response Task* (*SART*); and (7) *Sustained Attention to Response Task Variability* (*VAR_SART*).

Height is measured in the health assessment by a qualified nurse. One potential issue with older people's height is that there could be shrinkage as a result of bone density loss (Fernihough and McGovern, 2015; Huang et al., 2013). In order to address this issue, the analysis on this paper focuses on individuals aged 50 to 70 (inclusive). Controls for age, sex, education and childhood circumstances are also included. Education is a potential pathway linking height and cognition in later-life. Childhood circumstances likely are the most relevant factors affecting both height and cognition. Childhood circumstances are based on retrospective self-reports between birth and age 14. Details of all variables, along with summary statistics, are provided in Table 1. Some of the questions concerned with the respondent's childhood socioeconomic and family circumstances were included in the third wave of TILDA. Therefore, the sample includes individuals aged 50 to 70 who participated in both Waves 1 and 3, with no missing observations on the variables of interest. The final sample size is 3,545 respondents.

4. Regression Results

To make interpretation easier, the natural logarithm of height and the seven cognition variables is taken so that the association between height and cognition can be considered as an elasticity. The transformed scores of *CTT1*, *CTT2*, *CRT*, VAR_*CRT*, *SART* and *VAR_SART* are then multiplied by "-1". This insures that a higher value of each of these variables corresponds a higher level of cognition, which makes interpretation of the estimates easier.

The estimated cognition-height elasticities are reported in Table 2. Three interesting results emerge. First, the height elasticity is positive and significant with respect to six cognition variables (see Panel 1). For example, a 1% increase in height is associated with 0.48% increase in the *MOCA* score or a 0.69% increase in the *CTT1* score. Second, the elasticity is still positive and significant in most regressions when education is controlled for, although it is smaller in magnitude (see Panel 2). Third, the inclusion of childhood variables has a modest effect on the magnitude of the elasticity (see Panel 3). An F-test suggests that the fraction of variation in cognition that is explained by the controls of the full specification is significantly larger than the fraction of variation explained when childhood characteristics are not controlled for. The regression results for the full specification are given in Table A1 in the Appendix.

The robustness of the results is tested in two different ways. First, the regressions are re-estimated using a sample of all respondents aged 50 and older (results not shown). The estimated elasticities are larger in magnitude than those reported in Table 2. However, a Wald-test suggests that this difference is not statistically significant at the 1% level. Therefore, the same conclusions are supported regardless of whether the sample is restricted to "younger" older people. This suggests that the issue of shrinkage in old-age is likely not a major problem when examining the relationship between height and cognition amongst older people. The authors suspect that this may be an outcome of using actual height versus self-assessed height.

Second, the association between height and occupational attainment is also investigated. If height impacts on cognition, and in turn cognition impacts on socioeconomic suceess you would expect height to directly impact on socioeconomic success. Since the sample consists of older people, only a fraction of the sample are working, so it is not possible to use wage or salary as a measure of socioeconomic success. However, TILDA collects information on occupation, based on "current job" for those in employment at the time of interview or on "most recent job" for those not in employment. In line with the classification proposed by the Central Statistics Office (CSO, 2012), respondents are assigned to six social class groups: *Unskilled*; *Semi-skilled*; *Skilled Manual*; *Non-manual*; *Managerial/Technica*l; and *Professional*. Since this variable is ordinal in measurement, an ordered logit model is estimated, which includes all the variables used in the cognition regressions. The coefficient of the (ln) height is 5.24, and is statistically significant well below the 1% level ($z = 5.7$). This suggests that being taller is associated with having a higher probability of being in a higher social class occupation. Figure 1 shows the shift in the occupation distribution towards the higher social class occupations associated with an increase in height of 9.2 cm (about one standard deviation, see Table 1).

5. Concluding Comments

This paper found that height is associated with those aspects of cognition which are more likely to decline in old-age, such as cognitive flexibility, processing speed, concentration and attention. Retrospective self-assessments of early-life conditions displayed significant associations with later-life cognition, but only had a moderate impact on the estimated height elasticity. The finding that adult height is a marker for nutrition and health in early-life is widely accepted in the literature. The findings of this paper suggest that height and retrospectively assessed early-life conditions might capture different aspects of early-life circumstances and that anthropometric markers are a useful complement to such retrospective information. A caveat to this is that the set of retrospective measures of childhood circumstances, and in particular of childhood health, included in TILDA and in the other international studies on ageing are not particularly strong. Possibly, weaker associations between height and later-life cognition would have been found had stronger measures of childhood circumstances been included. The association between height and later-life cognition decreased substantially once education was controlled for. This result confirms the findings of the previous literature that education is likely to be an important pathway in the relationship between early-life conditions and later-life cognition.

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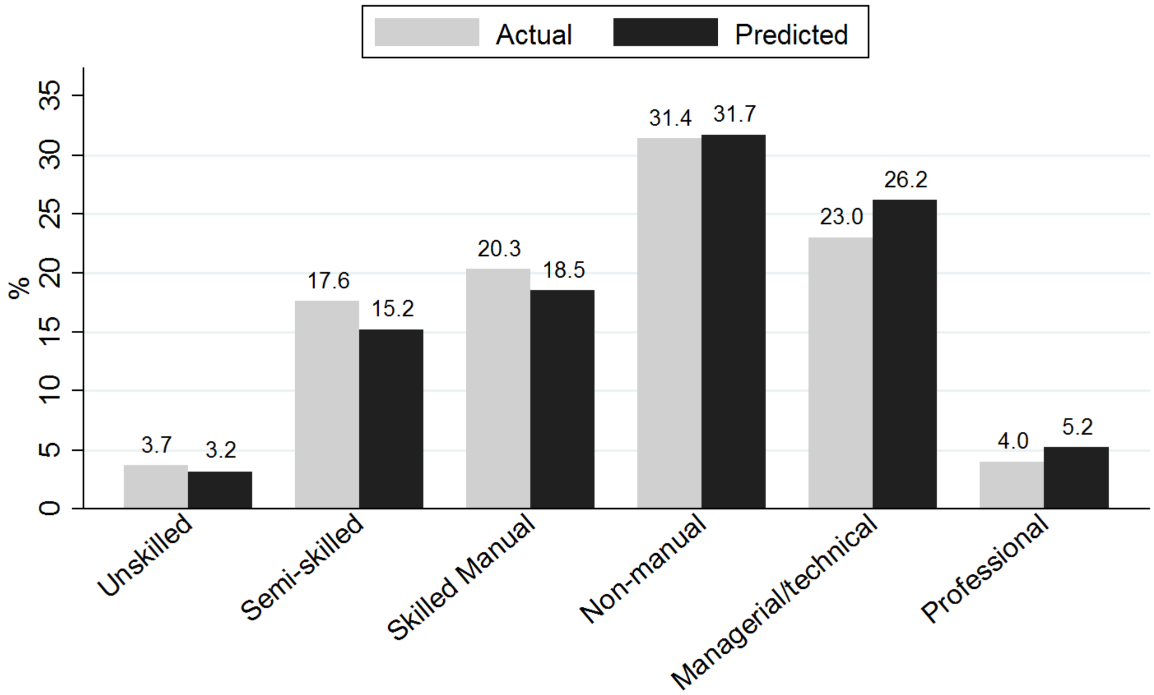
Table 1: Descriptive Statistics for Regression Variables

Mnemonic	*Definition*	*Measurement*	*Mean*	*St. Dev.*
Height	Height measured by nurse	Centimetres	167.0	9.2
MOCA	Montreal Cognitive Assessment	Measure of attention, concentration, memory, language, calculations, orientation, visuo-constructional skills, executive function and conceptual thinking. Outcome is overall score ranging from 0 to 30	25.3	3.1
CTT1	Color Trail Test 1	Measure of visual scanning and processing speed. Outcome is time taken to draw line connecting circles numbered 1–25 in consecutive order (seconds)	51.7	21.1
CTT2	Color Trail Test 2	Measure of visual scanning, attention and mental flexibility. Outcome is time taken to draw line connecting circles numbered 1–25 alternating between pink and yellow circles (seconds)	104.6	36.6
CRT	Choice Reaction Time	Measure of concentration and processing speed. Outcome is average time taken to release button on keyboard in response to stimulus (yes/no) appearing on computer screen; 100 repetitions (milliseconds)	502.3	133.0
VAR_CRT	Choice Reaction Time Variability	Outcome is standard deviation of time taken to release the button in response to the stimulus (yes/no) appearing on computer screen (milliseconds)	115.5	141.3
SART	Sustained Attention to Response Task	Measure of arousal, attention, processing speed, executive function. Outcome is average time taken for each key press in response to digits 1, 2, 4-9 appearing on computer screen for 4 minutes (milliseconds)	371.8	96.6
VAR_SART	Sustained Attention to Response Task Variability	Outcome is standard deviation of time taken to press key in response to digits 1, 2, 4-9 (milliseconds)	109.9	65.4
Age	Age of Respondent	Years	58.9	5.7
Male	Sex	Dummy: 1 for male; 0 for female	49.4%	
School	Schooling	Years completed	11.6	2.6
PoorFam	Self-reported socioeconomic position in childhood	Dummy: 1 for poor; 0 for average/well-off	22.7%	--
MotherNotWork	Mother ever worked outside the home in childhood	Dummy: 1 for mother never worked; 0 otherwise	68.2%	--
FatherNotWork	Father ever worked outside the home in childhood	Dummy: 1 for father never worked; 0 otherwise	6.7%	--
PoorHealth	Self-reported health in childhood	Dummy: 1 for poor/fair; 0 for excellent/very good/good	6.4%	--
NoBooks	Books in the accommodation respondent lived in childhood	Dummy: 1 for 0-10 books; 0 for 11+ books	43.9%	--
NoFeature	Features in the accommodation respondent lived in childhood	Dummy: 1 for no features (no fixed bath, no cold/hot running (piped) water supply; no inside toilet; no central heating; no electricity); 1 for 1+ feature	8.8%	--
HouseholdSize	Household size in childhood	Number of people, including respondent	7.3	2.9

Table 2: Cognition-Height Elasticity Estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ln(MOCA)	-ln(CTT1)	-ln(CTT2)	-ln(CRT)	-ln(VAR_CRT)	-ln(SART)	-ln(VAR_SART)
Panel 1: Regressors are: ln(height), age, sex							
	0.478***	0.692***	0.872***	0.326***	0.968***	0.172	0.577**
	(6.7)	(4.3)	(5.9)	(3.1)	(3.7)	(1.4)	(2.3)
R-sq (%)	4.6	10.9	10.5	2.5	2.6	1.8	4.4
Panel 2: Regressors are: ln(height), age, sex, education							
	0.362***	0.497***	0.643***	0.246**	0.801***	0.129	0.338
	(5.4)	(3.1)	(4.6)	(2.4)	(3.1)	(1.1)	(1.4)
R-sq (%)	10.6	13.3	14.8	3.7	3.4	2.0	6.1
Panel 3: Regressors are: ln(height), age, sex, education, childhood circumstances							
	0.348***	0.424***	0.610***	0.235**	0.780***	0.149	0.324
	(5.3)	(2.7)	(4.3)	(2.2)	(3.0)	(1.2)	(1.3)
R-sq (%)	13.2	14.9	17.3	4.2	4.3	2.8	7.2
N	3,545	3,545	3,545	3,545	3,545	3,545	3,545
Note: *** p< 0.01; ** p<0.05; and * p<0.10.							

Figure 1: Actual and Predicted Occupation Social Class Distribution



Note: Predicted distribution associated with an increase of height of 9.2 cm

Appendix A

Table A1: Regression Results, Full Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ln(MOCA)	-ln(CTT1)	-ln(CTT2)	-ln(CRT)	-ln(VAR_CRT)	-ln(SART)	-ln(VAR_SART)
Ln(Height)	0.348***	0.424***	0.610***	0.235**	0.780***	0.149	0.324
	(5.3)	(2.7)	(4.3)	(2.2)	(3.0)	(1.2)	(1.3)
Age	-0.00230***	-0.0158***	-0.0126***	-0.00330***	-0.00940***	-0.00402***	-0.0138***
	(-5.2)	(-14.9)	(-13.7)	(-5.3)	(-5.8)	(-5.1)	(-8.4)
Male	-0.0269***	-0.109***	-0.0849***	-0.0460***	-0.0212	0.0215	0.0653**
	(-3.7)	(-6.2)	(-5.5)	(-4.0)	(-0.7)	(1.6)	(2.4)
School	0.0105***	0.0171***	0.0200***	0.00756***	0.0151***	0.00422***	0.0202***
	(12.1)	(7.3)	(9.8)	(5.1)	(4.1)	(2.6)	(5.9)
PoorFam	0.0105	0.0126	0.00760	0.00187	0.0431*	0.00702	-0.0196
	(1.5)	(0.8)	(0.5)	(0.2)	(1.8)	(0.6)	(-0.8)
MotherNotWork	0.00670	-0.00436	0.00600	-0.00465	0.00823	0.00121	0.00920
	(1.3)	(-0.3)	(0.5)	(-0.6)	(0.4)	(0.1)	(0.5)
FatherNotWork	-0.0265**	-0.0556**	-0.0495**	-0.0301*	-0.0741**	-0.0623***	-0.0844**
	(-2.5)	(-2.1)	(-2.3)	(-1.9)	(-2.1)	(-3.3)	(-2.2)
PoorHealthChild	-0.00452	-0.0969***	-0.0240	-0.00916	-0.0464	0.0310*	-0.00296
	(-0.4)	(-3.6)	(-1.0)	(-0.6)	(-1.2)	(1.7)	(-0.08)
NoBooks	-0.0328***	-0.0553***	-0.0568***	-0.0115	-0.0441*	-0.0000392	-0.0406*
	(-6.6)	(-4.1)	(-4.7)	(-1.4)	(-2.0)	(-0.004)	(-1.9)
NoFeatures	-0.0390***	-0.0860***	-0.123***	-0.0310**	-0.124***	-0.0462***	-0.139***
	(-3.4)	(-3.6)	(-5.6)	(-2.0)	(-3.2)	(-2.6)	(-3.6)
HouseholdSize	-0.00128	0.000487	-0.00333*	-0.00124	-0.00305	-0.00181	-0.00670**
	(-1.4)	(0.2)	(-1.9)	(-1.0)	(-1.0)	(-1.1)	(-2.1)
Constant	1.489***	-5.218***	-7.109***	-7.248***	-8.091***	-6.456***	-5.580***
	(4.4)	(-6.4)	(-9.8)	(-13.2)	(-6.0)	(-10.5)	(-4.3)
N	3,545	3,545	3,545	3,545	3,545	3,545	3,545

Note: *** p< 0.01; ** p<0.05; * p<0.10.