Maastricht University

Time Discounting and Criminal Behavior

Citation for published version (APA):

Akerlund, D., Golsteyn, B., Grönqvist, H., & Lindahl, L. (2016). Time Discounting and Criminal Behavior. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(22), 6160-6165. https://doi.org/10.1073/pnas.1522445113

Document status and date:
Published: 31/05/2016

DOI:
10.1073/pnas.1522445113

Document Version:
Publisher's PDF, also known as Version of record

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:

www.umlib.nl/taverne-license

Take down policy
If you believe that this document breaches copyright please contact us at:

repository@maastrichtuniversity.nl

providing details and we will investigate your claim.

Download date: 26 Apr. 2024

Time discounting and criminal behavior

David Åkerlund[a,1], Bart H. H. Golsteyn[b,1], Hans Grönqvist[c,1], and Lena Lindahl[a,1,2]

[a]Swedish Institute for Social Research, Stockholm University, SE-106 91 Stockholm, Sweden; [b]Department of Economics, Maastricht University, 6200 MD Maastricht, The Netherlands; and [c]Department of Economics, Uppsala University, SE-751 20 Uppsala, Sweden

Edited by Jose A. Scheinkman, Columbia University, New York, NY, and approved April 13, 2016 (received for review November 16, 2015)

One of the most basic predictions of almost any model of crime is that individual time preferences matter. However, empirical evidence on this fundamental property is essentially nonexistent. To our knowledge, this paper provides the first pieces of evidence on the link between time discounting and crime. We use a unique dataset that combines a survey-based measure of time discount rates (at age 13) with detailed longitudinal register data on criminal behavior spanning over 18 y. Our results show that individuals with short time horizons have a significantly higher risk of criminal involvement later in life. The magnitude of the relationship is substantial and corresponds to roughly one-third of the association between intelligence and crime.

time discounting | intertemporal choice | crime

One of the most basic predictions of almost any model of crime is that individual time preferences matter (see, e.g., ref. 1). The reason is that individuals may differ in the way they balance the rewards of a crime that are savored immediately and its potential costs in terms of apprehension and punishment that are borne in the future. As noted by Wilson and Herrnstein, because "the rewards of crime usually precede the costs of crime [...] time discounting becomes extremely important in explaining criminal behavior" (2). However, empirical evidence on this fundamental property is essentially nonexistent.

In this paper, we empirically investigate whether individual time discounting predicts subsequent criminal involvement. Our investigation requires unusually rich data. Ideally, time discount rates should be measured before individuals start getting involved in criminal activity to ease complications due to reverse causation. It is further necessary to link this information to credible indicators of criminal involvement and to follow the individuals for a period that stretches well beyond the peak of the age–crime profile. These restrictions effectively rule out any recently constructed dataset.

Our data originate from a Swedish longitudinal dataset that contains information on children's time discount rates collected from a survey held in the year 1966 when the children were 13 y of age. The respondents' answers have been linked to administrative registers, which enables us to follow the 13,606 children who participated in the survey for a period of 18 y. Time discounting is measured through a question in which the children were asked to rate the extent to which they prefer: Swedish Krona (SEK) 900 [US dollar (USD) 140] today over SEK 9,000 (USD 1,400) in 5 y using a five-point scale (in 2013 year's price level). Our measures of crime originate from two sources: (*i*) interventions by social authorities due to delinquent behavior of children up to age 18; (*ii*) the universe of criminal convictions for all individuals between ages 15 and 31. Besides details about the type of crime, there is information on crime both at the extensive and intensive margins.

For several reasons, the dataset is ideal for our purposes. First, the survey was administered relatively early in life before the onset of illegal involvement; yet it was taken sufficiently late so that the respondents are likely to have been able to understand the nature of the question. The fact that the survey was conducted in all schools in the Stockholm metropolitan area implies that all pupils present at school during that particular day took part in the survey, which increases the external validity of our results. Moreover, the use of administrative data means there is virtually no sample attrition. Just as in the entire literature on preference parameters (see ref. 3 for a review), we focus on the predictive value of time discounting and avoid claims about causality. (Admittedly, causal effects are very difficult to elicit because—even in a laboratory setting—one cannot exclude the possibility that other preferences are also influenced by the experiment.) However, another key feature of the dataset is that it includes information on parental education and income. Being able to adjust for parental socioeconomic background in the analysis is important because it alleviates concerns that responses to the survey might reflect differences in the family budget constraint. An additional benefit is that the data include results on a cognitive ability test that was part of the survey. This is important as the literature on economic preferences has found that ability and time preferences interact (4, 5).

To preview our results, we find that time discounting significantly predicts criminal activity. When comparing the size of the relationship to that of the association between intelligence and crime, we find that the former is about one-third of the size of the latter. We also find that high discount rates predict crime more strongly at the extensive margin rather than for total crime (i.e., the number of crimes). The link is much stronger for property crime and among males with low intelligence (both for property and violent crime).

Our results thus confirm the central property of the standard model of criminal behavior that time discounting matters. This bears important policy lessons as one key implication of the model is that stricter sanctions will reduce crime because it lowers the present expected value of criminal activity (6). The effectiveness of sanctions as an instrument to fight crime, however, largely depends on how heavily potential criminals discount future events. If criminals have short time horizons, the delayed costs do not motivate them to refrain from criminal activities and punishment may not act as a key deterrent. Thus, policies that increase the likelihood of being caught (cf. ref. 7), such as

Significance

One of the most fundamental predictions of almost any model of crime is that individual time preferences matter. However, empirical evidence on this basic property of the model is essentially nonexistent. We empirically investigate whether individual time discounting measured at age 13 predicts subsequent criminal involvement up to age 31. We show that time discounting significantly predicts criminal activity and that high discount rates predict crime more strongly at the extensive margin rather than for total crime. The link is much stronger for property crime and among males with low intelligence.

Author contributions: D.Å., B.H.H.G., H.G., and L.L. performed research, analyzed data, and wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

Freely available online through the PNAS open access option.

[1]D.Å., B.H.H.G., H.G., and L.L. contributed equally to this work.

[2]To whom correspondence should be addressed. Email: lena.lindahl@sofi.su.se.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1522445113/-/DCSupplemental.

increased surveillance or police resources, are likely to be relatively more efficient for individuals with high discount rates.

This paper contributes to several strands of the literature. First, in the leading criminological theory of crime, the ability to exercise self-control in the face of opportunity is hypothesized to explain a large portion of all criminal behavior (8). Although the concept of self-control is related to that of time discounting, there is no consensus in the literature on the concept and measurement of self-control (9–12). Self-control is assumed to be coalesced with a number of interrelated individual characteristics such as impulsiveness, lack of persistence, and inability to delay gratification. Some studies have used behavioral markers such as the length of time one can squeeze a hand grip, keeping within lines while drawing a maze, or various betting behaviors. Other studies use self-reported measures, such as the self-reported inability to avoid thinking about white bears when instructed to do so or reports by parents or teachers. A summary of different measures used is found in ref. 13. Given the variety of measures, it is not surprising that the empirical examinations provide mixed evidence. [See also the metaanalysis provided by Pratt and Cullen (14).]

Only a few studies provide longitudinal evidence on the relationship between self-control and behavior. The seminal work by Walter Mischel and coauthors (15–17) analyzes the relationship between self-control and children's subsequent behavior. Their experiment measured delay of gratification by the time children aged 4 could wait for a larger treat relative to a smaller immediate treat. Another study in the same spirit but with a larger sample size measures self-control at various ages by a composite that among others incorporates parental–teacher ratings of children's aggression, hyperactivity, and impulsivity, with self-reports of attention problems and observational ratings of restlessness and stamina, for a cohort of around 1,000 New Zealand children. The results show that low values of the self-control index strongly predict the likelihood of being convicted in court (18). Nagin and Pogarsky (19) measure time preferences using survey questions asking the respondents to estimate the chances they would live to age 35, and how often during the past week they felt hopeful about the future. They find that respondents with high discount rates were more involved in criminal activities. These measures probably also do not adequately capture intertemporal trade-offs, however, because they could instead be seen as being a proxy for factors such as health or family background. Cadena and Keys (20) find that individuals who were classified as impatient by interviewers had lower educational attainment and reduced labor supply.

Our paper differs from this and other studies in the sense that the measure we use explicitly captures the trade-off between the present and the future faced by potential criminals. Although being related, the indexes on self-control used in other studies cannot easily be interpreted as measuring time preferences because most of their components, such as aggression and attention disorders, are not meant to capture the relative weight individuals place on current versus future events. Because our measure entails a hypothetical monetary trade-off between the present and the future, it is unlikely that this measure of time discount rates is related to self-control problems. The fact that we find stronger effects for property crime can also be interpreted as tentative evidence that self-control is not the major factor driving our results. Indeed, it seems plausible that self-control problems are more strongly connected to violent crime, which can be seen as crimes of passion, rather than property crimes that are financially motivated crimes, which typically involve an element of planning.

We also contribute to the growing literature concerning the predictive value of time preferences for real-world outcomes. This literature employs direct measures of time discounting. Several studies have documented that time preferences in the adult population are significantly correlated with field outcomes such as occupational choice (21), credit card borrowing (22), and smoking (23). Sutter et al. (24) relate risk attitudes and time preferences to health-related behavior and savings decisions in an experimental setting. Their cross-sectional evidence suggests that discount rates among children aged 10–18 correlate with their body mass index, savings as well as spending on alcohol and tobacco. In an intertemporal choice laboratory experiment, Dohmen et al. (5) find that patience among adults is significantly associated with higher cognitive ability. Golsteyn et al. (25) show a strong negative correlation between high discount rates during childhood and various indicators of human capital, health, and lifetime income. The association is robust when controlling for factors such as family socioeconomic background and ability, and persists well into adulthood.

Materials and Methods

The data used in this study are a longitudinal dataset called the Stockholm Birth Cohort (SBC).* The SBC is a matching of two longitudinal datasets: the Stockholm Metropolitan Study (SMS) and the Swedish Work and Mortality Database. For the purpose of this study, we use only the SMS part of the SBC, which consists of all children born in 1953 in the Stockholm metropolitan area.

The data include information from a school study that was conducted in 1966 when the cohort members were 13 y of age. During one school day, pupils at practically all schools in the county filled out two questionnaires, including the question that we use to elicit time discounting, and took a spatial cognitive ability test, which we use to measure cognitive ability. An important aspect of the survey is that it took place at school, which gave it a mandatory character. As a result, the nonresponse rate is only 9% (the percentage of pupils absent on that particular school day). (Although one could in principle be worried that absent children may have higher than average discount rates, it seems likely that the overwhelming majority of the children were absent because of actual sickness.) The low nonresponse rate in combination with the fact that the survey was held among all students in the county is likely to increase the external validity of our study. This is an advantage compared with laboratory-based studies in which the participants may be self-selected on the basis of their discount rate. Impatient individuals could, for example, be less likely to sign up for participation in a laboratory experiment. On the other hand, laboratory-based studies benefit from the use of real payments, whereas our type of study relies on a hypothetical question about time discounting and it is not certain that stated choices perfectly correspond to choices made in real life.

The children answered the following question: "If you had to choose between SEK 900 [USD 138] now versus SEK 9,000 [USD 1,380] in five years, what would you choose?" (note that these amounts are presented in current prices). The set of possible answers was as follows: "Certainly SEK 900 now" (1), "Probably SEK 900 now" (2), "Cannot choose" (3), "Probably SEK 9,000 in five years" (4), "Certainly SEK 9,000 in five years" (5). Because the answers do not necessarily map into a monotonic scale, we present the coefficients on separate dummy variables for each answer category. By current standards, our measure is a relatively rough measure of time discount rates. For instance, we cannot distinguish exponential and hyperbolic discount rates. Future research may link more precise measures to criminal behavior. It will take many years, however, before a link between precisely measured time preferences at age 13 and criminal behavior until age 31 will become available.

Fig. S1 shows the distribution of the answers. Despite the very high implied annual discount rate of 58%, 13% of the children state that they prefer SEK 900 today over SEK 9,000 in 5 y. Around one-half of these children (6% of the total sample) report that they certainly prefer the SEK 900 today. The discount rate is well in line with discount rates used in other experimental and field studies (see, for example, ref. 26, which provides an overview of the wide variation in time preferences reported in various articles).

Although the Swedish murder rate is one of the lowest among all developed countries, other types of crimes are relatively more frequent. Farrington et al. (27) show that the Swedish crime rate in 1980 is comparable to

*The description of the data is partly based on the study by Golsteyn et al. (25). Their paper also uses data from the Stockholm Birth Cohort (SBC). More details about the SBC data can be found in the study by Stenberg and Vågerö (31). The data we use are proprietary so we are prevented to post the data online. The data can, however, be accessed by other researchers under the following conditions. Every interested (foreign or domestic) researcher is free to access the SBC data subject to approval from the Board of Ethical Approval and the Governing Board of SBC. These terms apply both for original articles and for replications. The data are made available free of charge. We are able to provide all codes needed for replication of our analysis.

other countries such as England and Wales and the United States for many types of crimes including assaults. This is also the conclusion that can be drawn from more recent statistics on crime rates in the European Union countries. Details about convictions are incorporated from the Swedish National Crime Register (Person- och belastningsregistret), which is administered by the Swedish National Police Board (Rikspolisstyrelsen). It contains data on the number of crimes reported to the police that have been connected to the cohort member. The reports are based on convictions in criminal trials. There is also information from the Child Welfare Committee (CWC) data (Socialregisteruppgifter) for children under age 18. The CWC also received information concerning criminal behavior from schools, parents, neighbors, and shopkeepers. In most cases, it was not required by law to report these crimes to the police, unless a serious crime was involved. The fact that we have information on crime from another source than criminal convictions is advantageous because there is a risk that individuals with high discount rates are more likely to be convicted for a crime conditional on actually having committed the crime. Although we believe that this risk is likely to be small, analyzing CWC data provides a reality check of our estimates. This means that we have access to all offenses and juvenile delinquencies for every individual between age 13 and 31 (year 1966–1984) that either led to a criminal conviction or to the involvement of the CWC. The dataset we use has no information about criminal convictions after 1984. (It is not possible to add this information because the personal identifiers for the dataset have not been saved.) We follow the standard procedure in the literature and focus on the types of crimes that account for most of the social costs of crime: violent crime and property crime. The former includes crimes of physical violence or threats of violence and the latter theft and receiving stolen goods. We also examine whether an individual committed any type of crime.

It is worth mentioning that all crimes that were reported to the police and committed by persons under age 18 were reported by the police to the CWC. Thus, there is some overlap between criminal convictions and variables concerning juvenile delinquency reported in the CWC data. The CWC records are more accurate for children under age 15 because the police were not allowed to file records against them unless in unusually serious cases. They are, however, required to report each crime to the CWC, which keeps track of them.

The dataset contains several other variables of interest to us. We use a spatial cognitive ability test as a measure of cognitive ability. The test, which was also taken at age 13, consists of 40 figures that are unfolded and need to be folded mentally. Similar to the Raven Progressive Matrices test, this spatial cognitive ability test measures fluid intelligence, which is often considered to be a purer measure of intelligence than tests of crystallized intelligence, such as regular IQ tests or achievement tests. Scores on crystallized intelligence tests are in part determined by intelligence but also partly by personality traits (28). [Note that IQ as measured by standard IQ tests would give an average of 100 (and SD of 15). Our measure of IQ, the spatial ability test, is not a standard IQ test, and therefore the average is different from 100.]

The dataset also contains a rich set of information on individual traits and family/social background. Most importantly, there is information on each parent's highest completed level of education (four levels) and each parent's income in 1963 (i.e., 3 y before the survey). We control for these variables in the regressions along with information on each parent's year of birth, and the month of birth of the cohort member.

The original SBC dataset matched with administrative registers consists of 13,606 observations. [In total, 15,118 children were born in 1953 in Stockholm County. However, not all children still lived in Stockholm at the time of the school survey (around 1%), and around 9% did not participate in the school survey due to absence from school, which leaves 13,606 observations.] An overwhelming majority of all crime is committed by males. Our main analysis therefore focuses on males, but we present our baseline results also for females in Tables S1 and S2. After selecting out observations with missing values on the time-discounting variable, we are left with 6,749 males. We show the descriptive statistics of the variables included in our analysis and the relationship between time discount rates and the variables in the data in Tables S3 and S4. To characterize the sample, we examined the link between the characteristics of individuals who differ in time discount rates by estimating a regression relating time discounting (a dummy for being having low discount rates) on individual and family characteristics. We found that most of the coefficients are statistically insignificant, with the exception of intelligence and father's income, which are both positively correlated with patience (Table S4).

Results

This section presents the results from our empirical analysis of the link between time discounting and criminal behavior. The tables show the coefficients on dummies for all answer categories to the question on time discounting. The reference group is individuals who with certainty prefer the immediate reward. All regressions control for month of birth, the educational level of each parent, cognitive ability, each parent's income, and each parent's year of birth.

Tables 1 and 2 show our main results. The tables present estimates for our two measures of crime: criminal convictions (ages 15–31) and CWC interventions. For each measure, we show results for crime both at the extensive margin (at least one crime) and for total crime.

We can see in Table 1 that individual time discounting significantly predicts criminal involvement at the extensive margin. Individuals who are more certain that they prefer to delay the reward are less likely to be convicted for a crime. The magnitude of the relationship appears to be substantial. Individuals who certainly prefer to delay the reward are 33% (0.096/0.291) less

Table 1. The link between time discounting and crime: Extensive margin

	Criminal convictions (age 15–31)			Child Welfare Committee (age 0–18)		
Timing of reward	Any crime	Violent crime	Property crime	Any crime	Violent crime	Property crime
Certainly immediate	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Probably immediate	−0.108***	−0.035*	−0.078***	−0.099***	−0.020	−0.088***
	(0.034)	(0.019)	(0.027)	(0.029)	(0.018)	(0.025)
Indifferent	−0.071**	−0.033*	−0.056**	−0.042	−0.008	−0.042
	(0.032)	(0.019)	(0.027)	(0.029)	(0.018)	(0.026)
Probably delay	−0.097***	−0.032**	−0.068***	−0.050**	−0.014	−0.044**
	(0.025)	(0.015)	(0.021)	(0.023)	(0.014)	(0.021)
Certainly delay	−0.096***	−0.021	−0.069***	−0.050**	−0.010	−0.048**
	(0.025)	(0.015)	(0.021)	(0.023)	(0.014)	(0.020)
Sample mean	0.291	0.066	0.145	0.213	0.058	0.143
Obs	6,749	6,749	6,749	6,749	6,749	6,749

The table shows the coefficients of ordinary least-squares regressions of crime indicators on dummies for each answer to the question whether the child at age 13 prefers SEK 900 (USD 138) today versus SEK 9,000 (USD 1,380) in 5 y. The amounts are presented in current prices. Each column represents a separate regression. The sample consists of male children born in Stockholm County in 1953. In each regression, the dependent variable is a dummy variable with value one if a crime was administered in the data. "Any crime" in CWC data refers to a decision by the CWC for delinquent behavior (each decision may involve multiple offenses) while "Property crime" and "Violent crime" refer to crimes in each category. All regressions control for dummies for month of birth, intelligence, educational level (four levels) of the parent, each parent's income (dummies per decile), and each parent's age (dummies per 10-y interval). ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level. Ref., reference group.

Table 2. The link between time discounting and crime: Intensive margin

	Criminal convictions (age 15–31)			Child Welfare Committee (age 0–18)		
Timing of reward	Any crime	Violent crime	Property crime	Any crime	Violent crime	Property crime
Certainly immediate	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Probably immediate	−0.941**	−0.123*	−0.296	−0.151**	−0.025	−0.456***
	(0.435)	(0.074)	(0.188)	(0.067)	(0.054)	(0.141)
Indifferent	−0.719*	−0.147**	−0.207	−0.042	−0.004	−0.154
	(0.416)	(0.068)	(0.181)	(0.069)	(0.052)	(0.147)
Probably delay	−0.655*	−0.085	−0.207	−0.071	−0.033	−0.230**
	(0.346)	(0.064)	(0.145)	(0.050)	(0.039)	(0.114)
Certainly delay	−0.581*	−0.068	−0.189	−0.062	−0.024	−0.245**
	(0.342)	(0.064)	(0.143)	(0.049)	(0.039)	(0.111)
Sample mean	1.926	0.156	0.666	0.371	0.146	0.735
Obs	6,749	6,749	6,749	6,749	6,749	6,749

The table shows the coefficients of ordinary least-squares regressions of crime indicators on dummies for each answer to the question whether the child at age 13 prefers SEK 900 (USD 138) today versus SEK 9,000 (USD 1,380) in 5 y. The amounts are presented in current prices. Each column represents a separate regression. The sample consists of male children born in Stockholm County in 1953. "Any crime" in CWC data refers to a decision by the CWC for delinquent behavior (each decision may involve multiple offenses), whereas "Property crime" and "Violent crime" refer to the number of crimes in each category. All regressions control for dummies for month of birth, intelligence, educational level (four levels) of the parent, each parent's income (dummies per decile), and each parent's age (dummies per 10-y interval). ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level. Ref., reference group.

likely to be convicted for any type of crime. To better understand the effect size, we standardized the variable to mean zero and unit SD, and reestimated the model. It turns out that the coefficient is about one-third as large as for that of our standardized measure of intelligence. The association between intelligence and crime is well documented in the literature. It appears that the statistical association between time discounting and crime is weaker for violent crime, although the magnitude of the relationship is about the same when placing the coefficient in relation to the mean of the dependent variable. For property crime, the statistical significance is much stronger. Turning to CWC data, we find similar results: strong associations between time discounting and any crime as well as for property crime. However, none of the coefficients for violent crime is statistically significant. [In relation to this, Nagin and Pogarsky (19) report evidence from a sample of adolescents in grades 7–12 that time preferences are not related to violent crimes. However, poor impulse control is related to violent crimes.]

It is evident that the individuals in the reference group clearly stand out as being more likely to engage in crime. Unfortunately, our measure of time discounting does not allow us to pin down the actual discount rate. Note that individuals who prefer the immediate reward may have an annual discount rate of anywhere between 58% and infinity. Our findings are therefore consistent with the idea that criminals have extremely high discount rates. It is worth mentioning that theory would not predict that only the most extreme category of future bias should matter. However, the idea that criminals have discount rates that substantially diverge from that of the overall population does not strike us as implausible. It is possible that individuals facing different intertemporal investment decisions do so using different discount rates. For example, the discount rate used when deciding how much to invest in education or work may differ markedly from the discount rate used when considering engaging in criminal activities. The results in Golsteyn et al. (25) suggest that that this may very well be the case. Using the same sample as in the present paper, they find clear indications that the coefficients for the different answers to the time preference question are increasing (in absolute numbers) when looking at outcomes such as educational attainment, income, employment, and obesity. This can be interpreted as showing that individuals use smaller discount rates (below 58%) when making everyday choices involving work and lifestyle with payoffs occurring very far into the future but that the small portion of individuals in the population who commit crime has much larger discount rates than what we can observe in our data. This is also one of the messages from the model in ref. 6 where it is argued that uncertainty of punishment affects not only the expected income from crime but also the length of time in which a criminal can expect to earn that stream of income. As such, the expected income from crime must be discounted at a higher rate than the rate of discount for income from legal work.

In Table 2, we can see that the link between time discounting and total crime appears to be much weaker. For all outcomes, many of the coefficients are not statistically significant. Moreover, when interpreted in relation to the sample mean, the effect sizes are in general much lower. It therefore appears that time discount rates predict the onset of criminal involvement better than the frequency of its occurrence.[†] Put differently, being very impatient may induce some individuals to commit crime but after having gotten involved in crime, time discount rates matter less. One reason could be that factors such as reduced stigma outweigh the importance of time discounting after having developed a criminal lifestyle.

It is also useful to see how time discounting and crime correlate across age. To this end, we show the average probability of committing at least one crime at a given age for the group of individuals who certainly want the immediate reward (Not patient) and the rest of the sample (Patient) along with a 95% confidence interval (Fig. S2). We can see that, as in most other countries, crime peaks in the late teens and early twenties, and then falls. We can also see that individuals with the highest discount rate exhibit higher criminal participation for all ages.

We perform a number of sensitivity checks and an exercise where we try to probe deeper into the underlying mechanisms.

[†]This finding is in line with Blumstein et al. (32), who discuss the fact that the literature on criminal careers typically has done a better job predicting criminal behavior at the extensive margin rather than the intensive margin. The authors mention that factors associated with crime rates (such as age, race, and sex) are in the previous literature often assumed to be equally important at the intensive and extensive margin. However, based on their review of research on criminal careers, they conclude that such demographic variables do relate to the extensive margin, but they are only weakly related to the frequency of criminal behavior.

For example, to understand the importance of potentially confounding factors, Tables S5 and S6 build up the relation between time discount rates and crime, starting with the raw correlation and gradually extending the regression with more controls. The results indicate that the link between time discounting and crime is robust to changes in the set of controls. Because some of these covariates (e.g., parental income and education and child intelligence) represent perhaps the most obvious candidates for omitted variable bias, we interpret this finding as suggesting a limited scope for other (probably less important) omitted factors to bias our estimates in any meaningful way. Moreover, we find that controlling for children's years of schooling tends to reduce the coefficients. This provides suggestive evidence that time discount rates are associated to crime through its link to human capital investments.

The fact that we find stronger effects for property crime can also be interpreted as tentative evidence that self-control is not the major factor driving our results. Indeed, it seems plausible that self-control problems are more strongly connected to violent crimes, which can be seen as crimes of passion, rather than property crimes that are financially motivated crimes, which typically involve an element of planning. Another piece of evidence along this line comes from an exercise where we attempt to partially control for the possible influence of self-control. Self-control is sometimes measured using markers such as smoking, alcohol, and drug abuse. Because there is information in the data on whether individuals have been registered by social workers as being abusing alcohol or narcotics, we used this information and added a control to our baseline model for whether an individual was recorded as being abusing alcohol or narcotics (230 observations or 3.4% of the sample). Because the estimates are almost unchanged when adding this control (Tables S7 and S8), further support is given to the idea that our results primarily capture exponential time discounting.

Finally, we ran a series of regressions where we analyzed the link between time discounting and crime in different segments of the population (Tables S9–S11). The main finding is that time discount rates predict future involvement in both property and violent crime more strongly for individuals with below average intelligence compared with individuals with at least average intelligence, although we note that there is no meaningful difference between the two groups for any crime.

Concluding Remarks

This paper investigates the link between time discounting and criminal behavior. Drawing on a unique database that contains measures of time discount rates collected from a school-based survey at age 13 and longitudinal information on criminal involvement from administrative registers, we document that time discounting significantly predicts crime.

Our results are consistent with the predictions of the standard model of crime where individuals decide on whether or not to engage in crime depending on the immediate benefits from the crime and the costs from a potential future punishment. The model has been used to motivate the use of stricter sanctions as a way to deter potential criminals to engage in crime. Our results potentially have other policy implications in the sense that early interventions that make individuals more future-oriented may be used as a tool to combat crime. The results in the literature regarding the malleability of time preferences are not yet settled. Still, the results in Perez-Arce (29) do provide some support for the argument that educational investments may be one way to moderate high discount rates. This is interesting also because many studies have documented that increased education policy can be used as a way to combat crime (30). One reason for this could be that education makes individuals more future oriented.

Admittedly, our measure of time discounting is crude by modern standards that often focus on experimentally elicited discount rates. Nevertheless, because this paper represents, to our knowledge, the first empirical study of this relationship, we believe that it does make an important contribution to the literature. In fact, the dataset is ideal for our purposes. Anyone interested in learning about the link between adolescents' time preferences and adult criminal behavior would have to wait close to 20 y for contemporary data collection efforts to render a dataset more suitable to study this question than the one used in the present paper. Given that our measure is crude, it is, however, worth mentioning that we expect measurement error to play some role for the results. Because measurement error likely attenuates the coefficients, it is reasonable to believe that the true relationship between time discounting and criminal behavior actually is stronger than is the relationship reported in this paper.

ACKNOWLEDGMENTS. We thank the team behind the Stockholm Birth Cohort Study at the Centre for Health Equity Studies, Stockholm University, especially Sten-Åke Stenberg and Denny Vågerö, for providing the data; and participants at the Sixth Transatlantic Workshop on Organized Crime, for comments. This work was supported in part by the Swedish Council for Working Life and Social Research and the Swedish Foundation for Humanities and Social Sciences (L.L.); and Handelsbankens Forskningsstiftelser (B.H.H.G. and H.G).

1. Chalfin A, McCrary J (2014) Criminal deterrence: A review of the literature. *J Econ Lit*, in press.
2. Wilson JQ, Herrnstein RJ (1985) *Crime and Human Nature* (Simon and Schuster, New York), p 50.
3. Dohmen T (2014) Behavioral labor economics: Advances and future directions. *Labour Econ* 30:71–85.
4. Benjamin D, Brown S, Shapiro J (2013) Who is "behavioral"? Cognitive ability and anomalous preferences. *J Eur Econ Assoc* 11(6):1231–1255.
5. Dohmen T, Falk A, Huffman D, Sunde U (2010) Are risk aversion and impatience related to cognitive ability? *Am Econ Rev* 100(3):1238–1260.
6. Davis ML (1988) Time and punishment: An intertemporal model of crime. *J Polit Econ* 96(2):383–390.
7. Becker G (1968) Crime and punishment: An economic approach. *J Polit Econ* 76(2):169–217.
8. Gottfredson M, Hirschi T (1990) *A General Theory of Crime* (Stanford Univ Press, Stanford, CA).
9. Grasmick HG, Tittle CR, Bursik RJ, Jr, Arneklev BJ (1993) Testing the core empirical implications of Gottfredson and Hirschi's General theory of crime. *J Res Crime Delinq* 30:5–29.
10. Piquero AR, MacIntosh R, Hickman M (2000) Does self-control affect survey response? Applying exploratory, confirmatory, and item response theory analysis to Grasmick et al.'s self-control scale. *Criminology* 38(3):897–929.
11. Tittle CR, Ward DA, Grasmick HG (2004) Capacity for self-control and individuals' interest in exercising self-control. *J Quant Criminol* 20(2):143–172.
12. Goode E (2008) *Out of Control: Assessing the General Theory of Crime* (Stanford Univ Press, Stanford, CA).
13. Tittle C, Ward D, Grasmick H (2003) Self-control and crime/deviance: Cognitive vs. behavioral measures. *J Quant Criminol* 19(4):333–365.
14. Pratt TC, Cullen FT (2000) The empirical status of Gottfredson and Hirschi's general theory of crime: A meta-analysis. *Criminology* 38(3):931–964.
15. Mischel W, Shoda Y, Peake PK (1988) The nature of adolescent competencies predicted by preschool delay of gratification. *J Pers Soc Psychol* 54(4):687–696.
16. Mischel W, Shoda Y, Rodriguez MI (1989) Delay of gratification in children. *Science* 244(4907):933–938.
17. Shoda Y, Mischel W, Peake PK (1990) Predicting adolescent cognitive and self-regulatory competencies from preschool delay of gratification: Identifying diagnostic conditions. *Dev Psychol* 26(6):978–986.
18. Moffitt TE, et al. (2011) A gradient of childhood self-control predicts health, wealth, and public safety. *Proc Natl Acad Sci USA* 108(7):2693–2698.
19. Nagin D, Pogarsky G (2004) Time and punishment: Delayed consequences and criminal behavior. *J Quant Criminol* 20(4):295–317.
20. Cadena B, Keys B (2015) Human capital and the lifetime costs of impatience. *Am Econ J Econ Policy* 7(3):126–153.
21. Burks SV, Carpenter JP, Goette L, Rustichini A (2009) Cognitive skills affect economic preferences, strategic behavior, and job attachment. *Proc Natl Acad Sci USA* 106(19): 7745–7750.
22. Meier S, Sprenger C (2010) Present-biased preferences and credit card borrowing. *Am Econ J Appl Econ* 2(1):193–210.
23. Khwaja A, Silverman D, Sloan F (2007) Time preference, time discounting, and smoking decisions. *J Health Econ* 26(5):927–949.

24. Sutter M, Kocher M, Rutzler D, Trautmann S (2013) Impatience and uncertainty: Experimental decisions predict adolescents' field behavior. *Am Econ Rev* 103(1): 510–531.
25. Golsteyn B, Grönqvist H, Lindahl L (2014) Adolescent time preferences predict lifetime outcomes. *Econ J* 124(580):F739–F761.
26. Frederick S, Loewenstein G, O'Donoghue T (2002) Time discounting and time preferences: A critical review. *J Econ Lit* XL:351–401.
27. Farrington D, Langan P, Tonry M, eds (2004) *Cross-National Studies in Crime and Justice* (US Department of Justice, Office of Justice Programs, Bureau of Justice Statistics, Washington, DC).
28. Borghans L, Golsteyn BH, Heckman J, Humphries JE (2011) Identification problems in personality psychology. *Pers Individ Dif* 51(3):315–320.
29. Perez-Arce F (2011) *The Effect of Education on Time Preferences.* RAND Labor and Population Series (RAND Corporation, Santa Monica, CA), WR-844.
30. Lochner L, Moretti E (2004) The effect of education on crime: Evidence from prison inmates, arrests, and self-reports. *Am Econ Rev* 94(1):155–189.
31. Stenberg SÅ, Vågerö D (2006) Cohort profile: The Stockholm Birth Cohort of 1953. *Int J Epidemiol* 35(3):546–548.
32. Blumstein A, Cohen J, Roth JA, Visher CA (1986) *Criminal Careers and Career Criminals* (National Academy Press, Washington, DC).