Individual Differences in Decision-Making: Evidence for The Scarcity Hypothesis From The English Longitudinal Study of Aging

Richard J. Tunney (r.tunney@aston.ac.uk)
Aston University
Richard J.E. James
University of Nottingham

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Abstract

We report the results of a pre-registered analysis of data from the English Longitudinal Study of Aging that was designed to test the hypothesis that economic scarcity is associated with individual differences in decision-making. We tested this hypothesis by comparing time preferences for different socio-economic groups and in geographical areas ranging from the most deprived to the least deprived in England using the English Indices of Multiple Deprivation. The data supported this hypothesis: People in the most deprived areas were more likely to prefer smaller sooner rewards than people from the least deprived areas. Similarly, people in technical or routine occupations tended to prefer smaller sooner rewards than people in professional or intermediate occupations. In addition, we found that gender, length of education, cognitive function, and subjective social status also predicted time preferences. We discuss these results in the context of theoretical models of scarcity-based models of choice behaviour and decision-making.

Introduction

Why are some people more impulsive than others? It is an important question because impulsivity is a risk factor for many of the behaviors that we, as a society consider problematic either when they are prohibited such as drug abuse, or are permitted but are taken to excess such as gambling, smoking tobacco, or drinking alcohol. Impulsivity also features as a criterion in a wide range of other psychiatric disorders, for example, Antisocial Personality Disorder, Bipolar Disorder, and Attention Deficit Disorder. It is important, therefore, to understand why some people are more prone to making impulsive decisions. Although twin studies suggest that around 50% of the variability in impulsivity is heritable [1,2], that leaves a further 50% attributable to environmental factors. Evidence suggests that impulsivity, and symptoms of psychiatric disorders that feature impulsivity as a criterion, may not be normally distributed across the population [3–5]. This suggests that differences in environmental circumstances might give rise to differences in levels of impulsivity. A reasonable question is to ask what these circumstances might be. In this paper we explore the possibility that individual differences in impulsivity arise from differences in economic environments. In short, we test the scarcity hypothesis of impulsivity.

The scarcity hypothesis

Resource insecurity in animals, and its analogue, economic scarcity in humans, is a leading candidate of an environmental driver of choice behaviour. It is well established that early childhood deprivation has serious consequences for children's neurobiological, social, behavioural, and cognitive development: Adults who have experienced severe deprivation as children for prolonged periods are more likely to be diagnosed with a wide range of psychiatric, cognitive, and social impairment [6]. Even within a more normal range of experience children from poorer backgrounds are less able to delay of gratification than children from more affluent backgrounds [7].

There are a number of plausible explanations why scarcity or resource insecurity might affect decision-making. For example, obesity is associated with perceived or actual food insecurity [8,9], potentially as an insurance against future deprivation [10]. This could be both metabolic in the sense that people and other animals tend to lay down greater fat stores and seek calorific foods when they encounter unpredictable food resources; and social in the sense that these effects appear to be greater in lower status than higher status individuals [9].

In some models scarcity directly affects decision-making because a scarcity of resources makes any decision about money are more salient, more frequent, and more immediate period of time than for more well-off people [11,12]. People in lower income brackets tend to spend a greater proportion of their income on housing, and are less likely to own their own homes. Similarly, people from less affluent socio-economic groups are more less likely to deposit money in savings accounts, are more likely to use any disposable income on short-term outgoings [13,14], spend a higher proportion of their income on lottery tickets [15], and are willing to accept higher rates of interest on loans even when eligibility is held constant [16]. Experimental manipulations designed to induce a 'poverty mindset' generally support this scarcity hypothesis. In a series of experiments reported by Shah et al [11] participants were given either small or large budgets to use in a series of economic games. When their budgets ran out loans were made available to continue playing. The participants given smaller budgets were more likely to borrow, and did so at higher rates of interest than the participants given larger budgets.

Since scarcity makes financial interactions more salient and more immediate, we reasoned that scarity may be a factor that uniderlying individual differences in impulsivity, and provide a plausible account for the uneven distribution of imulsivity across the demographic groups. A common factor in imulsivity is time preference.

Impulsivity as time preference

Impulsivity is a multi-faceted construct. However, a common theme is that impulsivity is associated with a general time preference for smaller-sooner rewards rather than larger-later rewards [17–20]. Delay discounting is a psychophysical measure of time preference in which people are given a series of choices between monetary rewards after increasing delay periods, for example from one day to ten years [21]. The relative preferences for $100 tomorrow rather than $1000 in say, ten years-time indicates the degree to which the individual discounts the future value of the $1000. By titrating the delay period, it is possible to derive a single parameter estimate (k) of an individual's or a group's relative preference for small-sooner rewards over larger later rewards. It is analogous to Mischel's delay of gratification test in children [20]. The validity of time preferences as a measure underlying impulsivity is its relationship with impulsive behaviours that are associated with addiction. Steeper discount rates are associated with a range of addictive behaviors including tobacco smoking [22], severity of Alcohol Use Disorders [23], gambling [24], cocaine and heroin use [25]. Evidence is also emerging that steeper discounting is also associated with

behaviors that are not at present formally regarded as behavioural addictions, but which may be categorized as such in the future, including eating disorders [26], and Internet Gaming Disorder [27].

The association between psychophysical and psychometric measures of impulsivity lends delay discounting a degree of construct validity. Discount rates are moderately correlated with established psychometric measures of impulsivity such as the Barratt Impulsivity Scale (BIS-11) [28–30] the UPPS Impulsivity Scale [31,32]. These psychometric measures however, contain a range of factors that we might not expect to be related to time preferences, and frequently are only poorly related to each other. Although time preferences and psychometric measures of impulsivity has a large heritable component a meta-analysis of available data [2] of more than 27,000 twin pairs across 41 studies provides compelling evidence for heritable and environmental influences across the spectrum of impulsivity. The results for laboratory tasks including time preferences indicate that additive and non-additive genetic effects explain 32% and 19% of the variance, respectively. Non-shared environmental effects explain 49% of the variance. Psychometric measures show a similar profile with additive genetic factors explaining 38% of the variance, non-additive genetic factors 13%, and non-shared environmental effects accounting for 50% of the variance in impulsivity. In the study that follows we test the hypothesis that at scarcity accounts for some of the individual differences in impulsivity.

Overview of the study

In the study that follows we make use of secondary data to first test the hypothesis that impulsivity in the form of time preference is not uniformly distributed across socio-economic groups. However, this evidence is only indicative that scarcity is a causal factor in impulsivity as an individual difference. Socio-economic status is typically recorded using occupation, and although occupations differ considerably in remuneration this does not imply poverty, and not every member of even the least affluent occupational groups experience significant and prolonged hardship. Instead we used the Indices of Multiple Deprivation to test the scarcity hypothesis to examine whether social deprivation predicts time preferences. Access to the Indices of Multiple Deprivation is restricted and requires a special license from the UK Data Service. We pre-registered our method and analysis with the UK Data Service in order to obtain this license and also with the Open Science Framework (DOI 10.17605/OSF.IO/X2QYR) prior to obtaining access to the data.

Method

The data were drawn from the English Longitudinal Study of Ageing (ELSA). This is a representative sample of about 11,000 people aged over 50 years living in England. The survey design is similar to the US Health and Retirement Survey. The first wave of the survey began in in 2002 and subsequent waves occurred at two-year intervals. The sample is periodically refreshed to compensate for attrition and to incorporate new cohorts of older adults. Wave 5 was conducted between 2010 and 2011 and included a measure of impulsivity that is closely related to delay-reward discounting. Of the 10,274 participants in

Wave 5, 1,557 respondents aged 50-74 were pre-selected completed the relevant suite of questions, and of these 1063 completed the time preference measure. The average age of the 479 male participants was 63.65 years (sd = 5.938), the average age of the 584 female participants was 62.68 (sd = 6.08).

Data Availability

The data are available from the UK Data Archive but a special license is required to access and use the Indices of Multiple Deprivation.

Ethics Approval and Informed Consent

The participants consented to take part in the English Longitudinal Study of Ageing which was approved by the National Research Ethics Service (London Multicentre Research Ethics Committee (MREC/01/2/91)). All methods were performed in accordance with the relevant guidelines and regulations. The research was conducted in accordance with the Declaration of Helsinki.

Time preference

The time preference measure was called the 'rectangle game'. This consisted of 12 questions between a fixed £25 in two weeks, or [£26, £28, £30, £32, £35] in one month; and [£26, £30, £35, 37, £40, £45] in two months. As an incentive the participants were each paid £20 for taking part in the survey plus an endowment of £10 to play the two games. They were told that they could win an additional £70 depending on the choices that they make, or lose £5 from the endowment. The computer randomly selected one of the trials from the game as payment.

English Indices of Multiple Deprivation

The English Indices of Multiple Deprivation (IMD) is the official UK government measure of relative deprivation in England. The IMD divides England into 32,844 neighbourhoods of around 650 households or 1500 residents. The 2015 data are based on the 2012-13 tax year. The overall index is composed of Income Deprivation, Employment Deprivation, Education, Skills and Training Deprivation, Health Deprivation and Disability, Crime, Barriers to Housing and Services, and Living Environment Deprivation. For our purposes the data are collapsed into quintiles of deprivation from poorest to wealthiest.

Socio-economic status

Social-economic status is recorded in the United Kingdom by occupation. The ELSA survey recorded socio-economic status using the National Statistics Socio-economic classification (NS-SEC). This system categorises occupations into a number of categories. We used the five-class model from 1 = Managerial, administrative, and professional occupations, 2 = Intermediate occupations, 3 = Small employers and own account workers, 4 = Lower supervisory and technical occupations, 5 = Semi-routine and routine occupations. These are intended to be nominal categories rather than ordinal classes [33]. However, they are naturally related to annual income and level of educational qualification.

Executive function

Executive function was assessed using a composite measure from five different tasks completed as part of the ELSA's cognitive function module, designed to test prospective memory, immediate recall, delayed recall, fluency, and attention. This approach has been previously described by James and Ferguson [34].

At the very beginning of the module, participants were told that they would be given a clipboard and pencil during the cognitive function testing. They were also told that when they were given these, they should write their initials in the top left-hand corner of the paper (prospective memory). Performance on this test was scored from 0 to 5 (5 = completed task correctly without prompting, 4 = partially completed the task (either wrote initials elsewhere or something in top left corner) without prompting, 3 = did something else, or declared they did not remember what to do without prompting, 2 = completed task after prompting, 1 = partially completed task after prompting, 0 = did nothing or failed to remember after prompting).

Participants were then randomly assigned to receive one of four different sets of words, which were then read aloud to the participant. The participant was then asked to tell the interviewer the words they could recall (immediate recall), and at the end of the module they were asked again without warning to recall the same list of words (delayed recall). During the module, participants were also instructed to say aloud as many animal names as they could think of in 60 seconds (fluency). Participants were also asked to complete a letter cancellation task (attention), in which they were instructed to cross out all instance of two letters on a sheet of text.

To develop the composite measure, these scores were entered into a principal components analysis. Parallel analysis indicated that all items loaded strongly onto a single component. As such, component scores were extracted using the regression method to index executive function.

Results

Pre-registered analysis

We began with our pre-registered analysis. Participants whose NS-SEC category and/or the age that they left education was not recorded were excluded from the analyses leaving participants 992 available for analysis. Figure 1 shows time preferences for each socio-economic group. Figure 2 shows time preferences for each quintile Index of Multiple Deprivation.

We entered age, gender (dummy coded with 1 = male, 2 = female), 5 factor NS-SEC, and Quintile Indices of Multiple Deprivation (from 1 = least deprived to 5 = most deprived), and age education ended as predictor variables, and the number of larger later choices as the dependent variable. We dummy coded the NS-SEC and used managerial as the reference category because we expected this group to be the least impulsive and because it was also the largest group (n = 394). The model was significant: $R^2 = .073$, $se = 4.003$, $F_{8, 999} = 9.797$, $p < .001$. The regression coefficients shown in Table 1 confirm our hypothesis

that Indices of Multiple Deprivation, Socio-economic Classification, and Age Education Ended were all reliable and independent predictors of time preferences. Neither age nor gender predicted time preferences.

Table 1 Regression coefficients for the preregistered analysis.

Predictor variable	Regression coefficients				
	b	*se*	*β*	*t*	*p*
Age	0.021	0.022	0.030	0.965	.335
Gender	-0.364	0.267	-0.044	-1.364	.173
IMD	-319	0.098	-0.104	-3.257	.001
Age education ended	0.183	0.091	0.070	2.001	.046
Professional vs intermediate	0.063	0.429	0.005	0.148	.882
Professional vs. Small employers	-0.403	0.416	-0.33	-0.969	.333
Professional vs lower technical	-2.415	0.500	-0.164	-4.832	.000
Professional vs Routine	-1.280	0.357	-0.138	-3.587	.000

Extended analyses

The dataset allows further analyses to test our hypothesis and allow us to examine variable that might confound or contribute to social status and decision-making. For example, subjective social status can be a better predictor of health outcomes than objective measures such as socio-economic group [34], and intelligence could be the common underlying factor between occupational group, or education. We were able to compute a proximal measure of cognitive function that approximated to a single measure of executive function (see Methods). The model was significant: $R^2 = .081$, $se = 3.966$, $F_{10, 931} = 8.090$, $p < .001$. Both cognitive function and subjective social status were reliable predictors of time preferences, but these were additional factors to deprivation and socio-economic status. The regression coefficients shown in Table 2.

Table 2 Regression coefficients for the extended analysis.

Predictor variable	Regression coefficients				
	b	*se*	*β*	*t*	*p*
Age	0.033	0.023	0.048	1.439	.150
Gender	-0.587	0.277	-0.071	-2.119	.034
IMD	-0.275	0.102	-0.090	-2.702	.007
Age education ended	0.27	0.98	0.10	0.273	.785
Cognitive function	0.412	0.150	0.096	2.745	.006
Subjective Social Status	0.021	0.009	0.084	2.380	.018
Professional vs intermediate	0.124	0.442	0.010	0.273	.779
Professional vs small employers	-0.206	0.432	-0.017	-0.477	.634
Professional vs lower technical	-2.123	0.516	-0.144	-4.118	.000
Professional vs routine	-0.962	0.374	-0.105	-2.576	.010

Discussion

Economic scarcity is associated with individual differences in decision-making [35]. Similarly, people from less affluent socio-economic groups are more likely to engage in, and suffer greater harms from, a range addictive behaviours such as smoking [36], alcohol consumption [37], and gambling [38]. We hypothesised that time preferences could be a mediating factor in the uneven distribution of addictive behaviours across socio-economic groups, and that individual differences in time preferences result, in part, from the experience of economic scarcity. In short, when resources are scarce or uncertain it may be reasonable, if not optimal, to consume available resources immediately rather than to save them for the future. This choice behaviour can become maladaptive when it becomes a general individual difference that is applied across a range of behaviours such as potentially addictive behaviours.

We tested this hypothesis by comparing time preferences for different socio-economic groups and in geographical areas ranging from the most deprived to the least deprived in England using the English Indices of Multiple Deprivation. The data supported this hypothesis: People in the most deprived areas were more likely to prefer smaller sooner rewards than people from the least deprived areas. Similarly, people in technical or routine occupations tended to prefer smaller sooner rewards than people in professional or intermediate occupations. We sought to exclude potentially confounding variable such as educational attainment or intelligence. To do so we constructed a variable to measure executive function and a proxy for intelligence, and controlled for the length of education. We also included a measure of subjective social status because this can be a better predictor of health than objective measures.

Executive function and subjective social status were reliable predictors of time preferences in their own right but did not eliminate the effects of either deprivation or socio-economic status. The data clearly show that people in more deprived geographical areas make more impulsive choices than people from more affluent geographical areas. We regard this as strong evidence for the scarcity hypothesis. But there is more than one potential mechanism by which scarcity can affect individual differences in choice behaviour.

Impulsivity as faulty foraging.

Decision-making in humans shares many similarities with foraging behaviour in other animals [39]. Choice tasks that indicate of time preferences are strikingly similar to models of optimal foraging, and a number of researchers have drawn parallels between them [41–43]. The foraging behaviour of groups and the choice behaviour of individuals are described by synonymous mathematical models[42,44].

Our hypothesis borrows from the Thrifty Phenotype Hypothesis [44] that links adult ill-health to pre-natal nutrition. In this model, low availability of nutrients during pre-natal development programs the foetus' metabolic systems to expect a sparse nutritional environment. This is an adaptive mechanism that allows the developing child to efficiently process scarce resources during childhood. But if, as is likely in developed economies, after birth the infant encounters abundant resources, the adaptation becomes maladaptive and could be a risk factor for adult diabetes and obesity. The basic premise is as follows: The experience of a scarcity or uncertainty in resources causes adaption of foraging behaviour. This adaptation becomes a stable individual difference that, as an adult, and in an abundant environment becomes maladaptive, leaving the individual vulnerable to addiction and other impulse control disorders. We propose that the experience of scarce or uncertain resources causes an adaptive shift in choice behaviour that motivates the individual to consume proportionately more of the currently available resources than they would when resources are abundant in the expectation that future resources will also be unpredictable. The consequence of setting the parameters that govern choice behaviour at an early age, leaves the child who experiences scarcity relatively more vulnerable to obesity, addiction and debt as an adult. Individual differences in decision-making may result from the foraging responses that make sense in different environmental conditions such as scarcity of resources. For example, in periods of abundant resources it does not make sense to deplete the available resources since these could be preserved for the future. Thus, in periods of abundance it is more optimal to exhibit self-control or delay gratification. However, in periods of scarcity it makes more sense to deplete the available resources even if that results in an uncertain future. The classic finding in humans is that children who performed poorly in the original Stanford Marshmallow test had poorer life outcomes [18,45] including higher BMI, alcohol and drug use.

In our model, we propose that children who encounter periods of scarcity acquire a foraging strategy that becomes a stable individual difference in adulthood choice behaviour. Behavioral evidence from other species is consistent with this hypothesis. For example, developmentally disadvantaged starlings tend to overmatch when foraging and are physically larger in adulthood than developmentally advantaged

birds [46]. Similarly, rats show greater sensitivity to resource allocation in predicable environments compared to unpredictable environments [47]. Pigeons show rapid adjustments in habitat matching when resource availability changes and that at group level sensitivity decreases as the unpredictability of the recourse availability increases [48].

Conclusion

People who experience economic scarcity appear to make more impulsive choice than people who live in more affluent areas. Similarly, people who work in manual occupations tend to be more impulsive than those who work in professional occupations. These effects are additional to, and independent of, the effects of education or cognitive function. We argue that the experience of economic scarcity has a casual influence on time preference as a relatively stable individual difference in decision making, which in turn provides an explanation for the uneven distribution of addictive behaviours across social groups.

Declarations

Author Notes

Correspondence concerning this article should be addressed to Richard J. Tunney, School of Psychology, Aston University, Birmingham, B4 7ET, United Kingdom. Email: r.tunney@aston.ac.uk.

Competing interests

The authors declare that there are no competing interests.

Author Contribution

RT and RJ made an equal contribution to the manuscript.

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Figures

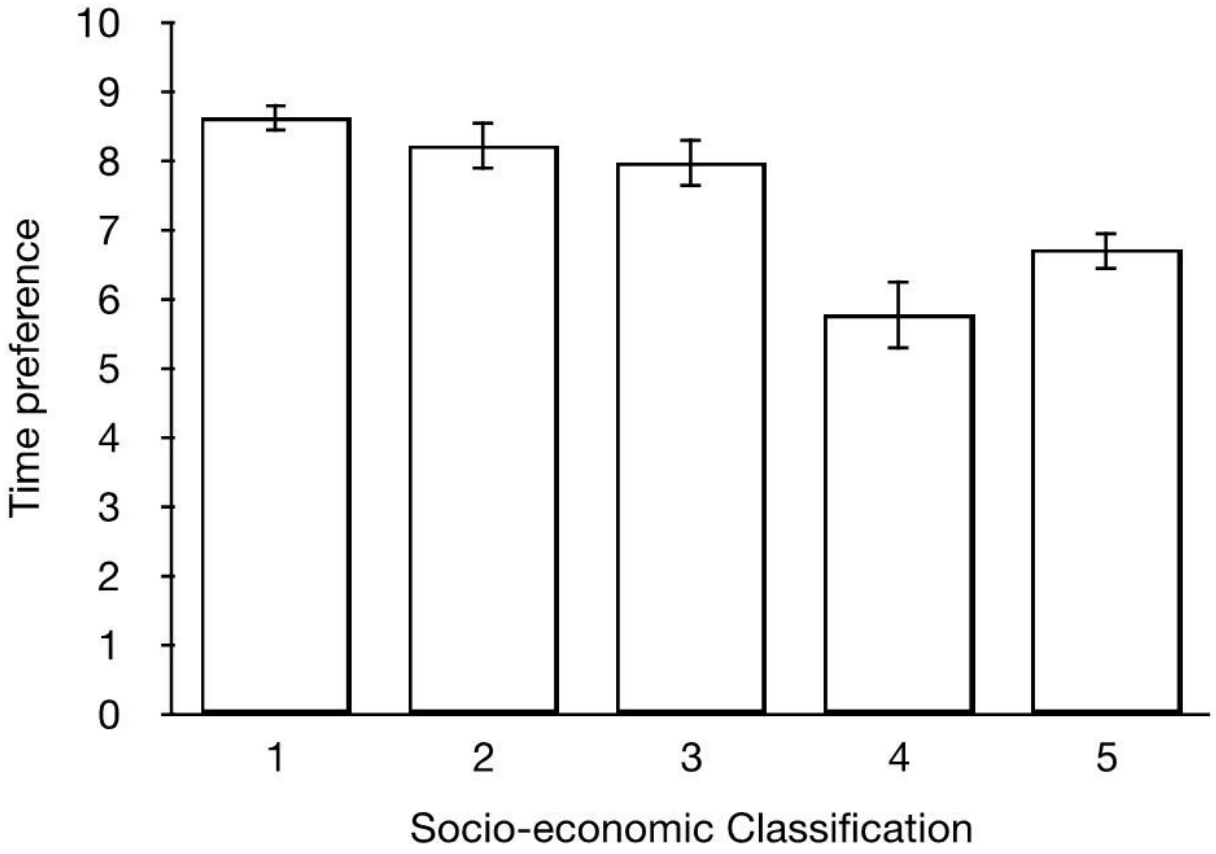

Figure 1

Showing time preferences (number of larger later choices) by Socio-economic Classification (1 = Managerial, administrative, and professional occupations, 2 = Intermediate occupations, 3 = Small employers and own account workers, 4 = Lower supervisory and technical occupations, 5 = Semi-routine and routine occupations).

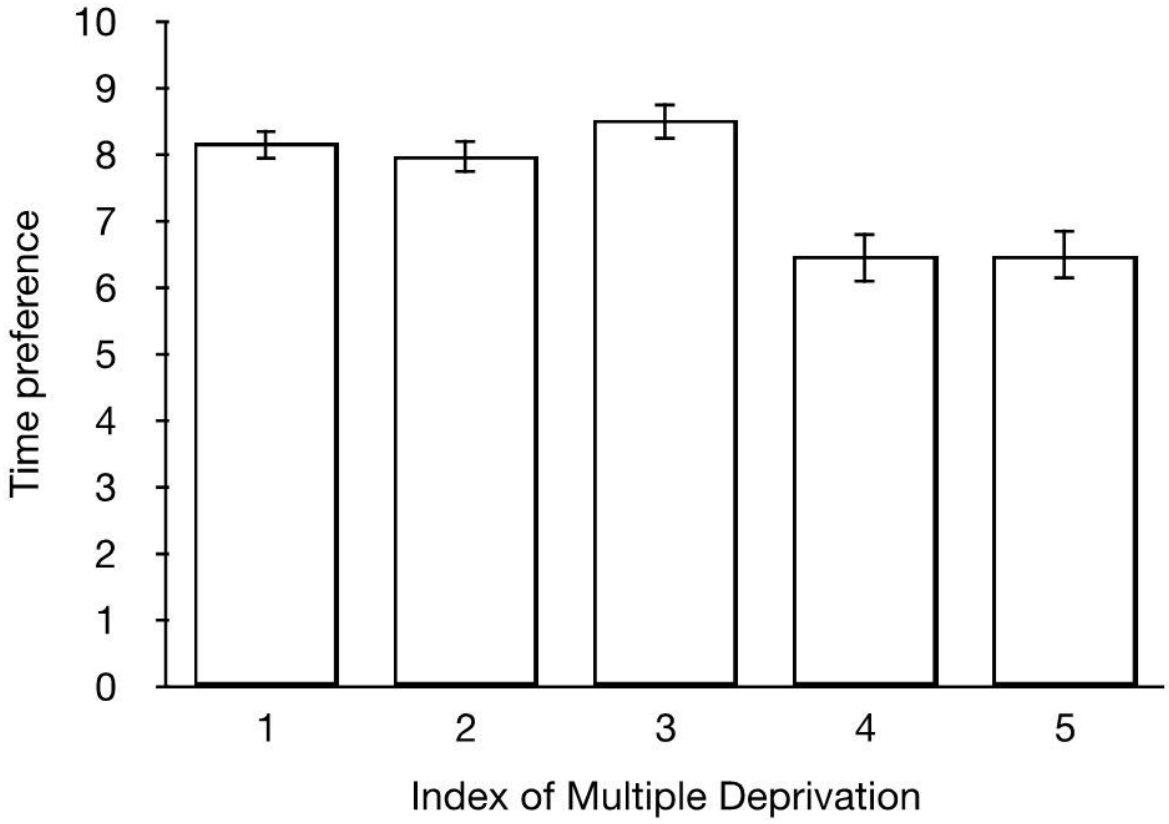

Figure 2

Showing time preferences (number of larger later choices) for each quintile Index of Multiple Deprivation from 1 = least deprived to 5 = most deprived.

Supplementary Files

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