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ARTICLE

CRIMINOLOGY

Structural predictors of choice: Testing a multilevel rational choice theory of crime

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Abstract

Extant research has provided support for the micro-level predictions of rational choice models of crime. Yet, a central feature of the rational choice perspective in the broader social sciences—that it is multilevel in focus, situating individuals within broader community social structures—has been neglected within criminology. In this article, we discuss and test a model that links community structural characteristics to several individual expectations and preferences relevant to crime. Using data from the Pathways to Desistance study, we find that objective levels of neighborhood concentrated disadvantage influence individuals' perceptions of, and preferences for, the risks, costs, and rewards associated with offending indirectly by affecting perceived disorder and perceived opportunities for legitimate avenues of success within one's neighborhood. The implications of a multilevel rational choice model of offending are discussed.

KEYWORDS

rational choice, neighborhood characteristics, crime, expectations, preferences

1 | INTRODUCTION

Although considerations of cost–benefit calculations have been integral to both classic and contemporary theoretical perspectives of crime (Becker, 1968; Grigoryeva & Matsueda, 2018; Hirschi, 1986; McCarthy, 2002), studies that emphasize offending as the outcome of a rational choice process continue to remain divorced from studies that highlight the importance of community structural factors (Matsueda, 2013). Even as rational choice scholars outside of criminology have increasingly embraced the idea that individual-level perceptions, preferences, and actions may be influenced by features of macro-level social context (Coleman, 1990; Hechter & Kanazawa, 1997), rational choice studies of criminal behavior have ignored how theoretically prominent community factors (e.g., concentrated disadvantaged, neighborhood disorder, the distribution of legitimate economic, and educational opportunities) influence cost–benefit assessments related to offending (Loughran et al., 2016; Matsueda et al., 2006; Piliavin et al., 1986). At the same time, many criminologists remain skeptical of choice-based perspectives in part based on the belief that structural constraints and disadvantage that serve as the foundation of most sociological perspectives are incompatible with economically motivated choice theories, and that the acknowledgment of a "rational" actor may render structural factors inoperative (Cullen, 2017). As Sampson (2012, p. 374) put it, "[T]here is something odd about the way many social scientists approach individual choice, almost as if they are spooked into thinking that choice renders the environment impotent."

The present study attempts to bridge this macro–micro divide by extending the typical rational choice approach to incorporate an assessment of how neighborhood characteristics may impact individuals' perceptions of, and preferences for, the (dis)incentives associated with offending. In doing so, we integrate insights from the literature on communities and crime on the potentially important role of individual exposure to high levels of neighborhood disadvantage with insights from the rational choice framework on how such exposure may influence choice inputs to make offending more likely. Drawing on Matsueda's (2013) seminal contributions, we argue that neighborhood concentrated disadvantage fosters subjective assessments of neighborhood disorder and limited access to legitimate opportunities, and together these objective and subjective neighborhood characteristics help shape individual perceptions of the risks, costs, and rewards associated with crime. This assertation is consistent with literature that has highlighted how community structural factors and social environment can influence individuals' subjective expectations through signals and information via Bayesian (Matsueda et al., 2006) and social learning (Akers, 1998) processes (see also Bruch & Feinberg, 2017). We suggest that higher levels of structural disadvantage within a community may lead individuals to view the rewards from crime as being more substantial, and the risks and informal social costs of crime to be lower. Additionally, we suggest that exposure to high levels of structural disadvantage may impact preferences by, among other reasons, leading individuals to be more tolerant of the risks and costs associated with crime and to attach greater value to the rewards from offending (Anderson, 1999; Hagan, 1991). Across each of these choice considerations, the literature has suggested that exposure to concentrated neighborhood disadvantage may be consequential primarily as a result of its tendency to fuel perceptions of disorder and limited opportunities within one's community (Sampson, 2012). Despite a clear recognition in the social science literature that community context may influence key components of individual decision-making (Coleman, 1990; Hechter, 2019; Matsueda, 2013), these predictions have not been examined in prior criminological research.

Our study offers new insights into how community structural conditions may impact individual assessments of costs, risks, and rewards associated with crime. We begin by discussing

the foundations of the multilevel rational choice framework for criminal behavior that underlies our research, delineating several hypotheses about how the community conditions we emphasize may impact choice considerations relevant to offending decisions. We then describe the data used to test those predictions, summarize the results and conclusions, and draw attention to future research needs.

2 | RATIONAL CHOICE PERSPECTIVE AND CRIME

Gary Becker's (1968) seminal contribution succinctly encapsulated the logic underlying choice perspectives. He suggested that offending decisions can be understood as a function of two components. The first embodies perceptions of the anticipated consequences of behavior (i.e., *subjective expectations*). When making decisions to offend, individuals consider the potential outcomes of the action such as the risk of detection by criminal justice agents (e.g., the police), the informal social costs (e.g., disappointing significant others, loss of respect from peers, and loss of a job) resulting from arrest and other sanctions, and the anticipated rewards (Matsueda et al., 2006). The rewards from crime include both the intrinsic rush and thrill associated with violating legal norms (Katz, 1988), as well as the social rewards—such as status and respect—that offending can incur (Matsueda et al., 2006; Nguyen, 2020).[1]

The second "choice component" emphasized by Becker (1968) encompasses *preferences* and marginal (dis)utilities[2] associated with the anticipated outcomes, which reflect how much individuals value and, in turn, weigh subjective beliefs when making offending decisions (Thomas & Vogel, 2019). For example, individuals can differ in their tolerance for risk: Some individuals may be *risk averse* in that changes in the likelihood of arrest have large deterrent effects on behavior, whereas others may be *risk tolerant*; in which case, the risk of arrest weighs minimally on offending decisions (Thomas & Vogel, 2019). Similarly, individuals may differ in their aversion to informal consequences that may arise from an arrest. Although some individuals are *cost-averse* and particularly concerned about disappointing intimate others or losing a job, others may be mostly indifferent to such outcomes (i.e., *cost tolerant*). The rational choice perspective also implies variability in how individuals weigh the rewards associated with offending. Some individuals may be acutely concerned about social status and be highly influenced by potential increases in social rewards that could derive from crime, whereas others are largely unmoved by considerations of social rewards (Steinberg, 2008). Finally, there may be differences in individual preferences for the intrinsic thrills and rush that crime provides (Katz, 1988). This could occur if some individuals are more inclined to engage in behaviors that elicit an emotional stimulus such as excitement. Thus, variation in preferences correspond to differences in how individuals value the (dis)incentives associated with criminal behavior, and this influences action choices by impacting how one weighs the risks, costs, and rewards to crime when making offending decisions (Thomas & Vogel, 2019).

[1] Another incentive derived from crime can be material gains such as money. More recent theoretical extensions of Becker have emphasized the importance of nonmaterial rewards, and contemporary research has suggested that *most* crimes offer little-to-no financial gains (Katz, 1988; Levitt & Venkatesh, 2000) and individuals are more likely to consider nonmaterial rewards when contemplating offending (Wright & Decker, 1994, 1997).

[2] Marginal (dis)utility is formally defined as $\partial U/\partial x$, or the change in expected utility (U) given changes in some subjective input x. As we detail below, in subjective expected utility models, this definition directly translates to the extent that individuals consider and weigh anticipated outcomes when making offending decisions.

As this description illuminates, preferences and subjective expectations are conceptually distinct in rational choice perspectives. Two individuals may hold the same perceptions about the anticipated outcome of a behavior (e.g., a 25 percent chance of arrest) but weigh those expectations differently when deciding whether to offend (Felson & Osgood, 2008). Preferences and subjective expectations are also measured in distinct ways. Typically, subjective expectations are observed directly through survey questions that query perceptions of the anticipated consequences of crime. In contrast, because preferences are inherently difficult to observe, they have been gleaned from regression models in which individual criminal involvement is regressed on subjective expectations, yielding coefficients that capture the weight individuals place on subjective expectations when making offending decisions (Thomas & Vogel, 2019; see also Bruch & Feinberg, 2017). Combining these distinct concepts and measurement approaches, rational choice models explain differences in offending through 1) differences in the perceptions of the risks, costs, and rewards of crime, as captured by the observed indicators; 2) differences in individuals' preferences related to crime (e.g., tolerance for risk), as captured in the associated regression slopes; or 3) some combination of these possibilities.

Rational choice theorists assert that individuals hold preferences related to crime and are, *on average*, responsive to risks, costs, and rewards associated with offending (McCarthy, 2002). Research findings support these predictions. Subjective expectations are predictive of offending for adolescents (Matsueda et al., 2006) and adults (Grasmick & Bursik, 1990), and among general (Lochner, 2007) and high-risk samples (Loughran et al., 2016; Piliavin et al., 1986). More recently, scholars have documented that changes in both expectations and preferences are important for explaining changes in offending from adolescence to young adulthood, and that individuals who have lower perceptions of arrest risk and who are more tolerant of arrest risk exhibit significantly higher offending rates (Thomas & Vogel, 2019).

Although the core *micro-level* predictions in rational choice theories of crime have received empirical support (Loughran et al., 2016; Matsueda et al., 2006), one potentially important limitation of the extant research is that it has not considered that community structural conditions may influence individual expectations and preferences. The distinction is related to the idea that perceptual formation occurs through a communication process presumably governed by both private (i.e., micro-level) and public (i.e., macro-level) information (Geerken & Gove, 1975). Some research has examined whether micro-level factors such as arrest and arrest avoidance influence the formation of individuals' perceptions of the risks, costs, and rewards to crime (Akers et al., 1979; Anwar & Loughran, 2011; Matsueda et al., 2006). Additionally, there is evidence that individual variability in preferences is a function, in part, of differences in individual traits and personality characteristics (Piquero et al., 2011; Thomas & McGloin, 2013). Nonetheless, rational choice studies have neglected the possibility that features of one's community may impact individual subjective expectations and preferences relevant to crime.

2.1 | Community Structural Factors and Rational Choice

Matsueda (2013) highlighted the prospects of rational choice theory for bridging macro- and micro-level explanations of crime and provided several examples of contextual factors impacting individual outcomes (e.g., mafia-related protection rackets and individual investment in social capital) that are consistent with predictions from a rational choice framework. We build on the logic of Matsueda's exposition, suggesting that neighborhood characteristics often highlighted in the theoretical and empirical literature on crime, especially conditions that coalesce in high

levels of socioeconomic disadvantage (e.g., Anderson, 1999; Sampson et al., 1997; Shaw & McKay, 1942), may impact individuals' subjective expectations and preferences.[3] We posit that concentrated neighborhood disadvantage may influence perceptions of risks, costs, and rewards through processes of communication and learning consistent with information and signaling theories (see also Shannon, 1948). Furthermore, exposure to high levels of neighborhood disadvantage may impact preferences through individuals' objective and perceived choice sets that, in turn, could lead individuals to be more, or less, tolerant of the risks and costs of crime and to place differential weights on social status and excitement when making offending choices.

2.1.1 | Community socioeconomic disadvantage and subjective expectations

Rational choice theorists argue that subjective expectations of behavior are formed—albeit imperfectly—through a process of communication (Geerken & Gove, 1975; Zimring & Hawkins, 1973). Individuals use information from "private" and vicarious experiences, as well as signals and cues from their environment when forming their perceptions of the anticipated consequences of crime. This idea that structural characteristics influence the flow of information, and in turn, individual perceptions, is central to many economic and sociological perspectives (see Bruch & Feinberg, 2017; Granovetter, 2005). It has been explicitly discussed with regard to crime within learning theoretical traditions such as those offered by Sutherland (1947) and Akers (1998), but it is also implicit in community-level perspectives that highlight an integral role for limited legitimate opportunities (e.g., Merton, 1938), social disorganization (e.g., Bursik & Grasmick, 1993; Shaw & McKay, 1942), and social and physical disorder (Sampson & Raudenbush, 1999; Wilson & Kelling, 1982) in generating crime.[4] This insight provides a critical foundation for how community structural conditions may influence subjective expectations.

We begin our explication with perceptions of arrest risk. Although research has indicated that proactive policing strategies often are disproportionately distributed in disadvantaged neighborhoods (see Kurlychek & Johnson, 2019; National Academies of Sciences, Engineering, and Medicine, 2018), most crimes come to the attention of the police through citizen reports, and there are reasons to believe such reporting is suppressed in disadvantaged neighborhoods. Skogan (1990) argued that disadvantaged neighborhoods are characterized by higher levels of actual and perceived physical (e.g., abandoned buildings and graffiti) and social (e.g., drunks in public, and loitering) disorder, which signals to people in the neighborhood that residents are unlikely to intervene or report crimes to the police (Wilson & Kelling, 1982). Extending this logic, if rates of police notification are suppressed in neighborhoods with high levels of concentrated disadvantage, and residents believe that the police are unlikely to respond when called, this may translate into

[3] We focus on levels of socioeconomic disadvantage as a dimension of community context as a result of its prominence within the criminological literature (Bursik, 1988; Sampson, 2012). Likewise, several concepts consistent with choice-related theories are related to criminal activity (e.g., fear of crime and arrest, and situational elements of decision-making; see Pickett et al., 2018; Simons & Burt, 2011; Wikstrom, 2017), but we focus on the central choice components of more traditional rational choice models stemming from the work of Becker (1968), namely, perceptions of, and preferences for, the risks, costs and rewards of crime.

[4] The parallels between rational choice and learning theories have been explicitly identified by many scholars (Akers, 1990, 1998; Anwar & Loughran, 2011; Matsueda et al., 2006; McCarthy, 2002; Stafford & Warr, 1993). Both perspectives argue that individuals form and update perceptions and beliefs based on experiences and information, and that such perceptions influence behavior.

lowered perceptions of arrest risk. Consistent with this assertion, research on Bayesian learning has documented that when individuals, or people they know, offend without being apprehended, there is a tendency to lower perceptions of arrest risk (Anwar & Loughran, 2011; Wilson et al., 2017). Furthermore, neighborhood-level research has indicated that individuals residing in disadvantaged neighborhoods are less likely to report (or have intentions to report) crime when it occurs (Baumer, 2002; Berg et al., 2013; Slocum et al., 2010), and that even when crimes are reported, they are less likely to translate into an arrest (Litwin, 2004; Mancik et al., 2018; Petersen, 2017; Vaughn, 2020). Nonetheless, little research has examined whether persons from neighborhoods with high levels of socioeconomic disadvantage perceive arrest risk to be low relative to those who live in less disadvantaged communities (Kim et al., 2014).

Community characteristics also may influence perceptions of the informal social costs of crime. Structurally, high levels of disadvantage often lead to weakened institutions of social control (Bursik & Grasmick, 1993), which inhibits effective socialization and reduces social bonds that impose informal costs for criminal behavior. This is consistent with the implicit logic of classic (Briar & Piliavin, 1965; Shaw & McKay, 1942; Toby, 1957) and contemporary (Bursik & Grasmick, 1993; Sampson, 2012) social disorganization perspectives (see also Kornhauser, 1978). From a cultural perspective, scholars have noted that high levels of socioeconomic disadvantage and associated perceptions of disorder may signal that criminal activity is common and unlikely to result in social stigma (Harding, 2009). Sampson and Bartusch (1998) found that individuals residing in disadvantaged communities are more tolerant of criminal behavior, indicating that they may be less likely to informally sanction law violation. Thus, by increasing perceived neighborhood disorder, concentrated disadvantage may translate into lower subjective costs associated with criminal behavior. Furthermore, the adverse labor market consequences typically associated with criminal activity also may be suppressed in communities with high levels of social and economic disadvantage (Sullivan, 1989). In such areas, offending and experiences with arrest may be unlikely to compromise job prospects already perceived to be limited (Fagan & Freeman, 1999). Pragmatically, this suggests that high levels of socioeconomic disadvantage may foster perceptions that legitimate opportunities are limited (Sampson & Wilson, 1995; Wilson, 1987), thereby signaling to individuals that crime and arrest are less likely to invoke negative social consequences.

There are also reasons to anticipate that community socioeconomic disadvantage might impact expectations of the social *rewards* associated with offending. Ehrlich's (1973) economic model of crime suggests that individuals exposed to high levels of social and economic disadvantage may perceive greater social rewards from offending compared with others. A similar prediction emerges from early Chicago school theorizing and research on the consequences of living in a neighborhood with high levels of socioeconomic disadvantage (Shaw, 1930; Sutherland, 1947). This classic scholarship suggests that high levels of concentrated disadvantage can give rise to adaptive cultural codes that, among other content, illuminate potential social rewards that may accrue from crime. This idea has reemerged in contemporary scholarship as well (Sampson & Wilson, 1995). As embodied in Anderson's (1999) observations, residing in a neighborhood with high levels of concentrated disadvantage may fuel widespread perceptions that legitimate economic opportunities are scarce, which can in turn foster emergent street codes that promote individual adoption of cultural codes (e.g., beliefs that interpersonal violence can be used to "campaign" for respect and that violence is an effective means of maintaining and enhancing social status) and facilitate violence and other forms of offending (Harding, 2009; Kubrin, 2005; Sampson & Wilson, 1995). Indeed, a rich tradition in criminology asserts that high levels of social and economic disadvantage contribute to "differential social organization" that shapes perceptions of disorder and available economic prospects in a community, which in turn increases the

transmission of norms that reward criminal conduct (Matsueda, 1988; Shaw, 1930; Sutherland, 1947).

Finally, concentrated neighborhood disadvantage may impact perceptions of the intrinsic rewards associated with crime (Katz, 1988; Nagin & Paternoster, 1993). Research has found that expectations of intrinsic rush and thrills are one of the strongest and most consistent predictors in rational choices models of offending (Loughran et al., 2016; Matsueda et al., 2006). For this reason, we believe it is imperative to assess the ways in which community structural factors influence perceptions of intrinsic rewards from crime, but we acknowledge that the theoretical linkages between community structure and perceptions of thrill and excitement from crime are less established than those previously discussed. To be sure, scholars have noted that perceptions of excitement and thrill are not uniform across individuals and have been critical of Katz's failure to describe antecedent factors associated with perceptions of excitement when offending. Most notably, McCarthy (1995) argued that a more comprehensive understanding of the intrinsic rewards to crimes can be attained by assessing the influence of potentially salient background and structural factors. To date, the possibility that residing in neighborhoods with high levels of concentrated disadvantage influences intrinsic rewards to crime has not been explored.

2.1.2 | Community socioeconomic disadvantage and preferences

Neighborhood conditions also may impact individual preferences related to crime. In particular, the preferences for the risks, costs, and rewards of crime are likely to vary across neighborhood contexts as a result of the influence that community structural disadvantage has on individuals' choice sets (Bruch & Feinberg, 2017). Choice sets are unobservable, reflecting what individuals (consciously or unconsciously) believe are feasible possibilities within a given context. Such choice sets are finite and vary across individuals (see Baseghayen et al., 2021). When perceived choices are constrained, it can shift individuals' preferences in ways that impact behavioral decisions. Consider the example of constrained choices on employment prospects and the impact this tends to have on legal reservation wages (i.e., the lowest wage an individual is willing to accept for a particular job). If an individual has poor employment prospects, she or he may be willing to accept a job at a lower wage rate than would be the case if a wider range of choices were available (Krueger & Mueller, 2016). In this way, someone who is generally risk averse but views employment prospects as limited may be willing to accept a risky job at a lower rate, thus, shifting his or her preferences toward a greater tolerance of risk. Limited choice sets also may shift preferences in ways that lead individuals to place greater value on other markers of success, such as job prestige or motherhood (Devine & Kiefer, 1991; McRae, 2003).

Prominent sociological scholarship has argued that individual choice sets can be formed both consciously and unconsciously. Consciously, this can occur through perceptions of social isolation and structural disadvantages that reduce individuals' expectations of going to college or acquiring a stable job (Sampson & Wilson, 1995). Unconscious choice sets are consistent with Bourdieu's (1984) concept of habitus. Habitus, in part, concerns the hierarchy of tastes and preferences that vary, at least on average, across different segments of the social structure (e.g., social class). Bourdieu argued that habitus can be influenced by "contextual cues" that signal what is both possible and valued (Bridge, 2001). Similarly, Sampson (2012, p. 367) suggested that perceptions of disorder can impact individuals in multiple ways, "many of which are implicit or operate below conscious awareness." In other words, exposure to high rates of disadvantage fuel perceived disorder, which in turn may unconsciously influence individuals' perceived feasibility of choices

and shape preferences. Building on the notion that individuals' choice sets may be influenced by community structural environments, we argue that higher levels of neighborhood disadvantage influence perceptions of neighborhood disorder and the availability of legitimate avenues for success, which in turn shape individual preferences related to the risks and costs associated with crime and to preferences associated with social status and excitement that may accrue from crime.

Typically, risk and cost preferences range on a continuum from risk/cost tolerance (people who are unmoved by increases in costs and risks) to risk/cost aversion (people for whom increases in risks and costs have a large impact on behavior). We suggest that individuals from highly disadvantaged communities may be more tolerant of the risks and costs associated with crime when compared with individuals from less disadvantaged areas. In advancing this prediction, we draw on the notion of a *criminal reservation wage* (Fagan, 1992), which reflects the risks and costs individuals are willing to accept before engaging in crime. In areas with limited prospects to attain conventional markers of success, the potential "pay off" to offending—regardless of the level of risk and cost—is more likely to be perceived as worth it (Fagan & Freeman, 1999). In this way, marginal increases in the risks and costs of crime are unlikely to appreciably "deter" behavior. Classic theoretical contributions in sociology have implied that tolerance for risks and costs may emerge as a cultural value in highly disadvantaged communities (Miller, 1958). Sullivan (1989) argued that in some socioeconomically disadvantaged neighborhoods, arrest and the associated costs are "just part of doing business," and Fagan (1992) noted that a higher tolerance for the risks and costs associated with crime (e.g., arrest) in such areas can yield higher returns on illegal earnings. These arguments suggest that high levels of neighborhood socioeconomic disadvantage can influence unobserved choice sets and promote cultural adaptations that shift preferences toward greater tolerance for risks and costs.

Finally, exposure to high levels of neighborhood socioeconomic disadvantage also may lead individuals to place greater value on social status and excitement. We noted that limited choice sets toward conventional goals can lead individuals to place greater value on other goals, including social and intrinsic rewards. This is consistent with classic and contemporary subcultural theories of crime. Cohen (1955) argued that members of the lower class often confronted difficulties attaining educational and economic outcomes that are symbolic of middle-class success, and as a result, they were more likely to assign value to alternative goals that are more readily attainable, such as attaining status and respect (see also Cloward & Ohlin, 1960). More recent scholarship has similarly suggested that an individuals' "sense of worth is determined by the respect" she or he garners from others (Anderson, 1999). As with the formation of expectations, the influence that structural factors have on preferences for intrinsic rewards has received little scholarly attention. Nevertheless, some scholars have suggested that individuals in disadvantaged communities may have stronger preferences for the excitement and thrills associated with crime. Miller (1958) indicated that the limited considerations of employment and education typically characterized by routine and repetitiveness shifts individuals' preferences toward emotional stimulation and quests for excitement: "[M]any of the most characteristic features of lower-class life are related to the search for excitement or thrill" (p. 11). Moreover, contemporary ethnographic research on individuals who engage in illicit conduct in disadvantaged communities often finds that the quest for excitement and sensory stimulation is a strong motivator to break the law (Jacobs et al., 2003; Wright & Decker, 1994). Connecting these ideas, we suggest that individuals in disadvantaged communities are not just more likely to perceive crime as more socially and intrinsically rewarding but to also have greater preferences for such rewards.

Figure 1 provides a heuristic summary of our synthesis of the extant literatures on rational choice and how concentrated disadvantage may shape individual perceptions and preferences. As

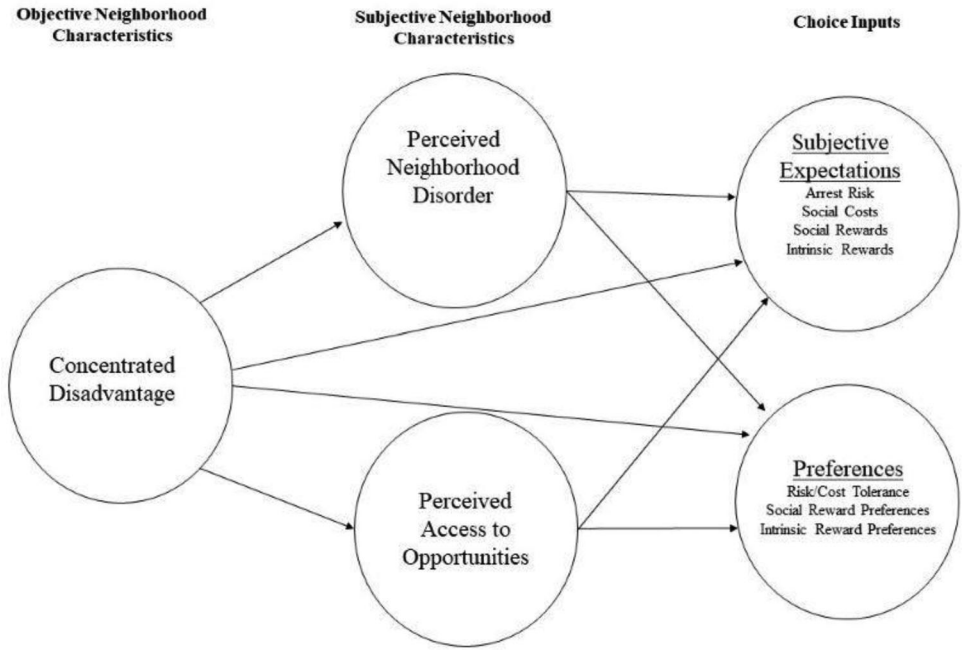

FIGURE 1 Theoretical model of relationship between selected neighborhood characteristics and choice inputs

the figure reveals, this integration suggests that concentrated neighborhood disadvantage alters subjective assessments of disorder and available legitimate opportunities in one's local community, which in turn influence individual perceptions of risks, costs, and rewards associated with crime and the weight people attach to these dimensions of choice.

3 | CURRENT STUDY

The specific predictions assessed in the present study are outlined in table 1. We test these predictions with a design that integrates objective neighborhood (defined administratively as "block-groups") indicators of concentrated disadvantage and subjective neighborhood indicators of perceived disorder and access to economic opportunities with data on individual expectations of the risk of arrest, informal social costs, and social and intrinsic rewards associated with offending, as well as the associated preferences related to offending (i.e., the weight placed on the expectations associated with offending decisions).

4 | DATA

We analyze panel data from the Pathways to Desistance Study (Mulvey, 2012), a longitudinal investigation of the transition from adolescence to adulthood for a sample of persons ($N = 1{,}354$) convicted of a criminal offense (usually a felony) in the juvenile or adult court systems in Maricopa County, AZ (Phoenix) and Philadelphia County, PA. Descriptive statistics for the sample are

TABLE 1 Predicted directions of relationships between neighborhood measures and rational choice inputs in a multilevel rational choice theory of offending

	Objective Neighborhood Measure	Subjective Neighborhood Measures	
Variables	Concentrated Disadvantage	Neighborhood Disorder	Access to Legitimate Opportunities
Subjective Expectations			
Perceived Risk and Costs	–	–	+
Anticipated Social and Intrinsic Rewards	+	+	–
Preferences			
Preferences for Risks, Costs and Rewards	+	+	–

displayed in table 2. Most of the Pathways sample is non-White (44 percent Black/African American and 29 percent Hispanic) and male (82 percent), and this group was on average 15 years old at the time of the baseline interview. Importantly, the sample comes from block-groups that differ extensively on indicators of objective levels of disadvantage. We rely primarily on data collected in the ten follow-up interviews, the first six of which were conducted at 6-month intervals, and the final four of which were conducted annually. Our total pooled sample captures 7,778 $N \times T$ observations nested within 1,240 individuals, which represents 92 percent of the initial baseline sample.[5]

4.1 | Outcome Variables

4.1.1 | Perceived arrest risk

At each interview, respondents were asked how likely it is that they would be caught and arrested if they committed each of the seven following types of crime: assault, robbery, stabbing someone, breaking into a home or store, stealing clothes from a store, destroying property, and auto theft. Response options ranged from *no chance* (= 0) to *absolutely certain to be caught* (= 10); thus, higher values indicate that respondents perceived the likelihood of arrest risk to be greater. The mean score over the panel is 5.980 (standard deviation [SD] = 2.965), indicating that across the seven crimes individuals believe, there is, on average, a 60 percent chance of arrest risk when offending. In our study, and consistent with prior work (Paternoster, 1986; Thomas et al., 2020), perceived arrest risk is captured through a latent trait estimated using a confirmatory factor analysis (CFA; alpha at baseline = .89; root-mean-square error of approximation [RMSEA] < .05; comparative fit index [CFI] ≥ .98).

[5] We utilize latent trait models to estimate our outcomes of interest, which allows us to retain individuals who are missing information on individual items comprising these scales. Individuals who are missing information on entire scales are excluded from the analysis. Most of these individuals were missing complete information during a recall period. We present the means of the averaged values in table 1. As a robustness check, we estimated all of our models using the means rather than the latent scores and the results are identical to those presented in text.

TABLE 2 Descriptive information on variables used from analytic sample in the Pathways data ($N = 1{,}240$, $N \times T = 7{,}778$)

Variables	Mean/%	Standard Deviation	Minimum	Maximum
Outcome Variables				
Perceived Arrest Risk[a]	5.980	2.965	0	10
Anticipated Social Costs[a]	3.210	.928	1	5
Anticipated Social Rewards[a]	1.826	.518	1	4
Perceived Intrinsic Rewards[a]	1.708	2.327	0	10
Risk Tolerance[a]	−.199	.060	−.329	.230
Cost Tolerance[a]	−.099	.046	−.188	.202
Social Reward Preference[a]	1.221	.372	.008	2.749
Intrinsic Reward Preference[a]	.181	.117	−.128	.798
Neighborhood Measures				
Concentrated Disadvantage	−.022	.966	−1.762	4.306
Perceived Neighborhood Disorder	2.296	.811	1	4
Access to Legitimate Opportunities	3.538	.601	1	4
Individual Controls				
Age	19.324	2.325	14	26
Male	80.509	—	0	100
Black	38.005	—	0	100
Hispanic	33.672	—	0	100
Parental SES	50.787	11.871	11	77
Household Composition	3.273	1.941	0	9
Residential Mobility	1.691	.880	1	7
Biological Parents Married	16.405	—	0	100
Impulse Control	3.291	.958	1	5
IQ	85.581	13.304	55	128
Street Time	.941	.137	.01	1

Note: SES = socioeconomic status.

[a]We present the raw means of these variables in the descriptive table, but in our analyses, we use standardized measures.

4.1.2 | Informal social costs

Anticipated informal social costs were captured by asking respondents how likely they would experience one of the following costs if arrested: lose respect from close friends, lose respect from family members, lose respect from a girlfriend or boyfriend, lose respect from neighbors or other adults, be suspended from school, or find it harder to get a job. Response options ranged from *very unlikely* (= 1) to *very likely* (= 5), with higher values indicative of anticipating greater

informal social costs from arrest. We calculated the mean of the items at each recall period to capture respondents' anticipated informal social costs from arrest. The scale demonstrated adequate levels of internal consistency (alpha = .68 at baseline) with a mean value of 3.210 (SD = .928) over the panel. We estimate informal social costs as a latent trait through CFA (RMSEA < .05; CFI = .96).

4.1.3 | Anticipated social rewards

Perceived social rewards from crime were captured by asking respondents their level of agreement with statements about how similarly aged peers would react if the respondent engaged in three different crime types: stealing (e.g., *If I steal things other people my age will respect me*), fighting (e.g., *If I beat someone up, other people my age will respect me*), and robbery (e.g., *If I rob someone, people my age will be afraid to mess with me*). Response options ranged from *strongly disagree* (= 1) to *strongly agree* (= 4), with higher values reflecting a greater tendency to view crime as eliciting social rewards. We averaged the items at each recall period for each individual to create a single average anticipated social rewards scale. The average scale displayed high levels of internal consistency (alpha = .82 at baseline). Over the panel, the mean average social reward score of our analytic sample is 1.826 (SD = .518). In our empirical models predicting perceptions of anticipated social rewards, we utilize a latent trait measure captured through CFA (RMSEA = .07; CFI = .95).

4.1.4 | Perceived intrinsic rewards

Respondents were asked how much "thrill" or "rush" they would experience when committing seven types of crimes. These seven crimes are identical to the crime types captured in the perceived arrest risk scale. Response options ranged from *no fun or kick at all* (= 0) to *a great deal of fun or kick* (= 10). We averaged responses across these items to create a mean intrinsic rewards score for each respondent at each time point (alpha = .88 at baseline). On average, individuals did not report crime to be especially thrilling or exciting (mean = 1.708, SD = 2.327 over the panel). As with the other expectations, when predicting perceptions of intrinsic rewards in our main analyses, we rely on a latent trait measure of perceived intrinsic rewards estimated through a CFA (RMSEA < .05; CFI ≥ .98).

4.1.5 | Preferences

The Pathways data do not contain measures directly gauging individual preferences for the risks, costs, and rewards to crime. Nonetheless, as we explain in greater detail below, we follow the precedent of recent research to estimate latent (i.e., revealed) individual preferences by regressing self-reported offending on the respective subjective expectations measures at each time point (see also Bruch & Feinberg, 2017). This strategy—analogous to a multilevel random coefficient model—estimates a random slope for each individual capturing the influence that changing expectations have on their offending behavior. The resulting measures correspond directly to conceptualizations of preferences and marginal (dis)utilities by capturing how changes in an expectation impact predicted changes in behavior—that is, the weight that individuals place on an expectation. We estimate four preferences associated with our four subjective expectation

measures: *tolerance for risk* (perceived arrest risk), *tolerance for costs* (anticipated social costs), *social reward preferences*, and *intrinsic reward preferences*.

4.2 | Explanatory Variables

4.2.1 | Neighborhood concentrated disadvantage

Levels of concentrated disadvantage are measured monthly in the Pathways data in a manner that is consistent with most prior research (Sampson, Morenoff, et al., 2005; Sampson, Raudenbush, et al., 1997). Specifically, monthly concentrated disadvantage is calculated using a weighted factor score of four block-group characteristics drawn from the 2000 Census: proportion of individuals living in poverty, proportion of residents on welfare, proportion of households headed by a single parent, and proportion of residents that are unemployed. Over the entire panel, the monthly factor scores ranged from −1.763 to 4.306, where higher values are indicative of greater concentrated disadvantage (mean = −.022, SD = .966).[6] Individuals who spent the entirety of the recall period institutionalized were not eligible to be given a block-group disadvantage score, so these respondents are excluded during the corresponding period. To address our research questions, we created a single concentrated disadvantage score for each recall period, combining data across months within periods. This harmonized the measure of concentrated disadvantage with other indicators, which were not available monthly. To account for residential mobility of the Pathways sample within recall periods, we defined the indicator of concentrated disadvantage as a weighted average that placed greater weight on the block-group(s) in which respondents resided for the longest duration. In supplementary analyses discussed below, we obtained substantively identical results when restricting the analysis to nonmovers—that is, individuals who resided in the same residence over the entire recall period.[7]

The multilevel model described above suggests that the anticipated association between concentrated neighborhood disadvantage and subjective risks, costs, rewards, and preferences may arise, in part, because exposure to disadvantaged neighborhood environments fosters perceptions of widespread disorder and limited legitimate opportunities for advancement in one's neighborhood. To assess this, we incorporate indicators of respondent's perceived neighborhood disorder and perceived access to legitimate opportunities.

4.2.2 | Perceived neighborhood disorder

Respondents' perceptions of neighborhood disorder are captured at each wave of the Pathways data utilizing items similar to those applied in prior research to capture perceptions of the

[6] Although block-groups are commonly employed in studies assessing neighborhood influences on social behavior, we recognize both smaller and larger geographic units that may also influence choice inputs (see Vogel, 2016).

[7] This suggests that the noted residential mobility is not a threat to the inferences we draw, perhaps because when moves did occur among sample members, it was most often to a block-group with a similarly high (or low) level of concentrated disadvantage (e.g., the correlations across monthly values are greater than .93), which parallels findings reported in studies of inter-neighborhood mobility patterns with other data sets (e.g., South & Crowder, 1997). Nonetheless, to account for potential differences associated with residential mobility, we include the number of moves within recall periods as a control variable in the regression models described below.

environment immediately surrounding an adolescent's home (Sampson & Raudenbush, 1999). Specifically, the perceived neighborhood disorder scale comprises 21 items asking about respondents' perceptions of how often they observe physical (e.g., "cigarettes on the street or in the gutters" or "graffiti or tags") or social (e.g., "adults fighting or arguing loudly" or "people using needles or syringes to take drugs") disorder in their neighborhood. Response options ranged from *never* (= 1) to *often* (= 4), with higher values indicative of perceptions of higher levels of neighborhood disorder. At each recall period, we use the mean across the 21 items to create an overall perceived neighborhood disorder score. The neighborhood disorder scale demonstrated high levels of internal validity (alpha = .94 at baseline) and had a mean score of 2.251 over the panel.[8]

4.2.3 | Perceived access to legitimate opportunities

Individuals' perceptions of success through legitimate avenues in their neighborhood are captured in the Pathways data through the motivation to succeed scale (Eccles et al., 1998). At each wave, individuals were asked how much they agree with six statements querying their assessment of the opportunities available to them for schooling and work. These include the following: 1) *In my neighborhood it is easy for a young person to get good job;* 2) *most of my friends will graduate from high school;* 3) *in my neighborhood, it is hard to make money without doing something illegal* (reverse coded); 4) *college is too expensive for most people in my neighborhood* (reverse coded); 5) *there is not much opportunity to succeed like kids from other neighborhoods* (reverse coded); and 6) *the chances of getting ahead/being successful are not very good* (reverse coded).[9] Response options were on a five-point Likert scale ranging from *strongly disagree* (= 1) to *strongly agree* (= 5). These items demonstrated acceptable levels of internal consistency (alpha = .66 at follow-up 1) and are averaged at each time point, with higher values reflecting greater perceived opportunities for success (mean = 3.538, SD = .601 over the panel).

4.3 | Control Variables

We control for several individual-level factors that may serve as important confounders in assessing the relationships between neighborhood disadvantage, subjective neighborhood conditions, and costs, rewards, and preferences associated with crime. These include gender, age, race and ethnicity, parental socioeconomic status (SES), household size, family structure, the proportion of time an individual spends outside of a correctional institution ("street time"), capacity for impulse control, and IQ. We also control for individuals' residential mobility in each recall period (the number of unique residences) because prior research has suggested that mobility can impact

[8] As with the concentrated disadvantage measure, individuals who spent the entirety of the recall period in a correctional institution were not asked questions pertaining to perceived neighborhood characteristics and are treated as missing for the corresponding time period.

[9] Two items do not explicitly use the term "neighborhood," but the respondents are prompted prior to the full set of items that the questions are querying about opportunities available in their neighborhood and are asked in the context of several other items explicitly referencing their own neighborhood. Reinforcing this point, the correlations of the items not using the term "neighborhood" are similar in size as the other items are to each other.

individuals' subjective expectations (Kijowski & Wilson, 2021).[10] For reference, a summary of the items comprising these measures is presented in table S1 in the online supporting information.[11]

5 | ANALYTIC STRATEGY

Our analysis is organized around the three core empirical goals implied above: 1) assessing the relationship between neighborhood disadvantage and subjective expectations; 2) assessing the relationship between neighborhood disadvantage and latent preferences; and 3) assessing the extent to which the estimated relationships between neighborhood disadvantage and expectations/preferences are mediated by perceptions of neighborhood disorder and limited access to opportunities. To accomplish these objectives, we first estimate the overall relationship between neighborhood socioeconomic disadvantage and our outcome measures, net of the individual-level control variables, and we then estimate models that include perceptions of limited legitimate opportunities and greater disorder within respondents' neighborhoods. We subsequently decompose the estimates for concentrated disadvantage into direct and indirect effects. The four indicators of subjective expectations (risk of arrest, anticipated informal social costs, expected social rewards, and perceived intrinsic rewards) are estimated with random effects models with robust standard errors. For the analysis of latent preferences relevant to offending decisions, we applied a two-stage approach, the first of which focused on estimating latent preferences, and the second of which focused on modeling the relationship between the neighborhood disadvantage on those estimated latent preferences.

With regard to the first stage of the latent preference analysis, a widely deployed strategy is to allow an individual's behavior to reveal what he or she values in practice—an approach known as estimating *revealed preferences* (see Bruch & Feinberg, 2017).[12] Revealed preferences can be estimated through a discrete choice random utility model, which relies on a multilevel modeling framework to estimate a random coefficient that captures the weight individuals place on some choice input when making a behavioral decision, a framework that directly corresponds to conceptualizations of "preferences" (McFadden, 1978; see also Thomas et al., 2022). We adopted this strategy in the present study by estimating a discrete choice random utility model to estimate individuals' preferences for the risks, costs, and rewards associated with criminal behavior. At each recall period, respondents were asked how many times during the recall period they engaged in 21 different offenses. When possible, we estimated preferences by relying only on the offense

[10] We include control variables that may serve as confounders because our focus is in on establishing whether neighborhood disadvantage and perceptions of neighborhood disorder and legitimate opportunities are related to costs, rewards, and preferences. As we note in the Discussion section, other individual-level variables available in the Pathways data (e.g., exposure to delinquent peers and perceived legitimacy) are more appropriately considered as potential mediators that may help to explain any observed relationships between neighborhood conditions and individual choice sets, which should be explored in future research.

[11] Additional supporting information can be found in the full text tab for this article in the Wiley Online Library at http://onlinelibrary.wiley.com/doi/10.1111/crim.2022.60.issue-4/issuetoc.

[12] Revealed preferences—in which preferences are reflected in actions—can be contrasted with *stated* preferences in which scholars use direct survey responses asking subjects to report or rank how much they value different things. Two key drawbacks of stated preferences are that human beings often have a poor understanding of what they value in practice, and that many data sources do not contain measures of such preferences. As a result, random utility models similar to what is employed here are widely used to estimate preferences and choice. We refer the readers to Bruch and Feinberg (2017) for an elaborated discussion of estimating preferences in sociological research.

types that directly correspond to the measures comprising the respective subjective expectation measure.

The latent preferences for perceived arrest risk and perceived intrinsic rewards were estimated with a three-level hierarchical logistic model, with crimes nested within time points nested within people and the outcomes defined as binary indicators of the seven crimes that correspond to the items comprising the arrest risk and intrinsic reward scales (individuals are coded 0 if they did not engage in the offense, and 1 if they committed the act one or more times). For social reward preferences, we limit the outcome to the three offenses that correspond to the social reward scales (i.e., fighting, robbery, and theft), with items again coded as binary indicators differentiating individuals who reported that they did (coded 1) or did not (coded 0) commit an offense. Thus, for these three expectations, we can estimate the odds that an individual i will engage in crime type c at time $t+1$ through the models:

Risk tolerance:

$$Log\left(Y_{ict+1}=1/Y_{ict+1}=0\right)=\delta_{0it}+\delta_{1it}Risk_{ict}+\gamma it+e_{ict} \tag{1}$$

Intrinsic reward preferences:

$$Log\left(Y_{ict+1}=1/Y_{ict+1}=0\right)=\pi_{0it}+\pi_{1it}PersReward_{ict}+\gamma_{it}+e_{ict} \tag{2}$$

Social reward preferences:

$$Log\left(Y_{ict+1}=1/Y_{ict+1}=0\right)=\theta_{0it}+\theta_{1it}SocRew_{ict}+\gamma_{it}+e_{ict} \tag{3}$$

The random coefficients in each of these models represents the weight that individuals place on the respective expectation when making offending decisions. For example, δ_{1it} in equation 1 captures an individual's tolerance for arrest risk, in that large negative values indicate that increases in the likelihood of arrest have a large deterrent effect on behavior, and values closer to zero or even positive would indicate that individuals at time t are tolerant of arrest risk or risk seeking. Similarly, large positive coefficients associated with *SocRew* (θ_{1it}) and *PersReward* (π_{1it}) suggest that these expectations have a large effect on one's likelihood of engaging in crime and, thus, have preferences for the associated rewards.

Because the items capturing social costs are not crime specific, we cannot similarly estimate a unique coefficient for each individual at each wave. Instead, we estimated an average slope for each individual i across the entire panel. We rely on a total offending variety score capturing the number of crime types (among the 21 available items) a respondent committed during the recall period. That is, cost tolerance is captured by estimating an individual's crime variety at time $t+1$ using a multilevel negative binomial equation:

Cost tolerance:

$$Log\left(\lambda_{it+1}\right)=\beta_{0i}+\beta_{1i}SocialCosts_{it}+\gamma_{it}+e_{it} \tag{4}$$

Strong negative values on β_{1i} would indicate that informal social costs have a large deterrent effect on behavior, whereas values closer to 0 would suggest that individuals are unresponsive to informal social costs.

We present the full results of these discrete choice random utility models in table S2 of the online supporting information, although for our purposes, their key function is to yield an associated estimate of latent preferences to be used as outcomes in regression models that

represent the second stage of our assessment, which focuses on examining the association between neighborhood socioeconomic disadvantage and latent preferences relevant to offending decisions. Notably, the variance components associated with the latent preference estimates suggest that all exhibit significant variation across individuals. Furthermore, the estimated latent preferences are approximately normally distributed. For interpretation purposes, we standardized these measures to have an approximate mean of 0 and standard deviation of 1, and we present the descriptive information in table 2.

In the second stage of our analysis of latent preferences, we estimated random effects panel models of latent preferences associated with arrest risk, social rewards, and intrinsic rewards. We used ordinary least squares (OLS) to model preferences for social costs, regressing the average cost-tolerance slope for each individual on panel-averaged scores of neighborhood socioeconomic disadvantage and the individual-level control variables.[13] In all these models, we weighted the estimate of preferences by the precision of the estimate derived from the random utility model for each observation (Raudenbush & Bryk, 2002), and we estimated robust standard errors.

6 | RESULTS

6.1 | Concentrated Disadvantage, Expectations, and Preferences

The regression results are presented in tables 3 and 4. Focusing first on the estimated associations between neighborhood socioeconomic disadvantage and the outcomes considered, table 3 reveals several noteworthy patterns. With regard to subjective expectations (models 1–4), we find that higher levels of disadvantage are associated with significantly lower perceptions of arrest risk (model 1, $b = -.146$, standard error [SE] = .042, $p < .001$) and informal social costs associated with experiencing arrest (model 2, $b = -.057$, SE = .016, $p < .001$). Additionally, as shown in model 3, individuals residing in areas characterized by higher levels of concentrated disadvantage perceive the anticipated social rewards from crime to be significantly higher, on average, compared with individuals from less disadvantaged areas ($b = .030$, SE = .008, $p < .001$). For intrinsic rewards (model 4), the direction of the observed pattern is contrary to our prediction; concentrated disadvantage is *negatively* related to expectations of excitement and thrill associated with offending, although the coefficient ($b = -.064$, SE = .035, $p = .066$) is not statistically significant at a .05 alpha level using a two-tailed test.

Models 5 through 8 in table 3 present the results of the equations predicting latent preferences. The results indicate that individuals from disadvantaged neighborhoods do not differ significantly from others with respect to their tolerance of arrest risk or social costs (models 5 and 6), or in their preference for social rewards (model 7). We do find evidence that concentrated disadvantage exhibits a significant positive association with preferences for intrinsic rewards ($b = .013$, SE = .005, $p = .015$). This suggests that even though individuals residing in areas characterized by higher levels of disadvantage do not associate crime with higher intrinsic rewards, they place significantly greater weight on the anticipated intrinsic rewards associated with crime. The latter is consistent with the arguments made by some cultural theorists (Hagan, 1991; Miller, 1958).

[13] Proper temporal ordering is built into the models. The neighborhood measures capture the characteristics of where individuals resided *during the last recall period*, whereas the subjective expectations outcomes reflect their *current perceptions of risk, costs, and rewards*. Furthermore, our preference measures reflect one's preferences over the recall period, which is consistent with our hypotheses.

TABLE 3 Random effects models estimating the impact of neighborhood factors on subjective expectations of risks, costs, and rewards from crime ($N = 1,240$)

	Subjective Expectations				Preferences			
Variables	**Arrest Risk Model 1 b (SE)**	**Social Costs Model 2 b (SE)**	**Social Rewards Model 3 b (SE)**	**Intrinsic Rewards Model 4 b (SE)**	**Risk Pref. Model 5 b (SE)**	**Cost Pref. Model 6 b (SE)**	**Social Reward Pref. Model 7 b (SE)**	**Intrinsic Reward Pref. Model 8 b (SE)**
Concentrated Disadvantage	−.146 (.042)***	−.057 (.016)***	.030 (.008)***	−.064 (.035)†	.016 (.017)	−.028 (.035)	−.001 (.003)	.013 (.005)*
Perceived Neighborhood Disorder	—	—	—	—	—	—	—	—
Perceived Access to Legitimate Opportunities	—	—	—	—	—	—	—	—
Age	.048 (.011)***	.049 (.005)***	−.003 (.002)	−.077 (.010)***	−.041 (.005)***	−.057 (.021)**	−.002 (.001)**	−.005 (.001)***
Male	−.956 (.119)***	−.173 (.048)***	.125 (.021)***	.611 (.090)***	.042 (.038)	.277 (.074)***	.310 (.037)***	.175 (.064)**
Black	−.685 (.126)***	−.310 (.052)***	.134 (.024)***	−.469 (.114)***	−.138 (.051)**	−.019 (.075)	−.502 (.075)***	−.373 (.076)***
Hispanic	−.317 (.117)**	−.122 (.051)*	.021 (.023)	.064 (.124)	−.125 (.055)*	.084 (.070)	−.145 (.082)†	−.171 (.085)*
Parental SES	.003(.004)	−.001 (.002)	.000 (.001)	−.000 (.004)	−.001 (.003)	−.003 (.002)	−.002 (.003)	−.002 (.002)
Household Composition	−.031 (.014)*	−.005 (.006)	.004 (.003)	−.004 (.012)	.009 (.007)	−.041 (.018)*	−.000 (.001)	.006 (.002)***
Residential Mobility	−.033 (.026)	−.001 (.012)	.004 (.006)	.009 (.024)	.107 (.016)***	.034 (.005)***	−.007 (.002)***	.019 (.004)***
Biological Parents Married	.074 (.111)	.056 (.050)	−.002(.024)	.102 (.126)	.004 (.053)	.117 (.070)†	−.064 (.077)	−.062 (.087)
Impulse Control	.248 (.032)***	.030 (.014)*	−.101 (.006)***	−.400 (.028)***	−.167 (.015)***	−.503 (.035)***	.010 (.002)***	−.029 (.004)***
IQ	−.010 (.004)**	.003 (.001)†	−.000 (.001)	.009 (.003)**	−.000 (.001)	.006 (.002)**	.001 (.002)	−.004 (.002)†
Street Time	.560 (.179)**	.035 (.075)	−.136 (.034)***	−.110 (.155)	−.376 (.108)***	−.581 (.095)	.000 (.014)	−.034 (.026)

NOTES: N × T = 7,778. Pref. = preference; SES = socioeconomic status.

***p < .001; **p < .01; *p <.05; †p < .10 (two-tailed).

Previous research has suggested that exposure to higher levels of concentrated neighborhood disadvantage is associated with greater perceived disorder and fewer opportunities for advancement among individuals (e.g., Ross & Mirowsky, 2001; Sampson & Raudenbush, 1999; South et al., 2003; Wilson, 1987). This is confirmed in the Pathways data, with concentrated disadvantage exhibiting strong bivariate correlations with the individual-level measures of perceptions of social and physical disorder ($r = .54$) and perceived access to educational and economic opportunities ($r = -.35$), as well as being a strong and statistically significant predictor of these indicators of perceived neighborhood conditions in regression models (neighborhood disorder: $b = .364$, SE = .010, $p < .001$; perceived opportunities: $b = -.124$, SE = .008, $p < .001$; see table S3 in the online supporting information). In turn, as noted earlier, the theoretical literature has highlighted individual differences in perceived disorder and legitimate opportunities as potentially relevant to explaining why exposure to concentrated neighborhood disadvantage may be associated with different expectations and preferences related to crime. To explore that possibility, we reestimated the regression models after integrating the two indicators of perceived neighborhood conditions, the results of which are presented in table 4. After discussing these results, we decompose the estimated effects concentrated disadvantage on the choice inputs studied into direct effects and indirect effects through perceived neighborhood conditions (table 5).

This analysis reveals that perceived neighborhood disorder is significantly and inversely associated with perceptions of arrest risk (model 1: $b = -.350$, SE = .042, $p < .001$), but it is not significantly associated with a reduction in the anticipated informal social costs associated with arrest, as expected (model 2). Additionally, perceived neighborhood disorder is positively associated with the perceived social (model 3: $b = .032$, SE = .009, $p < .001$) and intrinsic (model 4: $b = .101$, SE = .038, $p < .01$) rewards associated with criminal activity, which is consistent with theoretical expectations. Perceived access to legitimate opportunities also exhibits significant relationships with the indicators of subjective expectations about crime that are in line with theoretical expectations. Specifically, respondents who perceive greater access to legitimate opportunities indicate greater perceived arrest risk (model 1, $b = .267$, SE = .049, $p < .001$) and anticipated social costs (model 2: $b = .061$, SE = .023, $p < .001$) from engaging in crime. Additionally, perceived access to legitimate opportunities is significantly and negatively related to perceived social (model 3: $b = -.130$, SE = .011, $p < .001$) and intrinsic (model 4: $b = -.157$, SE = .038, $p < .001$) rewards. Thus, individuals who perceive more opportunities for economic and educational success in their neighborhood tend to view crime as offering fewer social rewards and as less exciting, on average.

After controlling for the two indicators of perceived neighborhood conditions, the estimated relationship between concentrated neighborhood disadvantage and perceived intrinsic rewards is amplified and is now statistically significant at conventional levels ($b = -.118$, SE = .037, $p = .001$). This association is contrary to the theoretical expectations outlined above, and it implies that individuals from socioeconomically disadvantaged neighborhoods are *less* likely than those from more affluent areas to perceive the prospects of engaging in crime as exciting and thrilling. We speculate about the meaning of this pattern in the discussion.[14]

Models 5 through 8 in table 4 present results for latent preferences that incorporate the indicators of perceived disorder and perceived legitimate opportunities within respondents'

[14] We believe that it is unlikely that the amplification effect is a result of multicollinearity for several reasons. First, such an effect was not observed for the other outcomes. Second, the correlations between concentrated disadvantage and the subjective neighborhood measures are notable but only moderately strong (e.g., $r = .54$). Finally, the variance inflation factor (VIF) when including all of the predictors is low (= 1.36).

TABLE 4 Random effects models estimating the impact of neighborhood factors on preferences for risks, costs, and rewards from crime (N = 1,240)

	Subjective Expectations				Preferences			
Variables	**Arrest Risk Model 1 b (SE)**	**Social Costs Model 2 b (SE)**	**Social Rewards Model 3 b (SE)**	**Intrinsic Rewards Model 4 b (SE)**	**Risk Pref. Model 5 b (SE)**	**Cost Pref. Model 6 b (SE)**	**Social Reward Pref. Model 7 b (SE)**	**Intrinsic Reward Pref. Model 8 b (SE)**
Concentrated Disadvantage	.003 (.044)	−.042 (.018)*	.003 (.009)	−.118 (.036)**	−.030 (.018)†	−.149 (.040)***	.000 (.003)	.005 (.006)
Perceived Neighborhood Disorder	−.350 (.042)***	−.021 (.019)	.032 (.009)***	.101 (.038)**	.103 (.023)***	.202 (.050)***	.030 (.003)***	.020 (.005)**
Perceived Access to Legitimate Opportunities	.267 (.049)***	.061 (.023)**	−.130 (.011)***	−.157 (.038)***	−.070 (.024)**	−.288 (.065)***	−.009 (.004)*	−.013 (.006)*
Age	.036 (.011)***	.048 (.005)***	−.000 (.002)	−.073 (.010)***	−.038 (.005)***	−.062 (.020)**	−.002 (.001)**	−.005 (.001)***
Male	−.914 (.117)***	−.166 (.048)***	.112 (.021)***	.593 (.090)***	.032 (.038)	.267 (.065)***	.312 (.073)***	.173 (.064)**
Black	−.590 (.123)***	−.298 (.051)***	.119 (.022)***	−.500 (.113)***	−.165 (.052)***	−.067 (.074)	−.502 (.075)***	−.379 (.076)***
Hispanic	.305 (.113)**	−.113 (.050)*	.007 (.022)	.055 (.124)	−.126 (.054)*	.060 (.072)	−.143 (.083)†	−.170 (.085)*
Parental SES	.007 (.004)†	−.001 (.002)	−.000 (.001)	−.001 (.004)	−.002 (.001)	−.005 (.002*	−.002 (.003)	−.002 (.002)
Household Composition	−.028 (.014)*	−.005 (.006)	.004 (.003)	−.005 (.012)	.008 (.007)	−.041 (.017)*	−.000 (.001)	.006 (.002)***
Residential Mobility	−.025 (.026)	.002 (.012)	.001 (.006)	.005 (.024)	.106 (.016)***	.034 (.005)***	−.008 (.002)**	.019 (.004)***
Biological Parents Married	.043 (.109)	.054 (.050)	.001 (.024)	.109 (.125)	.013 (.053)	.123 (.068)†	−.064 (.077)	−.061 (.087)
Impulse Control	.200 (.032)***	.022 (.014)	−.086 (.006)***	−.376 (.029)***	−.152 (.015)***	−.434 (.035)***	.009 (.002)***	−.027 (.004)***
IQ	−.012 (.004)**	.002 (.001)	.000 (.001)	.010 (.003)**	.000 (.001)	.007 (.002)***	.001 (.002)	−.004 (.002)†
Street Time	.487 (.178)**	.031 (.073)	−.113 (.034)***	−.089 (.156)	−.350 (.108)***	−.413 (.096)***	.000 (.014)	−.031 (.028)

NOTES: N × T = 7,778. Pref. = preference; SES = socioeconomic status.

***p < .001; **p < .01; *p <.05; †p < .10 (two-tailed).

neighborhoods. Two important patterns emerge from these results. First, perceptions of neighborhood disorder and legitimate opportunities for advancement in one's neighborhood are associated with estimated latent preferences in the expected manner. Heightened perceptions of neighborhood disorder are associated with a greater tolerance for both the risks and the costs associated with crime (e.g., Model 5: $b = .103$, SE $= .023$, $p < .001$; Model 6: $b = .202$, SE $= .050$, $p < .001$). Additionally, perceptions of legitimate opportunities for success are inversely related to tolerance for arrest risk (model 5: $b = -.070$, SE $= .024$, $p < .001$) and key social costs of crime (model 6: $b = -.288$, SE $= .065$, $p < .001$). These patterns suggest that when individuals perceive more opportunities for success, they are more apt to be deterred by threats of arrest and the informal consequences attached to crime. With respect to latent preferences for the rewards to crime, the results show that perceived neighborhood disorder is positively related to preferences for both social (model 7: $b = .030$, SE $= .003$, $p < .001$) and intrinsic (model 8: $b = .020$, SE $= .005$, $p < .001$) rewards associated with crime. This finding suggests that individuals who perceive greater levels of social and physical disorder place greater weight on the anticipated social rewards from crime when choosing to offend (or not). Perceived access to legitimate opportunities is negatively related to preferences for social rewards (e.g., model 7: $b = -.009$, SE $= .004$, $p < .05$), suggesting that individuals who perceive greater avenues for legitimate success are less influenced by the anticipated social rewards to crime. We similarly see that perceived access to legitimate opportunities is negatively related to intrinsic reward preferences (model 8: $b = -.013$, SE $= .006$, $p < .05$).

Second, we find no evidence that concentrated neighborhood disadvantage exhibits a significant direct relationship with individuals' preferences associated with crime in a manner consistent with our predictions. The significant positive relationship between concentrated disadvantage and preferences for intrinsic rewards observed earlier (see model 4) is attenuated and is no longer statistically significant after controlling for perceived disorder and perceived opportunities. Furthermore, after accounting for perceived neighborhood conditions, the results in table 4 reveal one counterintuitive pattern that diverges from the expectations we derived from the theoretical literature. Specifically, drawing insights from theories of concentrated disadvantage and subcultural adaptation (e.g., Miller, 1958; Sullivan, 1989), we expected individuals from disadvantaged neighborhoods to exhibit greater tolerance for social costs associated with crime. In contrast to this expectation, model 6 indicates that concentrated neighborhood disadvantage exhibits a significant *negative* association with tolerance for social costs ($b = -.149$, SE $= .040$, $p < .001$) after controlling for perceived neighborhood disorder and perceived access to legitimate opportunities, suggesting that individuals from disadvantaged neighborhoods have a *lower* tolerance for crime-related social costs (e.g., losing respect from others). Although speculative, this may reflect the importance of maintaining a highly respected status within disadvantaged neighborhoods, which has been identified as a key ingredient for avoiding physical harm (Anderson, 1999).

6.2 | Indirect Effects of Concentrated Disadvantage Through Perceived Neighborhood Characteristics

We noted earlier that, because expectations of and preferences for the risks, costs, and rewards of crime are formed subjectively, concentrated disadvantage may affect these choice inputs indirectly by shaping perceptions of disorder and access to legitimate opportunities. In other words, living in a neighborhood with high levels of concentrated disadvantage may lower the perceived formal

and informal costs individuals associate with crime, in part, because living in such a neighborhood tends to foster high levels of perceived disorder and to promote beliefs that there are limited legitimate opportunities for advancement. Some of the patterns observed in tables 3 and 4 align with this prediction, but to assess it more formally, we estimated the indirect effects of concentrated disadvantage on our choice outcomes through perceived neighborhood disorder and access to legitimate opportunities using a generalized structural equation model with random effects. We report these indirect effects in table 5.

The mediation results suggest that concentrated neighborhood disadvantage exerts the theoretically expected statistically significant indirect effects on all four indicators of subjective expectations associated with crime (panel B, models 1–4). Furthermore, when compared with the total effects reported in table 3, the decomposition reveals that the total effects of concentrated disadvantage on perceived arrest risk and anticipated social rewards are nearly entirely attributable to its indirect effects through perceived disorder and access to legitimate opportunities. Another noteworthy finding is that the surprising negative relationship observed in table 4 between concentrated neighborhood disadvantage and the intrinsic rewards associated with crime masks a positive indirect effect, which conforms to theoretical expectations (panel B, model 4). Overall, we find support for arguments that concentrated disadvantage reduces the subjective risks and costs of crime and increases the associated rewards of crime indirectly by increasing perceptions of limited opportunities and perceived disorder within one's neighborhood.

Regarding latent preferences, the primary story that emerges from our analysis is that they are not strongly influenced by differential exposure to concentrated neighborhood disadvantage, at least directly (see panel A, models 5–8). Nonetheless, concentrated disadvantage does exhibit significant indirect relationships with latent preferences, which arise in our analysis through perceived neighborhood disorder and access to legitimate opportunities (panel A, models 5–8). We observe significant positive indirect relationships between concentrated disadvantage and all four preference outcomes, which is consistent with the theoretical expectations described earlier. These results suggest that respondents from neighborhoods with higher levels of socioeconomic disadvantage exhibit greater tolerance for risks and costs and place more value on the rewards associated with crime in part because exposure to disadvantaged neighborhood environments increases perceptions of disorder and limited opportunities.[15]

7 | DISCUSSION

Some scholars remain skeptical about the utility of rational choice for explaining criminal behavior in part because of the perspective's emphasis on cost–benefit analysis internal to the individual and, in turn, the seeming neglect of structural conditions widely believed to be influential in promoting crime (Cullen, 2017). Becker's (1968) own dismissal of theories focused on social structure or individual differences in favor of pure individual choice undoubtedly contributed to such

[15] It is possible that the effects are driven not by the neighborhood environment but also by the lack of a stable environment. To assess this we restricted our analyses to individuals who never moved during each recall period. The results are consistent with the main analyses: Concentrated disadvantage predicts subjective expectations, but these effects are reduced to zero once perceptual measures are included. For preferences, concentrated disadvantage has no direct effects, but instead it operates indirectly through perceptual neighborhood factors. These results are present in the online supporting information in tables S4, S5, and S6.

TABLE 5 Direct and Indirect effects of neighborhood variables on subjective expectations and preferences ($N = 1,240$)

Variables	Arrest Risk Model 1	Anticipated Social Costs Model 2	Anticipated Social Rewards Model 3	Perceived Intrinsic Rewards Model 4	Risk Tolerance Model 5	Cost Tolerance Model 6	Social Reward Preferences Model 7	Intrinsic Reward Preferences Model 8
Panel A. Estimated Direct Effect of Concentrated Disadvantage								
Concentrated Disadvantage	−.005 (.038)	−.041 (.016)*	.003 (.009)	−.119 (.034)***	−.031 (.018)†	−.150 (.012)***	.000 (.003)	.006 (.005)
Panel B. Estimated Indirect Effects of Concentrated Disadvantage								
Total Indirect Effects of Concentrated Disadvantage	−.128 (.014)***	−.008 (.005)†	.024 (.003)***	.051 (.012)***	.038 (.007)***	.119 (.019)***	.001 (.0009)†	.008 (.002)***
Through Perceived Neighborhood Disorder	−.105 (.014)***	−.001 (.006)	.011 (.003)**	.036 (.012)***	.031 (.007)***	.080 (.020)***	.000 (.001)	.006 (.002)***
Through Perceived Access to Legitimate Opportunities	−.023 (.010)***	−.007 (.003)**	.013 (.002)***	.015 (.005)***	.007 (.003)*	.039 (.010)***	.001 (.0003)***	.002 (.001)*

Note: N × $T = 7,778$.

***$p < .001$; **$p < .01$; *$p < .05$; †$p < .10$ (two-tailed).

skepticism. Additionally, subsequent applications of rational choice theories to criminal behavior have remained focused on factors internal to an individual (i.e., their utility function) and have developed separately from, and often without reference to, theories that focus on structural factors associated with criminal activity (Matsueda, 2013). This parochialism has kept alive an unfortunate historical caricature offered many years ago by the economist James Duesenberry (1960, p. 233): "[E]conomics is all about how people make choices; sociology is all about why people don't have any choices to make."

We argue that this separation is both false and unnecessary. As McCarthy (2002, p. 423) noted, there is "a considerable conceptual overlap between the rational choice approach and more sociological theories of offending," and as Matsueda (2013, p. 285) asserted, "[R]ational choice principles offer a parsimonious microfoundation for macrosociological concepts and causal mechanisms." Against this backdrop, the present study considered whether theoretically prominent community structural conditions are associated with two key elements of a rational choice calculus: 1) subjective perceptions of risks, costs, and rewards to criminal involvement; and 2) the preferences, or relative weights, individuals attach to these subjective beliefs. Our results suggest that levels of concentrated disadvantage in subjects' block-groups is associated with lower perceptions of arrest risk and social costs associated with crime, and higher levels of anticipated social rewards from offending. These associations, however, operate through individuals' perceptions of neighborhood disorder and access to legitimate opportunities. We also observed that the subjective assessments of neighborhoods were predictive of preferences associated with crime in a manner that was consistent with our predictions: Individuals who perceive higher levels of disorder and limited access to legitimate avenues of success are, on average, more tolerant of the risks and costs associated with crime and place greater weight on the social and intrinsic rewards that go along with offending.

Our findings are consistent with evidence that perceptions are the result of a rational, Bayesian updating process in which individuals form and revise subjective beliefs in accordance with new information (Matsueda et al., 2006). Although most of the prior studies on this topic have focused on what economists would label "private information," such as personal and vicarious arrest and arrest avoidance (Anwar & Loughran, 2011; Lochner, 2007; Matsuda et al., 2006), our findings suggest that these perceptions also may be influenced by signals from the community (i.e., public information). This speaks to an important question about the role of objective information in the correspondence with individual perceptions of the criminal justice system (Kleck et al., 2005). Our findings also suggest that objective information in the form of concentrated disadvantage operates indirectly through individuals' subjective perceptions about the neighborhood, specifically neighborhood disorder and perceived opportunities for success, and as such, it implicates and reinforces the role of subjective, as opposed to objective, measures, in the process of belief formation (Sampson & Raudenbush, 1999). We advance this as a fruitful future research topic, notably the joint role of objective and perceived environment, along with individual experiences, in the process of subjective belief formation and updating.

That there was limited evidence that objective concentrated disadvantage directly influenced the preferences associated with crime reinforces the important distinction between expectations and preferences and highlights the complexity of the latter's formation. To be sure, risk of arrest, informal social consequences, and potential social rewards are all tied, to some extent, to an "objective" reality that can be communicated to individuals and thus influence perceptions. Preferences, on the other hand, are more idiosyncratic and can be influenced by a host of interrelated factors such as value orientations, cultural adaptations, personality characteristics, and perceived choice sets. The point is that these factors, compared with expectations, are less grounded in

an "objective" reality, and more likely, they are to be tied to an individual's own socialization, experiences, cognitions, and tastes. This is not to say that community structural factors have no influence on preference development—indeed, we found that perceived neighborhood factors that are strongly predicted by concentrated disadvantage have a strong impact on preferences—just that the influence that structure has on preferences is likely to be more individualistic since preferences are less tied to objective information. We believe that this may explain the finding that concentrated disadvantage is negatively related to expectations of intrinsic rewards in our full specification, which incorporated perceived neighborhood disorder and access to legitimate opportunities. Although we believe that there is an important distinction between perceptions of excitement and preferences for excitement, intrinsic rewards are unlike the other expectations in that they are also less grounded in reality (like preferences) and more likely to develop in an idiosyncratic fashion.

As scholars move forward in assessing both perception and preference formation, we believe that it is imperative to take seriously the role of community social structure in this process. Most prior work examining perception formation has almost exclusively assessed perceptions of arrest risk, and this has limited its focus to the factors internal to an individual, such as arrest, arrest avoidance, and vicarious experiences (Anwar & Loughran, 2011; Stafford & Warr, 1993). Similarly, the extant work assessing factors related to preferences for the risks and rewards associated with crime has tended to center on micro-level factors, such as self-control, impulsivity, and IQ (see Piquero et al., 2011). Our findings highlight the importance of larger community structural conditions—net of individual personality characteristics—in both perception and preference development and thus answers calls to emphasize the role of social structure in understanding individual choices to engage in criminal behavior (Matsueda, 2013).

On this point, our results are supportive of a multilevel rational choice framework first proposed by Coleman (1990) and specifically applied to the study of crime by Matsueda (2013). We also emphasize that the findings are congruent with elaborations of Becker's (1968) original model offered and tested by doctrinaire economists, such as Ehrlich (1973), Myers (1984), and Grogger (1998). For instance, these models imply that crime, as described by an individual's utility function, is a function of legal market wage, which is itself necessarily a function of opportunity structure. In other words, individuals' choice sets are constrained by both environment and perceived opportunities that arise from the environment. This interpretation argues for the importance of an illegal reservation price for criminal involvement, which should be strictly lower for those individuals with limited legal opportunities or, more accurately, perceptions thereof. As such, we strongly encourage the development of studies elaborating the determinants of illegal reservation wages, similar to the rich analog literature of legal reservation wages informing the study of job search behavior (e.g., Cox & Oaxaca, 1992).

Future work also should examine the mechanisms that may mediate the influence of community structural disadvantage on subjective expectations and preferences conducive to offending. The purpose of this study was to establish the initial necessary link between community structural factors and rational choice inputs, but we speculated about potential intervening mechanisms for each of our outcomes of interest including, for example, differences in personal and vicarious experiences with arrest, exposure to delinquent associates, and exposure to prosocial value orientations. For example, it would be valuable for future research to assess how neighborhood disadvantage influences one's exposures to others who engage in criminal activity and, in turn, how this may impact perceptions of social rewards. Another potential for future work is to examine how neighborhood characteristics relate to one's arrest "signal" (number of arrests per number of crimes committed [Anwar & Loughran, 2011]) and how such differential signals in

turn impact perceptions of arrest risk. Indeed, we believe that illuminating the intervening mechanisms that link structural characteristics to perceptions of, and preferences for, the risks, costs, and rewards associated with crime has the potential to provide insight into both micro- and macro-level processes associated with offending.

Our study is not without limitations that open up additional avenues for future research. First, because our sample is restricted to adjudicated juvenile delinquents in Philadelphia and Phoenix, it is not representative of all youth and young adults. The Pathways data used for our study represents the only current source that incorporates items capturing neighborhood characteristics, as well as information about individual perceptions of the risks, informal social costs, and social and intrinsic rewards of crime. We believe that the use of the Pathways high-risk offending sample is informative, particularly for empirical tests of rational choice models (see Loughran et al., 2016). Extant research findings have also shown that the many rational choice inputs operate similarly in the Pathways data as they do in other, more representative samples (Lochner, 2007; Matsueda et al., 2006; Piliavin et al., 1986). For these reasons, we believe the current study—and the data employed—offer an important and informative initial test of a multilevel rational choice model of offending. Nevertheless, we recognize the value of formally testing the model offered here with a sample that is more representative of the general population, and we encourage future data collection that will facilitate such research.

Second, although we have emphasized the impact of concentrated neighborhood disadvantage, which is a central structural community-level construct in sociological and criminological studies of crime, many other "community factors" may be germane to shaping subjective expectations and preference that could not be included in our study. For example, deterrence theory identifies a prominent role of objective criminal justice policies and practices that often vary across communities (e.g., police deployment patterns, differing policing strategies, variability in the probability of detection, and differences in the severity of punishments) and may be important for influencing perceptions of arrest risk (Chalfin & McCrary, 2017; Zimring & Hawkins, 1973). Communities may also exhibit different cultural norms about the social costs and rewards associated with crime (e.g., Anderson, 1999; Berg et al., 2013). Furthermore, other characteristics such as neighborhood collective efficacy—even if not influencing perceptions and preferences directly—are likely to play a role in the extent to which proclivity for crime translates into criminal acts (Sampson et al., 1997). This ultimately speaks to neighborhood differences in the *situational opportunity to offend*, a concept that is independent of perception and preference formation but is nonetheless inherent in some rational choice models of crime (Paternoster, 1989). That is, the choice inputs modeled as outcomes here likely interact with situational opportunity to translate into acts of crime. It would be valuable for future studies to build on our analysis by considering these and other dimensions of community context that may shape subjective expectations, preferences, and behavior more generally.

Finally, we recognize the thorny issue of selection into neighborhoods. The models in our study reveal important *associations* between neighborhood characteristics and subjective expectations and preferences, but we caution against any *causal* interpretations of our findings as a result of potential concerns of selection bias. This issue is not unique to the present study as concerns over selection bias plague researchers seeking to examine neighborhood effects on individual outcomes. We believe that active selection into neighborhoods on the part of respondents is less of a concern given the predominately adolescent nature of our sample. We also attempted to account for some selection on observables by controlling for factors that likely impact neighborhood residence, including parental SES, whether one's biological parents are married, and residential mobility. Still, isolating the effects are difficult because of issues of simultaneity bias (see Lei et al.,

2019; Robbins et al., 2020). As such, we advocate for future work by researchers interested in gaining causal identification to seek to exploit exogenous shifts in location through the use of natural experiments or instrumental variable methods (Kirk, 2012).

In conclusion, choice and structure are not competing forces but complementary aspects of larger processes of social action (Hechter & Kanazawa, 1997; McCarthy, 2002). Our findings are consistent with work from a range of theorists highlighting the compatibility of choice theories of action at the individual level and macro-level theories emphasizing the importance of structural contexts and social environments (Coleman, 1990; see also Baumer & Arnio, 2016). We believe that it addresses the calls by those who expressly advocate for the broader inclusion of individual, micro-level choice theory into the study of crime (Nagin, 2007), those who have stressed the importance of accounting for macro-level factors that shape and constrain an individual's choice sets (Matsueda, 2006, 2013, 2017), and those who have called for more concerted efforts that link social structure and individual behaviors (Sampson, 2012). Our analysis suggests that an individual's choice set itself can be thought of as an individual difference that is attributable, in part, to community structural factors. In this manner, we argue that rational choice theories in fact can be thought of as highly compatible with sociological theories of crime that stress the role of external factors in the etiology of criminal behavior.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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