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Identifying psychological pathways to polyvictimization: evidence from a longitudinal cohort study of twins from the UK

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Abstract

Objectives Examine the extent to which cognitive/psychological characteristics predict later polyvictimization. We employ a twin-based design that allows us to test the social neurocriminology hypothesis that environmental factors influence brain-based characteristics and influence behaviors like victimization.
Methods Using data from the Environmental Risk Longitudinal Twin Study (N = 1986), we capitalize on the natural experiment embedded in a discordant-twin design that allows for the adjustment of family environments and genetic factors.
Results The findings indicate that self-control, as well as symptoms of conduct disorder and anxiety, are related to polyvictimization even after adjusting for family environments and partially adjusting for genetic influences. After fully adjusting for genetic factors, only self-control was a statistically significant predictor of polyvictimization.
Conclusion The findings suggest polyvictimization is influenced by cognitive/psychological characteristics that individuals carry with them across contexts. Policies aimed at reducing victimization risks should consider interventions that address cognitive functioning and mental health.

Keywords Polyvictimization · Social neurocriminology · Discordant-twin design · Self-control · Natural experiment

Statement of Pre-registration
The premise and analysis plan for this project was pre-registered on https://sites.google.com/site/dunedineriskconceptpapers/documents. Analyses reported here were checked for reproducibility by an independent data analyst who recreated the code by working from the manuscript and applied it to a fresh dataset.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11292-020-09422-1) contains supplementary material, which is available to authorized users.

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Introduction

Victimization experiences are not randomly distributed among members of society (see Finkelhor et al. 2011a). Research has repeatedly shown that certain individuals tend to experience victimization more often than others, which has prompted victimologists to analyze the causes and consequences of victimization clustering. Among the many important findings flowing from this body of research is the revelation that a portion of victims are at an elevated risk of becoming "polyvictims," a term used to describe individuals who experience "…multiple victimizations of *different kinds*… not just multiple episodes of the same kind of victimization" (emphasis in original; Turner et al. 2017, p. 756). In other words, polyvictimization denotes a certain cross-context vulnerability. Moreover, polyvictims present with mental health problems (Schaefer et al. 2018), risk of self-harm (Baldwin, 2019), substance abuse problems (Wright et al. 2013), other forms of adversity (e.g., serious illness, accident; Finkelhor et al. 2009a), and delinquent peer involvement (Ford et al. 2010) at rates that exceed those in the general population. All of these points emphasize the importance of studying polyvictimization and its antecedent risks.

The very presence of polyvictims poses theoretical and methodological challenges to traditional theories of victimization. For example, context and place-based theories (e.g., Cohen and Felson 1979) offer inadequate explanations given that polyvictims carry higher-than-normal risks of victimization *across* contexts and places (see Finkelhor and Asdigian 1996). This has inspired researchers to approach the study of polyvictimization in a way that differs from the more traditional study of victimization. Some, for instance, have taken a public health perspective that conceptualizes polyvictimization as if it were a syndrome needing intervention. Finkelhor et al. (2007) wrote that, "for some children, victimization is more of a 'condition' than an 'event'" (p. 9). And in 2009, Finkelhor and colleagues identified four distinct pathways to polyvictimization: (1) residing in a dangerous neighborhood, (2) living in a dangerous family, (3) living in a chaotic/multiproblem family, and (4) possessing emotional or psychological symptoms (also see Finkelhor et al. 2011a). Although there are many studies that can speak to the first three pathways of polyvictimization risk (e.g., Lauritsen 2003; Baldry 2003), relatively few studies have attempted to isolate the impact of the fourth pathway—the effect of emotional and psychological factors—on polyvictimization risk.

This focus coincides with the social neurocriminology perspective (Choy et al. 2015; Choy et al. 2017) of crime causation, wherein socio-environmental factors affect the development/function of brain-based biological factors that then increase the likelihood of later crime and delinquency. Applying the social neurocriminology perspective to the study of polyvictimization gives us reason to hypothesize that early environmental insults experienced during development give rise to brain-based risk factors (e.g., low cognitive ability, psychological symptoms; see Chen et al., 2016) that then increase the risk of later polyvictimization (Danese et al., 2017). Indeed, brain-based risk factors may be especially salient when discussing polyvictimization, specifically, because they represent a class of risk factors that are carried with the individual across all contexts and they likely exert a consistent influence on social interactions. While not discounting the role of underlying personal characteristics like genetic factors (e.g., Danese et al., 2017),

social neurocriminology proposes a causal chain from environment (e.g., developmental insults) to brain (e.g., low cognitive abilities, psychological symptoms) to behavior, giving Finkelhor and colleagues' (2009b) fourth pathway to polyvictimization firm theoretical grounding.

Yet, many studies attempting to examine this pathway have noted the difficulty in disentangling the effects of the individual-level factors from the neighborhood- and family-level risk factors (see Schaefer et al. 2018 for a discussion). What is needed, then, is a methodological approach that can hold constant the effects of neighborhood and familial risks so that the impact of emotional and psychological factors on polyvictimization risk can be properly identified. The current study will address this research need by drawing on the natural experiment of twin pairs—pairs of individuals that share their environment and much (or all, in the case of identical twins) of their genetic endowment. Doing so will allow us to control for all common environmental and familial influences when estimating the impact of cognitive and psychological risk factors on polyvictimization risk, leaving only the non-shared environmental influences as potential confounders.

Our data come from the Environmental Risk Longitudinal Twin (E-Risk) Study, which is a contemporary UK-based panel study of 2232 same-sex twins. The E-Risk study captures detailed information on a variety of victimization experiences in childhood through early adulthood. Additionally, the E-Risk Study has an extensive battery of measures of cognitive and psychological characteristics assessed in repeated clinical interviews, eight of which we examine for associations with polyvictimization (the selection of these characteristics is motivated in the next section). These features of the E-Risk Study afford us the opportunity to estimate the effects of a number of cognitive and psychological characteristics on later polyvictimization risk, while simultaneously holding constant the impact of familial and neighborhood factors. But before we turn to the analysis, we provide more detail about hypothesized pathways to polyvictimization and we briefly review prior work that has bearing on the cognitive and psychological factors that will be the focus of this study.

Pathways to polyvictimization

The first three pathways identified by Finkelhor and colleagues (2009b) resonate with the previous literature on routine-activities theory (Cohen and Felson 1979) and other environmental perspectives (e.g., discrete choice model; Bernasco and Block 2009) that suggest proximity to offenders is a key contributor to increasing one's risk of eventual victimization (Lauritsen 2003). Additionally, the second pathway (i.e., living in a dangerous family) captures potential developmental processes wherein traumatic experiences in the home translate into behavior outside of the home that increases a child's risk for victimization (Baldry 2003; Shields and Cicchetti 2001). And the third pathway (i.e., living in a multiproblem family) draws support from the parenting literature that finds negative outcomes for children who spend unsupervised time away from home in order to avoid a tumultuous home life (e.g., Esbensen et al. 1999).

The fourth pathway to polyvictimization—which is the primary focus for the present study—suggests that psychological factors may also play a role. Psychological symptoms can be expressed in a number of ways that may increase a person's risks of

experiencing victimization (Finkelhor 2008). Problematic behavioral styles that stem from psychological issues often engender antagonism in other youths (i.e., instigation; e.g., Perry et al. 2001) and leave the affected youth isolated and susceptible to bullying (i.e., selection; e.g., Bowes et al. 2009; Delfabbro et al. 2006). Additionally, possessing behavioral problems may cause peers and other individuals to view affected youths as less capable of defending themselves (i.e., [lack of] protection; e.g., Perry et al. 2001). The combination of easy antagonism, isolation from peers, and a high level of perceived vulnerability could make the individual a target for victimization irrespective of context (see also Turner et al. 2010a).

What should also be considered at this point is the evidence gleaned from a growing body of quantitative genetic studies examining victimization outcomes. Using data from a large national sample, both Beaver et al. (2009) and Boutwell et al. (2013) found that variation in victimization experiences was moderately heritable. In a more recent study, Beckley et al. (2018) reported convergent findings by analyzing data included in the current sample. One interpretation of this is that genetic variation partly produces variation in key psychological phenotypes, which then by extension can increase the risk of being victimized. Indeed, Boutwell et al. (2013) report evidence of such an effect, demonstrating that self-control predicted victimization, even after genetic influences were held constant using twin-based analyses (similarly, see Boutwell et al. 2017).

Despite the evidence mentioned above, comparatively little research has focused on the role of psychological factors in the etiology of polyvictimization. Among those studies that have, most suffer from two major limitations. The first limitation is an inability to control for the confounding influences of the first three pathways (i.e., neighborhood and familial risks). This is an important concern because factors at different levels (e.g., individual-, family-, and neighborhood-levels) are known to be associated with polyvictimization risk, meaning the various pathways are highly comorbid (see Aneshensel and Sucoff 1996; Moffitt and the E-Risk Team 2002; Repetti et al. 2002). In order to isolate and identify the effects of one pathway, it is necessary to adjust for the influences of the other three.

The second limitation is an inability to rule out reverse causality (i.e., that victimization causes psychological distress and not the reverse). Most of the research on the topic has examined psychological symptoms as an outcome, instead of a predictor, of polyvictimization (e.g., Finkelhor et al. 2009a; Soler et al. 2013; Turner et al. 2013; but see Turner et al. 2010a; and Schaefer et al. 2018). Contributing to this lack of focus on psychological symptoms as predictors is the fact that most research on polyvictimization is cross-sectional (e.g., Adams et al. 2016; Chan 2013; Ford et al. 2010; Pereda et al. 2014; Soler et al. 2013; Turner et al. 2010b; Turner et al. 2013). Importantly, Danese and colleagues (2017) made progress toward confirming the fourth pathway by clearly demonstrating the link between early cognitive deficits and later polyvictimization in two longitudinal cohorts (including the E-Risk). The current study extends that work to examine other cognitive and psychological factors as predictors of polyvictimization.

The current study will address these two limitations by leveraging several unique aspects of the E-Risk study. To address the first limitation (confounding), we use a discordant-twin design. The discordant-twin model is able to adjust for familial confounds that are common/shared between twins in the same family (e.g., genetic factors and home environments), allowing only the factors on which they differ to serve as predictors of differences in the outcome of interest.

The discordant-twin design can be thought of as a natural experimental design that can be expressed like a propensity score matching (PSM) analysis. In a PSM framework, individuals are matched on observed characteristics, leaving only the predictor of interest unmatched. In so doing, PSM creates a counterfactual scenario wherein a pair of "treated" and "untreated" cases are created, leaving only the discordance between them to predict the outcome of interest. In the language of PSM, we can think of discordant twins as two participants who have been perfectly matched on observed *and* unobserved factors that are shared between twins. As is shown in Fig. 1, twins are matched on genetic factors (when restricted to MZ twins), the early rearing environment, the school environment, and many other factors that might go overlooked were we restricted to matching on observables (Pingault et al. 2018). By leveraging the power of the discordant-twin design, we move closer to testing the true causal impact of individual differences in cognitive/psychological characteristics on polyvictimization (i.e., Finkelhor and colleagues' [2009] fourth pathway to polyvictimization), by adjusting for many of the factors that might confound that association.

In order to address the second limitation from prior research (reverse causation), we will leverage the longitudinal information available in the E-Risk data. Data are available on victimization and cognitive/psychological characteristics going back to age 5, which provides the ability to estimate the role of cognitive/psychological characteristics on future polyvictimization experiences after taking into account prior victimization experiences.

Having established Finkelhor and colleagues' (2009) fourth pathway to polyvictimization as a promising, but under-studied, area of victimization research, we now turn to the specific cognitive/psychological mechanisms that may be implicated in that pathway. Though a small number of studies have examined the role of emotional/psychological problems in polyvictimization risk, those studies have largely relied on a limited number of symptoms assessed in non-clinical interviews with the use of psychological screeners (e.g., the Trauma Symptom Checklist for Children used by Turner et al. 2010a; but see Danese et al., 2017; and Ford et al. 2010). In contrast, the current study will analyze a large number of cognitive and psychological characteristics that were assessed in clinical interviews across multiple phases of data collection.

Cognitive and psychological characteristics and polyvictimization risk

The ability of individuals to perceive, anticipate, and avoid personal victimization before it occurs may be a key protective factor for polyvictimization. However, certain levels of brain-based cognitive and psychological characteristics can

	DZ Twins		MZ Twins	
	Twin 1	Twin 2	Twin 1	Twin 2
Shared	Family Environment Genetic material (~50%)		Family Environment Genetic material (100%)	
Non-shared	Unique Environment	Unique Environment	Unique Environment	Unique Environment

Fig. 1 Shared (systematic) and non-shared (stochastic) sources of variation across twin types. *Note*: DZ = dizygotic, MZ = monozygotic

impede an individual's ability to respond to signals of risk in social environments—and in some cases, even precipitate the risk (e.g., Finkelhor 2008). The social neurocriminology perspective posits that brain-based factors are crucial mediators in the causal chain beginning with environment and leading to detrimental behavior (Choy et al. 2015; Choy et al. 2017). Thus, the current study integrates these perspectives to gain insight into the possible cognitive and psychological contributors to polyvictimization risk. As such, we consider how (1) cognitive and (2) psychological factors might affect polyvictimization risk.

Cognitive factors

Of all the possible indicators of cognitive function, intelligence has been the factor most often investigated in connection with offending (e.g., Bartels et al. 2010; Beaver and Wright 2011; Ellis and Walsh 2003; Hirschi and Hindelang 1977; Moffitt et al. 1995), and some research has linked intelligence with victimization risk (e.g., Beaver et al. 2016; Boutwell et al. 2017; Danese et al., 2017). But a less obvious aspect of cognitive function for research in this area involves a trait known as theory of mind (ToM). ToM is an ability that emerges early in the life course and encompasses a range of social skills necessary for navigating human interactions (Hughes et al. 2005). Among various tasks, ToM modulates the ability to recognize that other people have motivations and intentions that are their own, and that these may differ from your motivations and intentions. Thus, ToM involves attributing agency to others.

This becomes relevant to the current study in two respects. First, in order for someone to best read the intentions of another person, and thereby correctly anticipate their behavior, ToM capabilities become crucial. Assuming other parties have agency, and that their desires and goals may run counter to your own, is generally useful in both predicting how others will behave and navigating social life efficiently. Second, incorrectly reading the intentions of conspecifics—whether that includes peers at school, family members in the home, or strangers—can elevate risk in a variety of ways. Failure to correctly perceive even subtle cues that someone around you intends to harm you, or is actively harming you, could impede the ability to avoid the types of situations and people already known to increase victimization likelihood.

Self-control has also received attention from researchers studying victimization (Beckley et al. 2018; Boutwell et al. 2013; Jennings et al. 2012; Pratt et al. 2014; Schreck 1999). Variation in self-control is associated with variation in "crime and analogous behaviors" (Gottfredson and Hirschi 1990; see Pratt and Cullen 2000), and, as an outgrowth of the work being done on self-control, Schreck (1999) suggested it might also affect victimization risk. The logic of such a relationship was straightforward in that individuals lacking in the ability to regulate impulsive and risky behaviors may be more likely to encounter situations in which they interact with crime prone individuals and thus, increase their own risk for victimization. To date, research on the topic has consistently shown that as self-control declines, the risk of victimization increases (Pratt et al. 2014).

Intelligence, ToM, and self-control represent important and unique dimensions of cognitive function. Deficits in any one of these areas may have downstream consequences that lead individuals to inaccurately judge dangerous situations, fail to ascribe ill intentions to other individuals, or fail to restrain themselves from getting involved in risky situations. Put a different way, there are various mechanistic pathways that might link intelligence, ToM, and/or self-control to polyvictimization risk.

Psychological factors

Symptoms of psychological disorders may predispose the individual to bullying and other forms of victimization. Attention-deficit/hyperactivity disorder (ADHD), for example, presents with a range of impairments related to attention control, gratification delay, and impulse regulation (Thapar et al. 2001). Not unlike self-control, then, ADHD symptoms may increase the odds of various kinds of victimization outcomes like bullying (Stern et al. 2018). One might also expand the scope even further to consider other conditions often comorbid with ADHD, such as conduct disorder (Thapar et al. 2001). Conduct disorder is comprised of a range of early onset, and often severe, behavioral difficulties. These behavioral difficulties might act to further increase risk propensity, thereby increasing the odds of victimization and perhaps even polyvictimization experiences.

Another line of research has examined the role of internalizing disorders and victimization risk. Depression, for example, has been examined as both a contributor to and a consequence of victimization (Seals and Young 2003; Swearer et al. 2001; Sweeting et al. 2006). And considering their high degree of comorbidity, similar results to those for depression have been found for the association between anxiety and victimization (e.g., Grills and Ollendick 2002; Swearer et al. 2001).

Though rare among members of the general population, individuals who experience psychosis may be at greater risk of victimization (Raine et al. 2011). Early psychotic symptoms (i.e., delusions and hallucinations) have been demonstrated to be associated with the development of schizophreniform disorders later in adulthood (Fisher et al. 2013; Poulton et al. 2000). Because psychosis distorts the individual's perception of reality, those who experience it may be at higher risk of victimization through a number of mechanisms. Yet, the majority of research on the psychosis-victimization relationship has focused on a one-way association, wherein psychosis-like symptoms are believed to be the result of prior victimization (e.g., Arseneault et al., 2011; Campbell and Morrison 2007; Lataster et al. 2006; Mackie et al. 2011). Though a few studies have observed a bi-directional relationship between psychosis and traumatic events (e.g., Kelleher et al. 2013), most studies have been unable to explore the potential for the reverse relationship, wherein psychosis-like symptoms predispose individuals to victimization risk. One exception to this trend is a cross-sectional study in which it was found that peer victimization significantly mediated the association between early schizotypal personality and later aggression (Raine et al. 2011).

The current study aims to investigate what many previous studies have been unable to examine: the impact of psychological characteristics on later

polyvictimization experiences. By considering psychological symptoms to be potential precursors to polyvictimization and not simply one of its many outcomes, we hope to establish a more complete picture of the etiology of this phenomenon. Thus, we explore whether ADHD, conduct disorder, depression, anxiety, and psychosis are related to later-in-life polyvictimization experiences.

Methods

Data

We analyze data from the Environmental Risk (E-Risk) Longitudinal Twin Study, which is a longitudinal and nationally representative study that has tracked the development of a birth cohort of 2232 same-sex British twins who were sampled from a birth registry of twins born in England and Wales from 1994 through 1995 (Trouton et al. 2002). Full details of the E-Risk sample are described elsewhere (see Moffitt and E-Risk Study Team 2002). To briefly summarize, the sample was constructed in 1999 to 2000, when 1116 families (93% of those eligible) with same-sex 5-year-old twins participated in home-visit assessments. The full sample was evenly distributed across sex (49% male) and was comprised of 56% monozygotic (MZ; identical) and 44% dizygotic (DZ; fraternal) twin pairs. Families were recruited to represent the UK population of families with newborns in the 1990s, based on residential location throughout England and Wales and mother's age. Older mothers having twins via assisted reproduction were under-sampled to avoid an excess of well-educated older mothers, while teenage mothers with twins were over-sampled to ensure sufficient numbers of children growing up in high-risk environments, and to replace teen-mother families lost to the original register due to non-response.

These strategies ensured that the study sample was representative of the full range of socioeconomic conditions in the UK, as reflected in the families' distribution on a neighborhood socioeconomic index (A Classification of Residential Neighborhoods [ACORN], developed by CACI, Inc., for commercial use in Great Britain; Odgers et al. 2012).[1] E-Risk families' ACORN distribution closely matches that of households nationwide: 25.6% of E-Risk families live in "wealthy achiever" neighborhoods compared to 25.3% nationwide, 5.3 vs. 11.6% live in "urban prosperity" neighborhoods, 29.6 vs. 26.9% live in "comfortably off" neighborhoods, 13.4 vs. 13.9% live in "moderate means" neighborhoods, and 26.1 vs. 20.7% live in "hard-pressed" neighborhoods. It should be noted that the underrepresentation of "urban prosperity" in E-Risk is because such households are significantly more likely to be childless.

Follow-up home visits were conducted when the participants were aged 7 (98% participation), 10 (96%), 12 (96%), and 18 (93%). The home visits at ages 5, 7, 10, and 12 years included assessments with the participant as well as their mother (or primary

[1] ACORN uses census and other survey-based geodemographic discriminators to classify enumeration districts of approximately 150 households into socioeconomic groups. Such groups range from "wealthy achievers" with high incomes, large single-family houses, and access to many amenities, to "hard-pressed" neighborhoods dominated by government-subsidized housing estates, low incomes, high unemployment, and single parents. ACORN classifications were geocoded to match the location of each E-Risk study family's home (Odgers et al. 2012).

caretaker). Each twin participant was assessed by a different interviewer. With parent's permission, questionnaires were posted to the children's teachers. At age 18 years, 2066 participants were assessed. There were no differences between those who did and did not take part at age 18 in terms of socioeconomic status (SES) assessed when the cohort was initially defined ($\chi^2 = 0.86$, $P = 0.65$), age-5 intelligence scores ($t = 0.98$, $P = 0.33$), or age-5 externalizing behavioral ($t = 0.40$, $P = 0.69$) or internalizing emotional problems ($t = 0.41$, $P = 0.68$). Parents gave informed consent and twins gave assent between ages 5 and 12. Twins gave informed consent at age 18 years. Ethical approval for each phase of the study was granted by the Joint South London and Maudsley and the Institute of Psychiatry NHS Ethics Committee. After removing cases with missing values on our key variables, our final analytical sample was $n = 1986$ individuals (comprising 993 twin pairs).[2]

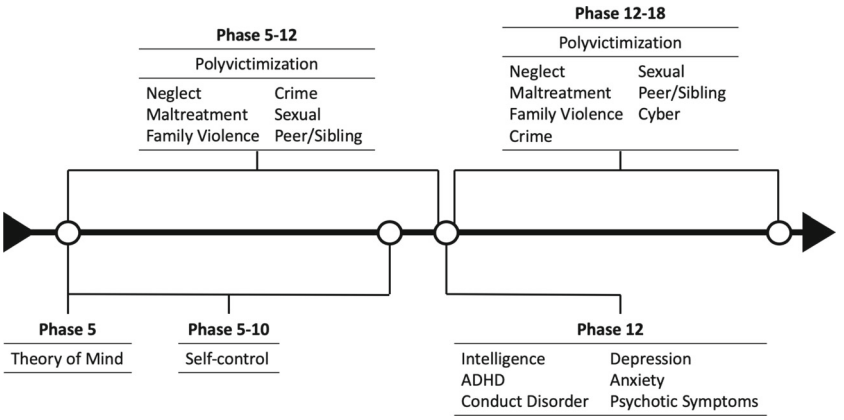
Measures

Polyvictimization Polyvictimization is defined as "multiple victimizations of *different kinds*" (Turner et al. 2017, p. 756); thus, we constructed our measure of *polyvictimization* by drawing on seven different victimization items. E-Risk participants took part in a clinical interview that probed their victimization experiences between the ages of 12 and 18 (see Fig. 2 for a description of the timing of key variables). The format of the interview was adapted (see Fisher et al. 2015) from the Juvenile Victimization Questionnaire 2nd Revision (JVQ-R2; Finkelhor et al. 2011b; Hamby et al. 2004) and assessed the participants' level of exposure to seven categories of victimization: crime victimization, maltreatment, neglect, family violence, sexual victimization, peer/sibling victimization, and cyber-victimization.

The severity of each form of victimization was rated using guidelines adapted from the manual for the Childhood Experience of Care and Abuse (CECA) interview schedule (Bifulco et al. 1994). Victimization severity was rated on a 3-point scale, wherein 0 indicated no victimization experiences, 1 indicated *probable* or *less severe* victimization,[3] and 2 indicated *definite* or *severe* victimization. *Polyvictimization* was computed by summing all victimization experiences that were rated as being 2 in severity, which resulted in a variety index of victimization types with scores that ranged from 0 to 5. Following Schaefer et al. (2018), this index was then winsorized to produce a four-category distribution where 0 = no severe victimization experiences (65.41% of the sample), 1 = one severe victimization experience (18.98%), 2 = two severe victimization experiences (9.21%), and 3 = three or more severe victimization

[2] A missing case analysis revealed that approximately 11% of the original families were missing data on one or more variables in the study. Closer examination revealed that 4% were missing phase 18 victimization values, 2% were missing phase 12 cognitive factor and psychological symptom values, and 2% were missing all values after phase 5. None of the remaining patterns of missing values comprised more than 1% of the sample. These patterns suggest that the majority of missingness in the sample was driven by sample attrition and not differential reporting. There was no substantive difference in reporting rates between MZ and DZ twins.

[3] Researchers cannot always get the precise facts from respondents about things like maltreatment and neglect, which are often kept secret by families. In the severity rating scale, "probable" means we had enough information to know that the child was not safe and something had happened (i.e., we could not code that child as "non-abused"), but we did not have the necessary details or evidence to firmly say that we knew what the abuse was (e.g., we could not code the child as "maltreated" as opposed to "neglected").



Note: ADHD=Attention-deficit/hyperactivity disorder

Fig. 2 Timeline of data collection of key variables. ADHD attention-deficit hyperactivity disorder

experiences (6.39%) (see Schaefer et al. 2018 for details). Descriptive statistics for all measures used in the analysis are provided in Table 1.

Table 1. Descriptive statistics for the analytic sample (n=1986)

	Polyvictimization			
Victimization Types	*Age 5-12 (%)*		*Age 12-18 (%)*	
0	(73.01)		(65.41)	
1	(20.69)		(18.98)	
2	(3.88)		(9.21)	
3+	(2.42)		(6.39)	
	Mean	SD	Min	Max
Cognitive Factors				
Intelligence	100.00	15.00	50.83	146.95
Theory of Mind	4.56	3.30	0	12
Self-control	0.02	1.00	-3.47	1.98
Psychological Factors				
ADHD	12.12	11.06	0	61
Conduct disorder	1.93	1.97	0	13
Depression	3.13	5.37	0	42
Anxiety	7.61	3.01	0	18
Psychotic symptoms	0.07	0.32	0	2
Zygosity				
Monozygotic Twins	1112			
Dizygotic Twins	874			

ADHD attention-deficit/hyperactivity disorder

Cognitive factors Most cognitive and psychological factors were assessed by age 12 to ensure temporal ordering of the predictors and later polyvictimization outcomes. However, certain variables (i.e., self-control and ToM) were assessed prior to age 12 due to their developmental nature. For example, ToM is thought of as a developmental milestone, the delay of which may signal the likely presence of additional developmental issues to come (e.g., autism-spectrum disorders). As ToM typically manifests during ages 3–5 (Wellman et al. 2001), it is not appropriate to assess ToM by age 12 as it is the initial timing/onset of the variables that is important and not its presence/absence at age 12. Similarly, self-control has been found to be developed in most children by the age of 10 (Moffitt et al. 2011); thus, it was measured using assessments ranging from ages 5–10.

Intelligence was assessed at age 12 using the matrix reasoning and information subscales of the Wechsler Intelligence Scale for Children, 4th Edition (Sattler & Dumont, 2004). These subscales were combined and converted into IQ scores ($M = 100$; $SD = 15$) using the procedure first developed by Tellegen and Briggs (1967) (see also Sattler and Ryan 2009). Higher scores reflect higher levels of intelligence.

Theory of mind (*ToM*) was assessed at age 5 by administering eight tasks that probed the respondents' ability in perspective taking (Hughes et al. 2005). The early assessment of ToM is necessary because it typically develops between ages 3 and 5, and delays in the development of ToM often signal deficits in critical social abilities. The first four ToM tasks tapped the respondents' ability to attribute a first-order false belief to a character in a story (e.g., a mistaken belief about an object's location or identity). The next four tasks tapped respondents' capacity to predict second-order false beliefs (e.g., a mistaken belief about a belief). Scores from all tasks were summed, creating a scale that ranged from 0 to 12 ($M = 4.56$; $SD = 3.30$), with higher scores representing greater ability in perspective taking.

Self-control was measured during the first decade of life via the use of teacher, parent, self, and interviewer-rated information and followed the procedures established by prior E-Risk research (see Beckley et al. 2018; see also Moffitt et al. 2011). In particular, we included a total of nine measures, all tapping observational ratings of children's lack of control at age 5; parent and teacher reports of impaired impulse control at ages 5, 7, and 10; self-reports of inattentive and impulsive behavior at age 7; and interviewer judgments of the personality trait of conscientiousness at age 10. The measures were factor analyzed and one factor was extracted. This factor score was coded so that higher scores represented higher levels of self-control.

Psychological factors All symptoms of psychological disorders were assessed at age 12 to preserve the temporal ordering of early psychological factors and polyvictimization by age 18. Participants were assessed for attention-deficit/hyperactivity disorder (*ADHD*) symptoms at age 12 using mother and teacher reports (see Polanczyk et al. 2010a). These reports probed for the presence of all 18 symptoms identified in the Diagnostic and Statistical Manual of Mental Disorders (DSM) IV. Symptoms were ranked on a three-point rating scale (i.e., "not true", "somewhat/sometimes", "very often true"). Combining scores across the 18 symptoms resulted in an ADHD index that ranged from 0 to 61 ($M = 12.12$; $SD = 11.06$), with higher scores indicating greater ADHD symptomatology.

The presence of *conduct disorder* was assessed at age 12 via a computer-assisted module that asked participants about behaviors that met the diagnostic criteria for the disorder delineated in the DSM IV (Robins et al. 1995; see Agnew-Blais et al. 2016). The measure for *conduct disorder* consisted of an index of the total number of clinical criteria met by each participant. The index ranged from 0 to 13 ($M = 1.93$; $SD = 1.97$), with higher scores representing more criteria met.

Depression was assessed at age 12 using the Children's Depression Inventory (CDI; Kovacs 1992), which is a 27-item self-report scale of depressive symptoms. The symptoms assessed by the CDI are categorized as cognitive, affective, or behavioral depressive symptoms. Respondents rated items on the CDI on a three-point Likert scale increasing in severity from 0 to 2. The summed item scores produced a scale that ranged from 0 to 42 ($M = 3.13$; $SD = 5.37$), with higher scores representing more depressive symptoms.

The presence of *anxiety* symptoms among participants was assessed at age 12 with the 10-item Multidimensional Anxiety Scale for Children (MASC-10; March et al. 1999). Each item of the MASC-10 was rated by the participant on a four-point Likert scale, producing scores that ranged from 0 to 18 points ($M = 7.61$; $SD = 3.01$), with higher scores representing more anxiety symptoms.

Psychotic symptoms of participants were assessed at age 12 in a private interview, in which seven symptoms were investigated (see Polanczyk et al. 2010b for an in-depth description of the interview procedure). The symptoms investigated in the interview fell into two categories: (1) hallucinations (e.g., "have you heard voices that other people cannot hear?") and (2) delusions (e.g., "have you ever known what another person was thinking, even though that person wasn't speaking, like read their mind?"), where mind-reading between twins was excluded. Total reported symptom counts ranged from 0 to 6. Due to high skewness, however, the psychotic symptoms variable was trichotomized into categories of "no symptoms" (i.e., 94.31% of the sample), "one symptom" (i.e., 3.98%), and "two or more symptoms" (i.e., 1.71% of the sample).

Covariates The discordant-twin method controls for a large number of unobserved covariates by design (i.e., parental endowments of genetic inheritance and early developmental environment), but additional influences were controlled by means of study design and statistical control. *Age* was controlled due to the cohort design of the data (i.e., all of the twins were born between 1994 and 1995), though we do control for birth order. *Sex* was also addressed by the study design as all twin pairs were of the same sex (i.e., none of the DZ twins were brother-sister pairs). Finally, *early polyvictimization* tapped victimization experiences that occurred before age 12. Variable construction for *early polyvictimization* followed the same procedure as the *polyvictimization* measure used as the outcome, with only one difference: cyber victimization was not included as one of the victimization types contributing to the overall index. After winsorization, *early polyvictimization* was a four-category index of victimization types, where 0 = no severe victimization experiences (73.01% of the sample), 1 = one severe victimization experience (20.69%), 2 = two severe victimization experiences (3.88%), and 3 = three or more severe victimization experiences (2.42%) (see Schaefer et al. 2018 for details). All analyses presented below were adjusted for the influence of this covariate.

It is worth noting that we excluded other covariates, in particular prior offending, not because we viewed them as unimportant. Rather, that decision was guided by the fact that prior offending is unlikely to have "causal" impact on the cognitive domains included herein. Thus, including them was unnecessary from a causal inference standpoint. Moreover, inserting them alongside early polyvictimization might also introduce other methodological issues (e.g., overcontrolling for variables, collider bias).

Plan of analysis

Relying on the natural experiment embedded in the discordant-twin design, the current study will assess the effect of cognitive and psychological characteristics in childhood (assessed at age 12 and earlier) on polyvictimization risk in adolescence and early adulthood (from age 12–18). The discordant-twin design involves analyzing twin pairs in a fixed-effects statistical framework (for a general discussion of the standard fixed-effects regression model, see Allison 2009; Wooldridge 2016), wherein all common/shared factors (i.e., genetic and early environmental factors) are controlled for by design. The discordant-twin model can be expressed algebraically as (see Kohler et al. 2011):

$$y_{1j}–y_{2j} = (\mu_1–\mu_2) + b_1\left(x_{1j}–x_{2j}\right) + b_2\left(c_{1\mathrm{j}}–c_{2\mathrm{j}}\right) + \left(e_{1\mathrm{j}}–e_{2\mathrm{j}}\right)$$

where $y_{1j} – y_{2j}$ represents the within-twin pair difference in polyvictimization from age 12 to 18 between twin 1 and twin 2 in family j, $\mu_1 – \mu_2$ represents the mean difference between participants arbitrarily labeled twin 1 and those labeled twin 2, b_1 reflects the effect of within-twin pair differences in the key independent variable on the outcome, b_2 represents the collective influence of the covariates, and $e_{1j} – e_{2j}$ estimates the impact of unmeasured within-twin pair differences on the outcome.

As the above equation illustrates, discordances in cognitive and psychological factors between the twins are analyzed for an association with discordance in later polyvictimization experiences. All the fixed-effects results presented below were estimated by linear regression. However, we performed robustness checks using Poisson regression and the substantive conclusions were unaltered. We present the linear regression results for ease of interpretation.

The primary analysis for this study proceeded in three steps. First, we conducted a preliminary analysis to assess the distributional properties of our measures and the characteristics of individuals grouped by their polyvictimization score. Second, the individual cognitive and psychological factors were analyzed for an association with polyvictimization experiences using fixed-effects regression in the full sample (i.e., including both dizygotic [DZ] and monozygotic [MZ] twins). The analysis was then repeated after limiting the sample to MZ twins. The significance of these separate steps is that they demonstrate the effect of moving from a partial control of genetic factors when analyzing MZ and DZ twins—where only 50% of genetic factors are controlled for DZs—to a full control of genetic factors in the MZ-only step. For predictors that are influenced by genes, the result of moving from the full sample including DZs to the MZ-only sample should be a weakening of their association with polyvictimization.

It is important to note that, due to concerns over the comorbidity of various psychological characteristics, each predictor is analyzed separately from the others. However, because research has demonstrated that most psychological disorders are comorbid with other disorders (Caron and Rutter 1991; Hasin and Kilcoyne 2012; Newman et al. 1998), it has become common practice to examine psychological disorders not only as individual disorders but also as a dimension of psychological dysfunction. The most common classification scheme of dimensions includes externalizing (e.g., ADHD, conduct disorder) and internalizing disorders (e.g., depression, anxiety), although studies have also demonstrated the validity of a threefold classification that includes thought disorders (e.g., psychosis)(see Schaefer et al. 2018).

In light of the dimensionality associated with major psychological disorders (Caspi et al. 2014), we carried out an additional step to the analysis to determine whether using a measure of general psychological symptomatology predicted polyvictimization experiences. To accomplish this, we conducted a principal components analysis (PCA) of the five domains of psychological symptoms examined above (i.e., ADHD, conduct disorder, depression, anxiety, and psychosis). Two principal components (PCs) were extracted (i.e., eigenvalues > 1) using an oblique extraction method (i.e., promax). The two PCs represent externalizing (i.e., ADHD and conduct disorder) and internalizing/thought problems (i.e., depression, anxiety, and psychosis).

All analyses control for birth order and *early polyvictimization* (i.e., up to age 12) in order to help sort out the temporal ordering of the relationships of focus. Additionally, because each predictor was assessed using a different metric, all of the measures were standardized (i.e., transformed into *z*-scores) prior to carrying out the analysis. Because the outcome measure was not standardized, the coefficient estimates reveal the impact of a standard deviation unit increase in the predictor on polyvictimization experiences.

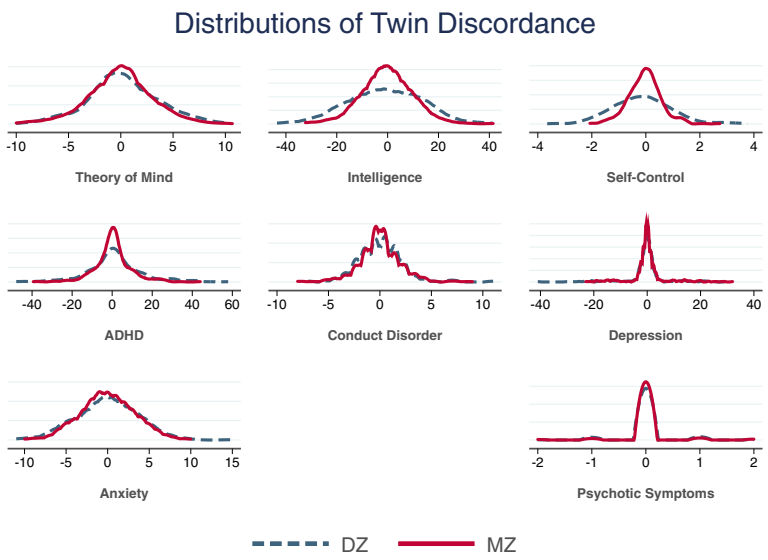
The third and final step in the analysis involved robustness checks to determine if the findings (1) were sensitive to the coding of the dependent variable or (2) vary by sex. To assess sensitivity to dependent variable coding, we recoded the polyvictimization measure to be dichotomous (i.e., no victimizations vs. at least one severe victimization experience) and repeated the main analyses. We tested for sex differences using a mixed-effects model that allowed us to assess the between-pair (but not within-pair) differences that are attributable to sex, because the E-Risk sample are all same-sex pairs.

Results

Preliminary analysis

The discordant-twin design relies on differences between members of a twin pair. Because twins (especially MZ twins) often resemble one another quite closely, it is possible that the rates of discordance in a sample of twins may be too low to use in a statistical model. To assess this possibility, we plotted the distributions of twin discordance across all of the predictors in our analysis (see Fig. 3).

Looking at Fig. 3, we see most of the predictors in the analysis (1) appear to have adequate variation to use in the analysis, (2) are normally distributed, and (3) have similar distributions across DZ and MZ twins. This final observation is especially



Note: ADHD=Attention-deficit hyperactivity disorder

Fig. 3 Distributions of dizygotic (DZ) and monozygotic (MZ) twin discordance across cognitive and psychological characteristics. ADHD attention-deficit hyperactivity disorder

important because similar twin differences across the DZ and MZ twin subsamples suggests that any findings from an MZ-only model (i.e., the most stringent model in the current analysis) are unlikely to be a result of MZ twins possessing different patterns of discordance compared to DZ twins.

There were also a number of patterns observable in Fig. 3 that suggest certain variables and results should be interpreted cautiously. For example, the distributions of twin differences in *self-control* were somewhat distinct for the MZ and DZ subsamples, particularly in terms of variation (MZ twins $SD = 0.598$; DZ twins $SD = 1.084$). Additionally, these disparate patterns were not the result of low rates of discordance in the sample, as all twins in the sample were discordant on the measure of self-control. Another pattern worth noting is for *depression*, where the distribution of twin differences is tightly clustered around zero. This occurred because depression was rare in the sample (i.e., 50% of the sample reported 1 or no symptoms), causing most twin pairs to show no discordance because neither twin presented with any depressive symptoms. Yet there was a large degree of discordance when at least one twin exhibited symptoms of depression. This occurred in 74.83% of such cases for MZ twins and in 79.79% of DZ twins. The pattern of discordance for *psychotic symptoms* also requires attention. In this case, twin discordances were heavily anchored at zero, indicating low rates of discordance in the overall sample. Indeed, only 12.5% of MZ twins and 15.8% of DZ twins were discordant for symptoms of psychosis. This result suggests the current analysis may have lower statistical power when assessing the effect of psychotic symptoms on polyvictimization.

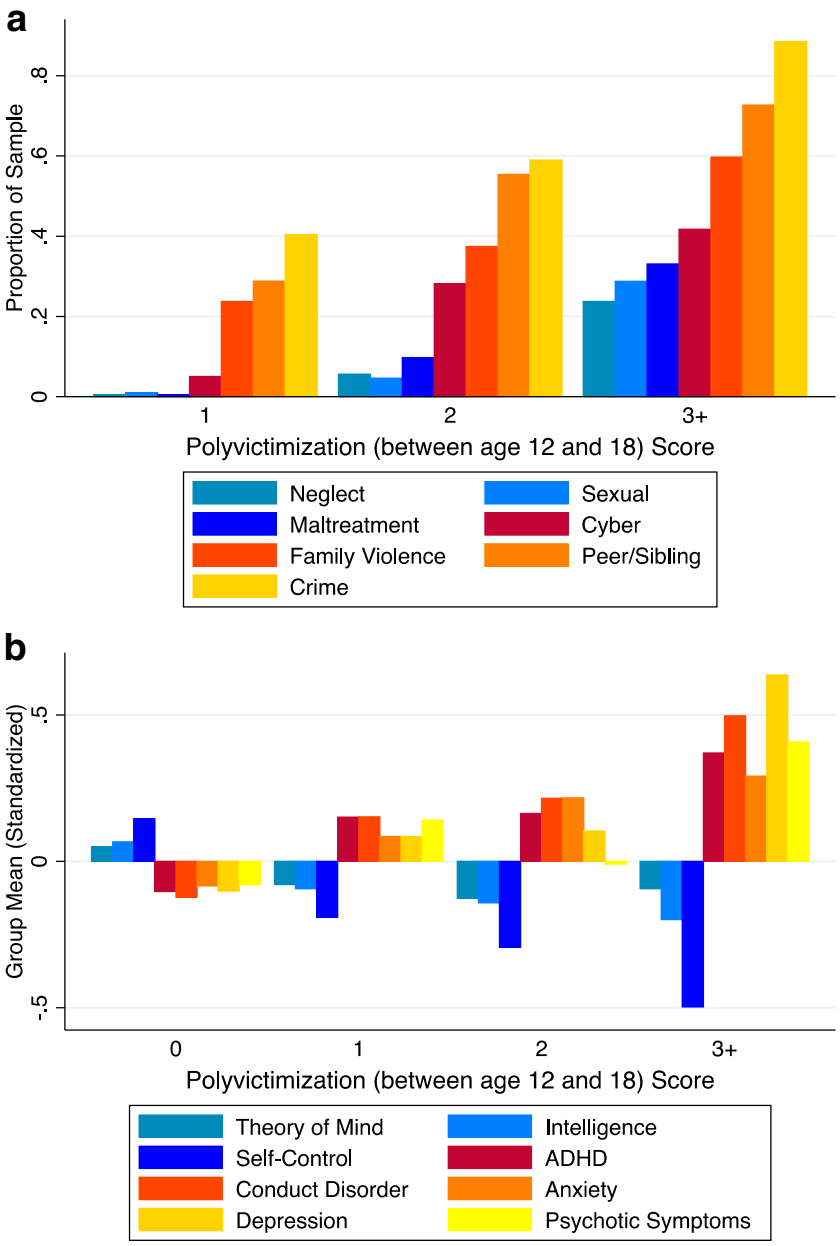


Fig. 4 Distribution of sample and group means, by polyvictimization score. **a** The proportion of the sample that experienced the seven types of victimization that contributed to the polyvictimization score. **b** The group mean level of cognitive/behavioral and psychological factors by polyvictimization score. ADHD attention-deficit/hyperactivity disorder

Next, we observe how the different types of victimization experiences contributed to the polyvictimization experiences between age 12 and 18. Looking at Fig. 4a, we observe monotonic increases in all forms of victimization as

polyvictimization increases. However, four specific forms of victimization appeared to be the most prevalent, and thus contributed to the polyvictimization scores the most: cyber, family violence, peer/sibling, and crime victimization. Interestingly, the remaining forms of victimization (i.e., neglect, sexual, and maltreatment) did not become substantively prevalent among the samples until polyvictimization scores reached 3+.

Finally, we assessed how our measures of cognitive and psychological factors at age 12 and earlier varied across levels of polyvictimization between age 12 and 18. The distributions are presented graphically in Fig. 4b which uses the polyvictimization score as the *x*-axis. In Fig. 4b, the mean values of the different predictor variables are presented on the *y*-axis. Looking at Fig. 4b, we see the expected patterns of association emerge. For example, the scores on cognitive measures taken in childhood (especially self-control) are the lowest for those in the highest polyvictimization groups during adolescence. Conversely, the average number of childhood psychological symptoms was highest in the highest adolescent polyvictimization groups. This pattern aligns with our expectations and suggests that cognitive and psychological problems are more prevalent among those with more victimization experiences.

Table 2 Fixed-effects regression of polyvictimization between age 12 and 18 on cognitive and psychological factors at age 12 and earlier

	Column 2.1 (full)		Column 2.2 (MZ)		Column 2.3 (full)		Column 2.4 (MZ)	
	β	*SE*	*β*	*SE*	*β*	*SE*	*β*	*SE*
Cognitive factors								
Intelligence	0.043	0.039	0.086	0.057				
ToM[a]	0.022	0.033	−0.046	0.042				
Self-control[a]	−0.111**	0.038	−0.155*	0.063				
Externalizing PC					0.066	0.034	0.040	0.049
ADHD	0.022	0.032	0.021	0.048				
Conduct disorder	0.078*	0.031	0.069	0.039				
Internalizing/thought PC					0.084**	0.029	0.026	0.036
Depression	0.034	0.026	−0.038	0.034				
Anxiety	0.066*	0.028	0.063	0.035				
Psychotic Symptoms	0.044	0.026	0.009	0.032				
N (twins)	1986		1112		1986		1112	

Each column presents estimates from separate models where polyvictimization from age 12 to 18 is regressed on each cognitive and psychological factor individually. All models adjust for prior polyvictimization and birth order

ToM theory of mind, *ADHD* attention-deficit/hyperactivity disorder

*$p < .05$; **$p < .01$

[a] Assessed earlier than age 12 phase of data collection. ToM was assessed at age 5 as a measure of specific developmental milestones associated with perspective-taking that occur around that age. Self-control was a composite of teacher, mother, and self-report information across multiple phases from age 5–10

Regression analysis

We now turn to the primary analysis. Presented in Table 2 are partially standardized regression coefficients (recall the cognitive and psychological variables were standardized, but polyvictimization was not). Each of the coefficients in Table 2 was estimated with separate regression models due to concerns over comorbidity (i.e., multicollinearity). All models control for *early polyvictimization* and birth order.

Looking at Table 2, significant associations with polyvictimization between age 12 and 18 were found for both cognitive and psychological characteristics measured at age 12 or earlier when analyzed using the full sample (see column 2.1 in Table 2). Specifically, there was a statistically significant negative association ($\beta = -0.111$; $P = 0.004$) between *self-control* and *polyvictimization* in the full sample. This finding indicates that, after partially adjusting for genetic factors (by design), early rearing environmental effects (by design), and prior victimization experiences (by inclusion of the covariate), a standard deviation increase in self-control is associated with a 0.111 decrease in the number of polyvictimization experiences. Of the externalizing disorders, only *conduct disorder* was a statistically significant predictor of adolescent polyvictimization. As expected, there was a positive (albeit modest) association ($\beta = 0.078$; $P = 0.011$) between *conduct disorder* and *polyvictimization*. Among age-12 internalizing/thought disorders, only *anxiety* ($\beta = 0.066$; $P = 0.004$) was a statistically significant predictor of adolescent polyvictimization, though the effect size was small.

The results from column 2.1 suggest that some associations are present between cognitive and psychological characteristics and later polyvictimization. Yet, the effect sizes were substantively small and not all of the predictors in each category were significantly associated with later polyvictimization experiences.

The estimates provided in column 2.2 come from models where the sample was restricted to MZ twins ($n = 1112$), which allows us to completely adjust for the influence of genetic factors as well as early shared environmental factors. Of the three statistically significant predictors of polyvictimization that were identified in column 2.1, only *self-control* remained a statistically significant predictor in column 2.2. After adjusting for all genetic and early environmental effects, *self-control* was negatively associated ($\beta = -0.155$; $P = 0.015$) with polyvictimization experiences during adolescence.

The principal component (PC) for externalizing behavior and the PC for internalizing/thought disorders were assessed for their association with polyvictimization between age 12 and 18 in columns 2.3 and 2.4. In column 2.3—which included the full sample—only the up-to-age-12 internalizing/thought PC was a statistically significant predictor of polyvictimization between ages 12 and 18 ($\beta = 0.084$; $P = 0.004$). It is worth noting that the externalizing PC was marginally significant at $P = 0.052$. Moving to column 2.4 (i.e., the MZ-only column); however, neither of the PCs reached statistical significance.

For comparison purposes, we also estimated the above analyses using ordinary least squares (OLS) regression that did not use a fixed-effects framework but did use clustered standard errors (see supplemental material). These models produced highly statistically significant coefficients in the expected directions for all cognitive and psychological predictors. There were only two exceptions (i.e., intelligence and ToM) to this general pattern of findings. Both intelligence and ToM failed to attain statistical

significance in either the full model (i.e., see column A.1) or the MZ-only model (i.e., see column A.2). Overall, the pattern of OLS results demonstrates how typical statistical models may be more permissive of unmeasured bias (e.g., shared environmental and genetic factors). The results of the twin fixed-effects models above account for this possibility.

Robustness checks

We performed robustness checks to determine (1) if the results were specific to polyvictimization or simply victimization in general and (2) if the results varied by sex. First, we created a measure of general victimization by dichotomizing the polyvictimization measure so that individuals who experienced no victimization between ages 12 and 18 were given a 0 and those who experienced at least one type of victimization received a 1. As before, we glean estimates by fixed-effects linear regression. In this case—with a binary outcome—the model can be considered the linear probability model (Long 1997). This was a preferred approach because the fixed-effect logistic regression can only analyze cases that are discordant on the outcome, meaning that concordant twins are omitted from the analytic sample (Allison 2009). Looking at Table 3, we see that with only one exception (i.e., *conduct disorder*), all

Table 3 Fixed-effects regression of general victimization between ages 12 and 18 on cognitive and psychological factors at age 12 and earlier

	Column 3.1 (full)		Column 3.2 (MZ)		Column 3.3 (full)		Column 3.4 (MZ)	
	β	*SE*	*β*	*SE*	*β*	*SE*	*β*	*SE*
Cognitive factors								
Intelligence	0.008	0.022	0.032	0.032				
ToM[a]	−0.005	0.019	−0.050*	0.024				
Self-control[a]	−0.054*	0.021	−0.071*	0.036				
Externalizing PC					0.010	0.019	−0.021	0.028
ADHD	−0.007	0.018	−0.016	0.027				
Conduct disorder	0.033	0.018	0.015	0.022				
Internalizing/thought PC					0.042**	0.016	0.020	0.021
Depression	0.001	0.015	−0.032	0.019				
Anxiety	0.038*	0.016	0.041*	0.020				
Psychotic Symptoms	0.032*	0.015	0.020	0.018				
N (twins)	1986		1112		1986		1112	

Each column presents estimates from separate models where general victimization from age 12 to 18 is regressed on each cognitive/psychological factor individually. All models adjust for prior polyvictimization and birth order

ToM theory of mind, *ADHD* attention-deficit/hyperactivity disorder

*$P < .05$; **$P < .01$

[a] Assessed earlier than age 12 phase of data collection. ToM was assessed at age 5 as a measure of specific developmental milestones associated with perspective-taking that occur around that age. Self-control was a composite of teacher, mother, and self-report information across multiple phases from age 5 to 10

significant relationships from Table 2 are replicated in the full sample columns (i.e., columns 3.1 and 3.3) when examining general victimization. Although, one additional relationship was revealed that was not observed in the polyvictimization analysis: *psychotic symptoms* positively and significantly predicted adolescent victimization ($\beta = 0.032$; $P = 0.03$).

Moving to the MZ-only columns of Table 3 (i.e., columns 3.2 and 3.4), the statistically significant relationship of *self-control* with victimization substantively replicated. However, two new findings also emerged in the MZ-only columns that were not observed when analyzing polyvictimization (i.e., in Table 2): *anxiety* was statistically significant in the MZ-only column ($\beta = 0.041$; $P = 0.042$) and the *ToM* measure became significant in the MZ-only column ($\beta = -0.050$; $P = 0.036$) after failing to reach statistical significance in all of the previous models. These results indicate that the majority of significant associations observed between childhood cognitive and psychological characteristics and polyvictimization in adolescence also apply to victimization more broadly, but victimization may be more general in terms of the factors that impact it.

Next, we investigated the interaction of cognitive and psychological characteristics with sex as a moderator of their influence on polyvictimization between age 12 and 18. As mentioned above, we are unable to model the within-pair sex differences in polyvictimization because the E-Risk twin pairs all share the same sex. We are able to investigate the between-pair sex differences, however, by comparing all-male and all-female pairs. Table 4 presents mixed-effects interaction models that compare the average male- and female-pair relationships between childhood cognitive and psychological characteristics and polyvictimization in adolescence. Presented in the table are the main effect estimates for each of the cognitive and psychological characteristics and the estimate of the cross-level interaction with sex (male = 0, female = 1). The main effect for the sex variable is not shown, but it was consistently positive, indicating that being female increased polyvictimization at ages 12–18. The main effect for sex was statistically significant in the interaction models with self-control ($\beta = 0.156$; $P = 0.001$), ADHD ($\beta = 0.102$; $P = 0.031$), conduct disorder ($\beta = 0.111$; $P = 0.015$), and the externalizing PC ($\beta = 0.153$; $P = 0.001$) in the full model, and it was not statistically significant in any of the MZ-only interaction models.

With only one exception (i.e., *conduct disorder*), the full-sample analysis (i.e., column 4.1) did not detect significant differences between male- and female-only twin pairs in terms of their associations between cognitive and psychological characteristics and polyvictimization. In the case of *conduct disorder*, however, the association with polyvictimization was significantly increased in female-only pairs (interaction term: $\beta = 0.096$; $P = 0.039$). This finding suggests that *conduct disorder* may play a disproportionate role in predisposing females to polyvictimization, despite females having fewer *conduct disorder* symptoms on average ($M = 1.52$) compared to the males in the sample ($M = 2.38$). The *conduct disorder-sex* interaction term became non-significant; however, when entered into the MZ-only analysis (i.e., column 4.2) (interaction term: $\beta = 0.061$; $P = 0.313$), meaning the findings from the full sample should be interpreted cautiously.

It should also be noted that the main effect term for *ADHD* emerged as a statistically significant ($\beta = 0.087$; $P = 0.003$ [full sample]; $\beta = 0.106$; $P = 0.009$ [MZ-only sample]) predictor of polyvictimization in these analyses, despite not achieving statistical

Table 4. Mixed-effects regression of polyvictimization between ages 12-18 on cognitive and psychological factors at age 12 and earlier, including an interaction with sex.

	Column 4.1 (Full)				**Column 4.2 (MZ)**			
	Main Effect		***Cognitive Factor × Sex***		***Main Effect***		***Cognitive Factor × Sex***	
	β	***(SE)***	*β*	***(SE)***	*β*	***(SE)***	*β*	***(SE)***
Cognitive Factors								
Intelligence	-0.022	(0.030)	-0.019	(0.044)	0.030	(0.041)	-0.061	(0.059)
ToM†	0.001	(0.030)	-0.029	(0.041)	-0.039	(0.042)	0.003	(0.056)
Self-Control†	-0.142***	(0.031)	-0.038	(0.045)	-0.166***	(0.043)	-0.031	(0.062)
	Main Effect		***Psychological Factor × Sex***		***Main Effect***		***Psychological Factor × Sex***	
	β	***(SE)***	*β*	***(SE)***	*β*	***(SE)***	*β*	***(SE)***
Psychological Factors								
Externalizing PC	0.128***	(0.031)	0.071	(0.049)	0.135**	(0.042)	0.047	(0.066)
ADHD	0.087**	(0.029)	-0.022	(0.048)	0.106*	(0.040)	-0.039	(0.066)
Conduct Disorder	0.106***	(0.030)	0.096*	(0.046)	0.111**	(0.039)	0.061	(0.060)
Internalizing/ Thought PC	0.099**	(0.033)	0.022	(0.046)	0.076	(0.042)	0.044	(0.060)
Depression	0.068	(0.036)	0.050	(0.051)	0.023	(0.048)	0.112	(0.069)
Anxiety	0.094**	(0.030)	-0.037	(0.041)	0.112*	(0.040)	-0.050	(0.054)
Psychotic symptoms	0.043	(0.035)	0.067	(0.051)	0.043	(0.040)	0.071	(0.063)
N (twins)	1986				1112			

*$P<.05$, **$P<.01$, ***$P<.001$; ToM=Theory of Mind; ADHD=Attention-deficit/hyperactivity disorder.

† Assessed earlier than age 12 phase of data collection. ToM was assessed at age 5 as a measure of specific developmental milestones associated with perspective-taking that occur around that age. Self-control was a composite of teacher, mother, and self-report information across multiple phases from age 5-10.

Note: Each column presents estimates from separate models where polyvictimization from age 12-18 is regressed on each cognitive/psychological factor individually. All models adjust for prior polyvictimization and birth order. Males are the reference category (i.e., male=0). Thus, the main effects columns represent the predictions for polyvictimization specific to male-only twin pairs and the interaction term columns represent the change in the main effects when examining female-only twin pairs.

significance in the previous analyses. The interaction term was not statistically significant. This tells us that *ADHD* plays a disproportionate role in predisposing males to polyvictimization.

Discussion

Polyvictimization has been brought to the fore of victimization research as a concept in need of attention because it has many unique theoretical implications. Previous perspectives on victimization have asserted that victimizations largely arise from processes that are ecologically structured (e.g., Cohen and Felson 1979). Polyvictimization, in contrast, implies that certain individuals carry their victimization risk with them across

contexts. Thus, polyvictimization requires explanations that go beyond ecological processes (Finkelhor and Asdigian 1996) and perhaps necessitate the integration of modern perspectives like social neurocriminology (Choy et al. 2015). Finkelhor and colleagues (2009) contributed to this explanation by identifying four potential pathways to polyvictimization: (1) living in a dangerous neighborhood, (2) living in a dangerous family, (3) living in a chaotic or multiproblem family, and (4) possessing emotional and psychological symptoms. While the first three pathways suggested familiar ecological processes, the fourth pathway implied the role of individual characteristics that would exert the kind of consistent influence implied by the cross-context vulnerability of polyvictims. Empirical research conducted to date has yet to fully examine that pathway, which was the springboard for the current study.

Our study sought to assess the impact of cognitive and behavioral and psychological symptoms on polyvictimization in adolescence and young adulthood while controlling for the other pathways identified by Finkelhor and colleagues (2009). No other study of which we are aware has done so while also preserving the time ordering of key variables, ruling out reverse causation, and accounting for the high likelihood of unmeasured familial confounds. To do so would be to thread together many of the existing ideas concerning the origins of polyvictimization into one coherent and rigorous test that is consistent with social neurocriminological foci. We attempted to accomplish these things by analyzing longitudinal data from the E-Risk Study and utilizing the discordant-twin design.

Our results revealed that, among the suite of cognitive and psychological domains examined, self-control emerged as the most consistent predictor of both polyvictimization and victimization more generally, even when using the most conservative approach of MZ-only discordant-twin models. These results, coupled with those from other rigorously controlled studies (e.g., Boutwell et al. 2013; Richmond-Rakerd et al. 2019; Schreck et al. 2006), seem to warrant consideration of self-control as a potentially causal contributor to victimization. Our results also demonstrated that anxiety and the internalizing/thought problem PC (of which anxiety is part) were predictive of both polyvictimization and general victimization. However, neither of these measures remained statistically significant when the sample was restricted to MZ twins. This may be due to the fact that these psychological domains all possess large (shared) genetic components (see e.g., Caspi et al. 2014) that are adjusted for when MZ twins are analyzed (see Kohler et al. 2011).

The findings also highlighted interesting patterns of association for early symptoms of conduct disorder. For example, symptoms of conduct disorder at age 12 were predictive of later polyvictimization, but not of general victimization. This finding may reflect some sensitivity in the conduct disorder variable (e.g., to the coding of the outcome variables), given that none of the other associations lost statistical significance in the general victimization model. Another interpretation might be that there exists some unique association between conduct disorder and polyvictimization that is not conserved when looking at victimization more broadly. Additionally, conduct disorder was the only predictor to significantly vary by sex, suggesting that symptoms of conduct disorder were a statistically stronger predictor of later polyvictimization for females than males.

This study assessed polyvictimization using methods advocated for by prior research (i.e., using a variety measure of victimization types; see e.g., Turner et al. 2010b).

However, a key aspect of polyvictimization remains untested: the origins and consequences of cross-context vulnerability (see Turner et al., 2016). Polyvictimization occurs when individuals are exposed to multiple types of victimization. An implied assumption is that as victimization types increase, so too will the number of contexts in which an individual is victimized. Thus, the cross-context vulnerability attributed to polyvictims is at best only inferred by traditional assessments that rely on variety measures alone. However, it is likely that both victimization types and victimization contexts increase monotonically with the total number of victimization experiences (i.e., as victimizations increase, so too does the probability of experiencing multiple types of victimization across multiple contexts). Unfortunately, variety measures do not provide the specificity needed to confirm this.

The current study lacked the information needed to determine how cognitive and psychological characteristics affect cross-context vulnerability directly. However, encouraging work by Turner and colleagues (2016) has begun to address this issue by using data from the National Survey of Children's Exposure to Violence II to directly assess the context, relationship to the perpetrator, and aggravating circumstances (e.g., the use of a weapon) surrounding victimization experiences. Their results demonstrated that polyvictims were more susceptible to being victimized across multiple contexts (i.e., at home, school, and other locations). Future efforts to study polyvictimization, and specifically the fourth pathway to polyvictimization, should endeavor to combine the strengths of the current study (e.g., longitudinal discordant-twin design, full clinical assessments) with a measure of victimization that directly assesses the contexts and circumstances surrounding victimizations. Together, such efforts could help scholars, clinicians, and public health workers understand the drivers of polyvictimization and allow them to develop effective interventions aimed at mental health that could help close off the fourth pathway to polyvictimization.

Considerations

The discordant-twin methodology offers one of the most stringently controlled tests of association and, in that regard, it can be considered a natural experiment that closely mimics a propensity score matching analysis that allows for the control of all shared environmental factors and (in the case of MZ twins) all genetic factors that might influence a relationship (Pingault et al. 2018). The discordant-twin design eliminates all the influence of both sources of systematic variation in cognitive and psychological characteristics (Plomin 2018), leaving only non-shared experiences to impact variation. The discordant-twin approach should thus be considered a highly conservative test of association because it only considers the relationship between a predictor and an outcome if the predictor varies between twins due to non-shared environmental events.

Given the model's ability to control for the many confounding influences tied up in shared background circumstances like early familial environment and genetic factors, the discordant-twin model is an ideal means for testing associations from a social neurocriminological perspective, wherein environmental events are thought to affect brain-based factors, which then go on to affect behavior. Statistically significant results in the current context suggest that the variation in cognitive and psychological characteristics, even when constrained to the portion of variation derived from non-shared

environmental impacts, was robust enough to predict polyvictimization in adolescence. This makes a strong statement about the influence of environmental exposures on brain-based factors and behavior, as predicted from a social neurocriminology perspective. Our findings make an even stronger statement about the potentially causal role that cognitive and psychological characteristics play in the etiology of polyvictimization, as our model excluded the effects of underlying genetic factors which have already been shown to play a role in the fourth pathway to polyvictimization (see Danese et al., 2017).

Despite our study's strengths, there are several limitations that should be kept in mind when contextualizing the findings. First, our data were drawn from a sample of twins, which may limit the generalizability of the results to singletons and other populations. We believe these concerns are allayed by evidence that indicates (1) twin data can be generalized to non-twin populations for the types of relationships studied here (see Barnes and Boutwell 2013) and (2) that the rates of victimization reported in the E-Risk study are not substantively different from those reported in other general surveys from the UK (see Fisher et al. 2015). A second limitation deals with the generalizability of our results outside of the UK. Prior studies using the E-Risk data have been shown to replicate in other samples drawn from New Zealand (e.g., Wertz et al. 2018) and the USA (e.g., Belsky et al. 2018). Thus, while it is important to acknowledge the potential for limited generalizability, we think it is a concern that is unlikely to have affected our substantive conclusions.

The third limitation that should be mentioned is that we were unable to establish the mechanisms that might link self-control and internalizing symptoms to polyvictimization. As aforementioned, some potential mechanisms have already been proposed in the literature (e.g., instigation, selection, and [lack of] protection; Finkelhor 2008). But victimologists will need to consider seriously the possibility that self-control and internalizing symptoms are causal factors and, therefore, specify more explicitly the pathways that may connect them to polyvictimization. The social neurocriminology perspective offers a unique angle from which victimologists might consider identifying the mediators on the causal pathway to polyvictimization.

Conclusion

The knitting together of pathways to victimization is important from a basic science standpoint, but it also has the potential to inform translational knowledge. Poor impulse regulation, for instance, is amenable to intervention (Piquero et al. 2010; Piquero et al. 2016) and may be especially responsive to certain psycho-therapies (Cabaniss et al. 2016; Preuss et al. 2017). Indeed, Pandey et al. (2018) recently meta-analyzed 17 cluster randomized trials and roughly 32 randomized clinical trials (over 23,000 subjects in total) in order to evaluate interventions intended to improve self-control skills in children and adolescents. The results clearly suggested that various interventions seemed to produce improvements in the self-regulatory outcomes of the participants.

These results intersect with our findings in three important respects. First, while randomized trials are rightly considered the "gold standard" in translational science, that type of study is often not a possibility for certain research questions,

including the current focus on psychological traits which cannot be experimentally manipulated. As such, twin and sibling designs, which as we noted function as powerful natural experimental designs, may allow for causal inferences in ways that associational studies cannot. Second, by utilizing the discordant-twin analysis, our results offered further evidence that self-control is linked with victimization outcomes, thus buttressing the findings of Pandey et al. (2018) in suggesting that psycho-social interventions aimed at improving self-control and self-regulation should directly diminish the risk of victimization in the population. Third, and finally, victimology as a field stands to greatly benefit from the application of genetically sensitive modeling approaches. Indeed, the outgrowth of sibling data used to study victimization should improve the ability of victimology to function as a translational science, capable of making deeper causal inferences about not only the origins of victimization, but also the best avenues for preventing it all together.

Consider also, as a final point, recent findings that revealed a consistent effect of self-control predicting both attempted self-harm, as well as the tendency to harm others (i.e., dual harmers) (Richmond-Rakerd et al., 2019). Put differently, childhood self-control demonstrates compelling evidence of being a possible causal factor in the prediction of harming oneself, harming conspecifics, and predisposing to various types of victimization. It stands to reason, then, that clinical interventions effective at improving self-regulatory skills early in life may net a widespread benefit for the individual and society.

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Compliance with ethical standards

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