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Intergenerational Transmission of Delay Discounting: The Mediating Role of Household Chaos

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Abstract

Introduction: Adolescence is a period when impulsive decision making may be especially vulnerable to environmental influences. Impulsive decision making is often assessed using a delay discounting paradigm, which measures the preference for smaller rewards sooner over larger rewards with a delay. Research is needed to clarify the relationship between parents' and adolescents' delay discounting and to identify related environmental processes that might facilitate the intergenerational transmission of delay discounting. The current prospective longitudinal study examined the competing mediating processes of household chaos and harsh parenting in the intergenerational transmission of delay discounting between parents and adolescents.

Methods: Participants included 167 adolescents (mean age = 14.07 years at Time 1; 53% male) and their parents (mean age = 41.98 years at Time 1; 87% female) recruited from the southeast United States. Parents' delay discounting was collected at Time 1, and adolescents' delay discounting was collected both at Time 1 and at Time 3 via a computerized delay discounting task. Parents and adolescents reported household chaos and harsh parenting at Time 2.

Results: A parallel mediation model indicated that parents' delay discounting at Time 1 indirectly predicted adolescents' delay discounting Time 3 residualized change scores (regressing Time 3 delay discounting onto baseline delay discounting) through household chaos but not through harsh parenting at Time 2.

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Conclusions: These results underline the importance of household chaos in facilitating the intergenerational transmission of delay discounting between parents and adolescents. Furthermore, our findings point to household chaos as a potential environmental target for interrupting intergenerational impulsivity.

Keywords

impulsivity; delay discounting; household chaos; harsh parenting; intergenerational transmission; decision making

Impulsive decision making is a dimension of impulsivity (MacKillop et al., 2016) that is typically assessed via a delay discounting paradigm which measures the preference for smaller, immediate rewards instead of larger rewards over a temporal delay (Bickel et al., 2007). The competing neurobehavioral decision systems (CNDS) theory suggests that immediate rewards disproportionately activate evolutionarily older, subcortical limbic and paralimbic systems and delayed rewards activate the more recently evolved cortical frontal-parietal systems (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012; Bickel et al., 2007; Bickel, Moody, Quisenberry, Ramey, & Sheffer, 2014; McClure, Laibson, Loewenstein, & Cohen, 2004). A delay discounting task recruits these conflicting systems, one that mediates impulsivity and reward seeking and the other that mediates higher order thought processes (Steinberg et al., 2009). Greater delay discounting has been associated with adolescent health-risk taking and problem behaviors including substance use initiation, substance use disorders (Bickel et al., 2007; Kim-Spoon, McCullough, Bickel, Farley, & Longo, 2015), gambling problems (Cosenza & Nigro, 2015; Dixon, Jacobs, & Sanders, 2006), Attention Deficit Hyperactivity Disorder (ADHD; Patros et al., 2016), and risky sexual behaviors (Kahn, Holmes, Farley, & Kim-Spoon, 2015). Preliminary research suggests delay discounting may be an etiological predictor of substance use (Audrain-McGovern et al., 2009). However, to date, little is known about environmental influences that contribute to the development of delay discounting. One important question is whether parents' delay discounting is related to adolescents' delay discounting and if so, what processes are involved in its intergenerational transmission.

Intergenerational Transmission of Delay Discounting

Extant research suggests adolescents' development of delay discounting may be influenced by both genetic and environmental factors. A preliminary heritability study of delay discounting in adolescent twins found significant genetic and environmental influences on adolescent delay discounting (Anokhin, Golosheykin, Grant, & Heath, 2011). Specifically, genetic factors significantly influenced adolescent delay discounting at ages 12 and 14, and these influences increased with age. Additionally, adolescents from low socioeconomic status (SES) preferred smaller, immediate rewards relative to their higher SES peers, indicating that environmental influences may also play an important role in shaping delay discounting, above and beyond heritability. However, this study only used a single choice response as an index of adolescent delay discounting and did not examine potential explanatory processes involved. Another preliminary study of the associations between delay discounting and smoking of mothers and adolescents did not find significant

associations between mothers' delay discounting and adolescents' delay discounting (Reynolds, Leraas, Collins, & Melanko, 2009). However, this study focused only on smoking and included only maternal primary caregivers. Thus, the paucity of studies examining the link between parents' and adolescents' delay discounting warrants further investigation of the contributions of parents' delay discounting and intervening influences in adolescents' delay discounting development.

Adolescents derive signals of resource predictability and abundance experientially, through direct interactions with their environments, or vicariously, through social interactions (Griskevicius, Tybur, Delton, & Robertson, 2011). Parents are primary socialization agents from whom adolescents glean cues about the relative stability of their contexts, resources, and opportunities for fine-tuning their decision making. These cues may influence adolescents' perceived likelihood of receiving delayed rewards (due to life expectancy, competition, or opportunity costs) to contribute to delay discounting (Stevens & Stephens, 2010). Household chaos and harsh parenting may be mediating environmental influences that explain how parents' delay discounting may be related to adolescents' delay discounting (Romer, Reyna, & Satterthwaite, 2017). It follows that adolescents' delay discounting may be influenced by parents' delay discounting as well as the environments they cultivate (Brumbach, Figueredo, & Ellis, 2009).

Harsh Parenting as a Mediating Influence for Intergenerational Transmission of Delay Discounting

Parents' delay discounting may influence their parenting practices. For example, the tendency to engage in harsh parenting practices including less inhibited aggression may be reflective of a parent's delay discounting. Indeed, parents with lower cognitive control are especially at risk for engaging in harsh parenting practices (Crandall, Deater-Deckard, & Riley, 2015), which have been associated with increased impulsivity in children (Neppl, Dhalewadikar, & Lohman, 2016). Additionally, there is evidence that mothers' poor discipline (measured by harsh discipline, poor implementation of discipline, and low confidence in discipline) may have a greater impact on adolescents' development of self-regulation (measured by effortful control) than positive parenting (Tiberio et al., 2016). Furthermore, impulsive parental implementation of discipline, especially discipline consisting of corporal punishment, has been linked with impulsive and aggressive behaviors in children (Gershoff et al., 2010). Thus, parents' impulsive decision making may result in greater harsh parenting, and in turn engender greater impulsive decision making in adolescents. Such a link may be explained by Gottfredson and Hirschi's (1990) model of self-control, which posits that control is first imposed and later internalized through parent-child socialization processes. Parents who demonstrate poor self-control and engage in harsh parenting practices are less likely to successfully promote adolescents' self-control development (Bridgett, Burt, Edwards, & Deater-Deckard, 2015).

Household Chaos as a Mediating Influence for Intergenerational Transmission of Delay Discounting

Parents' delay discounting may relate to the household environments they cultivate and their socialization of similar delay discounting in their adolescents. Specifically, parents' delay discounting behaviors (e.g., distractibility, disorganization, lack of planning, and unpredictability) may contribute to household chaos, characterized by a lack of structure, quiet, routine, or stability (Deater-Deckard, Chen, Wang, & Bell, 2012). Household chaos may have important implications for adolescents' development of impulsive behaviors and self-regulation. Specifically, noise and instability characteristic of chaotic households may preoccupy attention or impair cognitive functioning, which have been associated with the preference for immediate over delayed rewards (Evans, 2003, 2005; Mani, Mullainathan, Shafir, & Zhao, 2013). Indeed, routines and rituals have been found to implicitly facilitate children's inhibition of impulsive behaviors and delayed gratification (Rybanska, McKay, Jong, & Whitehouse, 2018).

According to life history theory, harsh and uncertain environments may orient adolescents' attention to the present instead of the future and thereby bias their preferences for immediate, certain rewards to avoid the possibility that delayed rewards may not materialize (Bulley, Henry, & Suddendorf, 2016; Griskevicius et al., 2011; Kaplan, Hill, Lancaster, & Hurtado, 2000; Mani et al., 2013). Interpreted through the lens of the stress-vulnerability hypothesis (Sinha, 2001), household chaos may be an environmental factor that heightens adolescents' vulnerability for maladaptive decision making such as delay discounting. For example, adolescents from chaotic households may exhibit greater impulsive choice to avoid unpleasurable environmental circumstances (e.g., noise, instability).

In chaotic household environments, frenetic conditions may confer the interpretation that the future lacks predictability to contribute to decision making that favors smaller more immediate rewards over larger, temporally distal rewards (Hill, Jenkins, & Farmer, 2008). Therefore, it is not surprising that adolescents from chaotic households have reported less optimistic beliefs about their futures which may lead to greater delay discounting where immediate rewards are a "sure thing" instead of future rewards that lack certainty (Thorstad & Wolff, 2018). Furthermore, household chaos has been shown to confer unique environmental risks for children's problem behaviors, beyond the contributions of parent-child relationships (Coldwell, Pike, & Dunn, 2006). Indeed, findings from an experimental study by Kidd, Palmeri, and Aslin (2013) indicate children's beliefs and behaviors about the advantages of delaying receipt of rewards may depend upon their perceptions of environmental reliability. Thus, a chaotic household may be one such mediator that explains the relationship between parents' delay discounting and adolescents' delay discounting, above and beyond parent-adolescent relationships.

The Present Study

The objectives of the present study were twofold: 1) To examine the associations between parents' delay discounting and adolescents' delay discounting and 2) To test competing mediating family and household processes that might explain intergenerational transmission

of delay discounting between parents and adolescents. We used a prospective longitudinal design to determine the intergenerational associations between parents' delay discounting and adolescents' delay discounting and tested parallel mediators of household chaos and harsh parenting. We hypothesized that greater parents' delay discounting would be related to lesser declines in adolescents' delay discounting. Further, we hypothesized that greater parents' delay discounting would be related to greater household chaos and greater harsh parenting, which would in turn be related to lesser declines in adolescents' delay discounting.

Methods

Participants

Participants were recruited from the southeast United States for their participation in a broader longitudinal study on adolescent brain development and health-related behaviors. Dyads were deemed ineligible to participate from the study's outset if adolescents presented contraindications for neuroimaging. The sample consisted of 167 adolescents (53% male) and their primary caregivers (83% biological mothers, 12% fathers, 1% grandmothers, 1% foster mothers, and 3% other). Adolescents were between the ages of 13 and 14 at Time 1 (M = 14.07, SD = 0.54), 14 and 15 at Time 2 (M = 15.05, SD = 0.54), and 16 and 17 at Time 3 (M = 17.01, SD = 0.55) and identified mostly as Caucasian (79%), followed by African-American (13.8%), more than one race (4.8%), Asian (1.8%), and American Indian/Alaska Native (.6%). Median annual household income was between $35,000 and $49,999 at the initial assessment. Parents identified mostly as Caucasian (88.6%), African-American (10.8%), and more than one race (.6%). Of the 167 dyads who participated in the study, 16 dyads did not return at Time 3 for reasons such as: Moved away (n = 1), extenuating circumstances (n = 2), declined participation (n = 8), and lost contact (n = 5). However, despite partially missing data from adolescents who did not participate at all time points, the final sample included 167 adolescents. Logistic regression indicated no significant baseline demographic differences (e.g., age, gender, race, and income) between the dyads who withdrew and those who continued throughout the study (all ps > .642). Data collection took place at the university offices where adolescents and their parents were interviewed separately by trained research assistants. Prior to participation, adolescents provided written assent and their parents provided written consent in accordance with the university's institutional review board approved protocol.

Measures

Harsh Parenting.—Adolescents were asked to rate the extent their parents directed verbal aggression or criticism towards them and parents were asked to rate the extent to which they directed verbal aggression or criticism towards their adolescents using three items from the Conflict subscale of the Parent-Child Relationship Inventory at Time 2 (Hetherington & Clingempeel, 1992). This subscale consists of questions such as, "How much do you yell at this child after you've had a bad day?" and uses a 5-point response scale ranging from 1 (*extremely*) to 5 (*not at all*). A composite was computed using an average of parent and adolescent responses on three items, reverse-scored, and averaged. Higher scores were

indicative of greater parent-child negativity. Subscale reliability was acceptable with internal consistency of α = .72 at Time 2 for adolescents and α = .69 at Time 2 for parents.

Chaotic Households.—The short version of the Confusion, Hubbub and Order Scale (CHAOS) was administered to adolescents and parents to measure self-reported degree of chaos in the household at Time 2 (CHAOS; Matheny, Wachs, Ludwig, & Phillips, 1995). This scale distinctly taps into the degree of ambient noise, crowding, and traffic in the household. Adolescents and parents were asked to rate six statements about their households such as, “You can’t hear yourself think in our home,” and, “We have a regular morning routine at home.” The items were rated on a 5-point Likert scale ranging from 1 (*definitely untrue*) to 5 (*definitely true*) and a composite was computed using an average of adolescent and parent responses on the six items at Time 2. Higher scores were indicative of greater household chaos. Scale reliability was consistent with prior studies (Deater-Deckard, Chen, Wang, & Bell, 2012; Deater-Deckard et al., 2009) with internal consistency of α = .64 at Time 2 for adolescents and α = .62 at Time 2 for parents.

Delay Discounting.—An index of adolescents’ and parents’ and delay discounting was derived using a computerized delay discounting task (Johnson & Bickel, 2002). Adolescents completed the task at Time 1 and Time 3 whereas parents completed the task at Time 1. Participants were given a series of hypothetical monetary decisions in which they made choices between an immediate monetary reward and a larger monetary reward with a delay. The reward amount chosen was $100. Choices were presented using the following delays: One day, one week, one month, and one year. Individual indifference points were calculated using the area under the curve (AUC) approach to measurement (Myerson, Green, & Warusawitharana, 2001). AUC values can range from 0 to 1, with 0 representing extreme discounting and 1 representing no discounting. We performed ordinal transformation of AUC values to retain equal contributions of each delay to the overall AUC using the prescribed methods of Borges, Kuang, Milhorn, and Yi (2016). We then used the Johnson and Bickel (2008) algorithm for identifying and excluding cases demonstrating nonsystematic discounting from the analysis for violating the assumption of monotonic decreases in discounting function. Data were identified as nonsystematic for either or both of two reasons: (1) If following the first delay, an indifference point was greater than the previous indifference point by 20% of the larger, later reward, and (2) if the last indifference point (calculated at one year) was not any different from the first indifference point (calculated at one day). Less than 10% of parent delay discounting cases were identified as nonsystematic (n = 14), whereas less than 5% of adolescent delay discounting cases were identified as nonsystematic at Time 1 (n = 6) and less than 5% of adolescent delay discounting cases were identified as nonsystematic at Time 3 (n = 6). We computed adolescents’ delay discounting residualized change scores by regressing Time 3 delay discounting on Time 1 delay discounting, with lower scores indicating lesser declines in adolescents’ delay discounting from Time 1 to Time 3.

Statistical Analyses

To test the significance of the putative mediators of harsh parenting and chaotic households in the link from parents’ delay discounting to adolescents’ delay discounting, we

simultaneously contrasted the individual indirect effects in a parallel mediation model (Preacher & Hayes, 2008). Because of the hypothesized associations between adolescent onset changes in impulsivity and subsequent health-risk taking behaviors, we tested the associations between parents' baseline delay discounting and adolescents' changes in delay discounting from Time 1 to Time 3. We conducted a paired *t*-test to test for significant changes between adolescents' delay discounting at Time 1 and Time 3. We also conducted Little's MCAR (1988) test for patterns of missingness on all study variables. The resulting pattern resembled a completely at random pattern (MCAR; Little's MCAR test on all variables in this study: $\chi^2 = 9.29$, $df = 11$, $p = .595$). Therefore, we used Full Information Maximum Likelihood (FIML) estimation with robust standard errors (MLR) to account for missing data and non-normal distributions. FIML is superior to listwise deletion, pairwise deletion, and similar response pattern imputation because it retains statistical power and produces unbiased estimates (Enders & Bandalos, 2001). We estimated the models using M*plus* version 8 (Muthén & Muthén, 1998–2017) and adhered to the Hu and Bentler (1999) recommended criteria for evaluating model fit using Root Mean Square Error of Approximation (RMSEA) values less than .06 and Comparative Fit Index (CFI) values greater than or equal to .95. We followed the recommendation of Mackinnon, Lockwood, and Williams (2004) to test the indirect effects using bias-corrected bootstrap confidence intervals (CIs). These CIs take non-normality of the estimates into account and are therefore not necessarily symmetric (Muthén & Muthén, 1998–2017). We compared the results including and excluding nonsystematic delay discounting cases and the findings were consistent regardless of whether nonsystematic cases were included in the analysis. Thus, the reported results include all cases.

Results

Prior to our analysis, data were screened for univariate outliers exceeding 3 standard deviations from the mean (Tabachnick & Fidell, 2007) and were tested for acceptable levels of skewness less than 3 and kurtosis less than 10 (Kline, 2011). Results of univariate general linear modeling (GLM) demonstrated that demographic variables at Time 1 were not significant predictors of adolescent delay discounting at Time 3, thus they were not included as covariates in the final analyses ($p = .266$ for adolescent age, $p = .221$ for adolescent gender, $p = .524$ for adolescent race, and $p = .116$ for household income). Descriptive statistics (means, standard deviations, ranges, and correlations) for study variables are shown in Table 1. Zero-order correlations between parents' delay discounting at Time 1 and adolescents' delay discounting at Times 1 and 3 were significantly positively correlated. Results from the paired *t*-test indicated adolescents' delay discounting significantly decreased between Time 1 and Time 3, $t(130) = -5.02$, $p = .000$ (see Table 1).

We tested the competing mediators of harsh and unpredictable environments at Time 2 by which parents' delay discounting at Time 1 might indirectly be associated with greater adolescents' delay discounting Time 3 residualized change scores (controlling for their baseline level of delay discounting). We first analyzed a fully saturated model that estimated all direct and indirect effects from Time 1 parents' delay discounting to Time 3 adolescents' delay discounting residualized change scores (see Figure 1; RMSEA = .00; CFI = 1.00; $\chi^2 = 0$, $df = 0$, $p = 0$). In this model, the indirect effect from parent delay discounting to

adolescent delay discounting via household chaos was significant (95% CI [.004; .11]), but harsh parenting was not (95% CI [− .02; .02]). Specifically, the path from Time 1 parents' delay discounting to Time 2 household chaos ($b = -1.00$, $SE = .24$, $p = .000$) and the path from Time 2 household chaos to Time 3 adolescent delay discounting residualized change scores ($b = -.04$, $SE = .02$, $p = .037$) were significant. Neither the path from Time 1 parents' delay discounting to Time 2 harsh parenting ($b = -.01$, $SE = .29$, $p = .980$) nor the path from Time 2 harsh parenting to Time 3 adolescent delay discounting residualized change scores was significant ($b = -.02$, $SE = .02$, $p = .183$). Additionally, the direct effect from Time 1 parent delay discounting to Time 3 adolescent delay discounting residualized change scores was not significant ($b = .04$, $SE = .07$, $p = .580$). Nonetheless, this nonsignificant direct effect from parents' delay discounting to adolescents' delay discounting residualized change scores did not preclude further tests of mediation given that a significant direct effect is not required for mediation (Hayes, 2014).

Next, we evaluated the nested model comparison between the full model and a trimmed model (removing non-significant paths including the direct path from Time 1 parents' delay discounting to Time 3 adolescents' delay discounting residualized change scores and the path from Time 1 parents' delay discounting to Time 2 harsh parenting and the path from Time 2 harsh parenting to Time 3 adolescents' delay discounting residualized change scores) using the Satorra-Bentler scaled chi-square statistic (Satorra & Bentler, 2001). Such model trimming was beneficial with respect to evaluating the overall model fit (because the full model was a saturated model which could not be evaluated for model fit). The results indicated that the trimmed model (the 'final' model) was more parsimonious than the full model ($\Delta\chi^2 = .21$, $\Delta df = 1$, $p = .434$). This final model exhibited excellent fit ($\chi^2 = .21$, $df = 1$, $p = .646$, CFI = 1.00, RMSEA = .00).

In the final model (see Figure 1), greater parents' delay discounting at Time 1 was related to greater household chaos at Time 2 ($b = -1.00$, $SE = .24$, $p = .000$), which in turn was related to lesser declining rates of adolescents' delay discounting from Time 1 to Time 3 ($b = -.06$, $SE = .02$, $p = .003$). The indirect effect from Time 1 parents' delay discounting to Time 3 adolescents' delay discounting residualized change scores via household chaos at Time 2 was significant (bias-corrected bootstrap 95% CI [.02; .11]).

Discussion

The present longitudinal study examined the intergenerational transmission of parents' and adolescents' delay discounting directly and indirectly. Consistent with the literature on adolescents' development of delay discounting, adolescents' delay discounting generally declined with age (Olson, Hooper, Collins, & Luciana, 2007; Steinberg et al., 2009). We interpret these developmental declines to potentially signify the closing of a developmental window of vulnerability for impulsive decision making brought on by asynchronously developing reward and reflective brain systems (Steinberg et al., 2009). Our hypothesis that greater parents' delay discounting would be related to greater adolescents' delay discounting over time was informed by evidence in the literature of a heritability component to delay discounting. This hypothesis was partially supported. Although greater parents' delay discounting at Time 1 was significantly related to greater adolescents' delay discounting at

Time 3 (see Table 1), it was not directly related to changes in adolescents' delay discounting from Time 1 to Time 3. To examine the mediating processes through which adolescents with highly impulsive parents tended to exhibit elevated impulsivity over time, we tested a parallel mediation model (Preacher & Hayes, 2008) which allowed us to evaluate the relative contributions of the competing mediators of household chaos and harsh parenting to the intergenerational transmission of delay discounting. We identified household chaos as the prominent mediator linking parents' delay discounting to changes in adolescents' delay discounting. Greater parents' delay discounting was subsequently related to greater household chaos, which in turn was related to lesser longitudinal declines in adolescents' delay discounting. In contrast, harsh parenting did not significantly mediate the link between parents' delay discounting and adolescents' delay discounting.

Our findings implicate household chaos as an intervening environmental influence that may alter otherwise typical developmental declines in adolescent delay discounting. These findings align with the stress-vulnerability model (Sinha, 2001), and indicate that chaotic household environments may facilitate the heritability of maladaptive decision making between parents and adolescents. That is, chaotic households may disrupt typically declining delay discounting trends from middle to late adolescence. As such, the effects of household chaos might be especially pernicious during adolescence when reward sensitivity is heightened and prefrontal cortical development associated with top-down self-regulation is underway (Casey, Jones, & Hare, 2008).

We hypothesized that household chaos and harsh parenting would exacerbate heritability risks for adolescents' delay discounting. According to life history theory, individuals derive cues from their environments about relative resource availability and these environmental cues have been linked with individual differences in impulsivity and risk taking across development (Griskevicius et al., 2011; Kaplan et al., 2000). Unstable or inconsistent environmental cues may elicit a heightened preference for smaller immediate rewards over larger delayed rewards (Ainslie, 1975). Individual differences in decisional biases may also contribute to delay discounting preferences. For example, individuals are typically more averse to losses than attracted to gains (Tversky & Kahneman, 1992) and greater familiarity with risky decision making may lower perceptions of related risk (Weber & Johnson, 2009). Thus, delay discounting choices may be complicated by unstable or unpredictable environmental cues and individual decisional biases that prioritize risk aversion over reward sensitivity and tend to underestimate risks.

Our findings suggest that beyond heritable similarity, parents may facilitate adolescents' delay discounting by cultivating chaotic household environments that impinge upon adolescents' reward-based decision making. We infer that the unpredictability and inconsistency characteristic of chaotic households may promote uncertainty about the stability of reward contingencies and thereby elicit decisions that favor immediate rewards. That is, one way for adolescents to cope with chaotic households could be to take immediate advantage of opportunities as they become available, lest they fail to come around a second time. The preference for immediate, certain rewards may also reflect aversion to potential loss of long-term gains that may never materialize. In chaotic households, this preference for immediacy could serve in an adolescent's favor to optimize reward receipt despite unreliable

reinforcement. However, beyond the confines of decision making in a chaotic home, the sustained preference for immediate rewards combined with the tendency to underestimate risks may exacerbate genetic and developmental predilections for risk-taking (Fields, Leraas, Collins, & Reynolds, 2009; Kahn et al., 2015; Kim-Spoon et al., 2015).

Prior literature suggests a parent's emotional state may prepare them to reactively engage in any variety of parenting practices (Teti & Cole, 2011) and parents who display unpredictable and volatile emotions may be at greater risk for engaging in harsh parenting practices (e.g., Hiraoka et al., 2016). There is also evidence that deficits in parent-adolescent relationship quality associated with harsh or insensitive parenting may be reflective of poor parental self-regulation (Johnston, Mash, Miller, & Ninowski, 2012). Given these risks, we hypothesized that greater parents' delay discounting would manifest in harsher parenting practices that would evoke greater delay discounting in adolescents in-turn. However, we did not find evidence that the association between parents' and adolescents' delay discounting is mediated by harsh parenting. Moreover, harsh parenting was related to neither parents' delay discounting nor adolescents' delay discounting. Our findings differ from prior research suggesting a significant association between parent-adolescent relationship quality and adolescent delay discounting (Kahn et al., 2015). This may be because the previous study examined positive parent-adolescent relationship quality whereas we examined negative parent-adolescent relationship quality as an index of harsh parenting. Perhaps, positive parent-adolescent relationship quality may be a more salient relationship for parents' and adolescents' delay discounting than negative dimensions of parenting, such as harsh parenting.

The current findings should be interpreted in the context of study limitations. First, most of the primary caregivers in the present sample were mothers. Future studies should consider investigating how adolescents' delay discounting might be differentially influenced by the nature of their relationships with their primary caregivers (e.g., biological relatedness, or caregiver role such as parent versus grandparent). Additionally, although we incorporated reports from multiple informants, household chaos was measured via parent and adolescent self-report. In-vivo observations of household chaos could help mitigate potential concerns related to reporter bias. Furthermore, the generalizability of the current findings to more culturally and ethnically diverse samples awaits further research. Finally, the current longitudinal design precluded our ability to make strong causal inferences. Experimental research would elucidate the causal associations among household chaos and delay discounting. Longitudinal studies involving delay discounting task-based neuroimaging would provide insight into the neurobiological processes underlying adolescents' delay discounting decisions to clarify whether elevated delay discounting developmental trajectories reflect sustained hyperactive responses to rewards, hypoactive executive functioning, or both.

Our results indicate a significant association between parents' and adolescents' delay discounting and provide further insight into the critical role of household chaos in facilitating the link between parents' delay discounting and adolescents' development of delay discounting. It stands to reason that adolescents' delay discounting development may be amenable to interventions targeting household chaos, which may be especially effective

during periods of rapid brain development (Casey et al., 2008). Indeed, researchers have found optimistic results from nascent delay discounting interventions (Sheffer et al., 2016), suggesting that delay discounting may be experientially influenced. Our findings highlight the role of household chaos in adolescents' delay discounting development and indicate that household targeted interventions (e.g., promoting consistent routines and improving household tranquility) may disrupt the intergenerational transmission of delay discounting.

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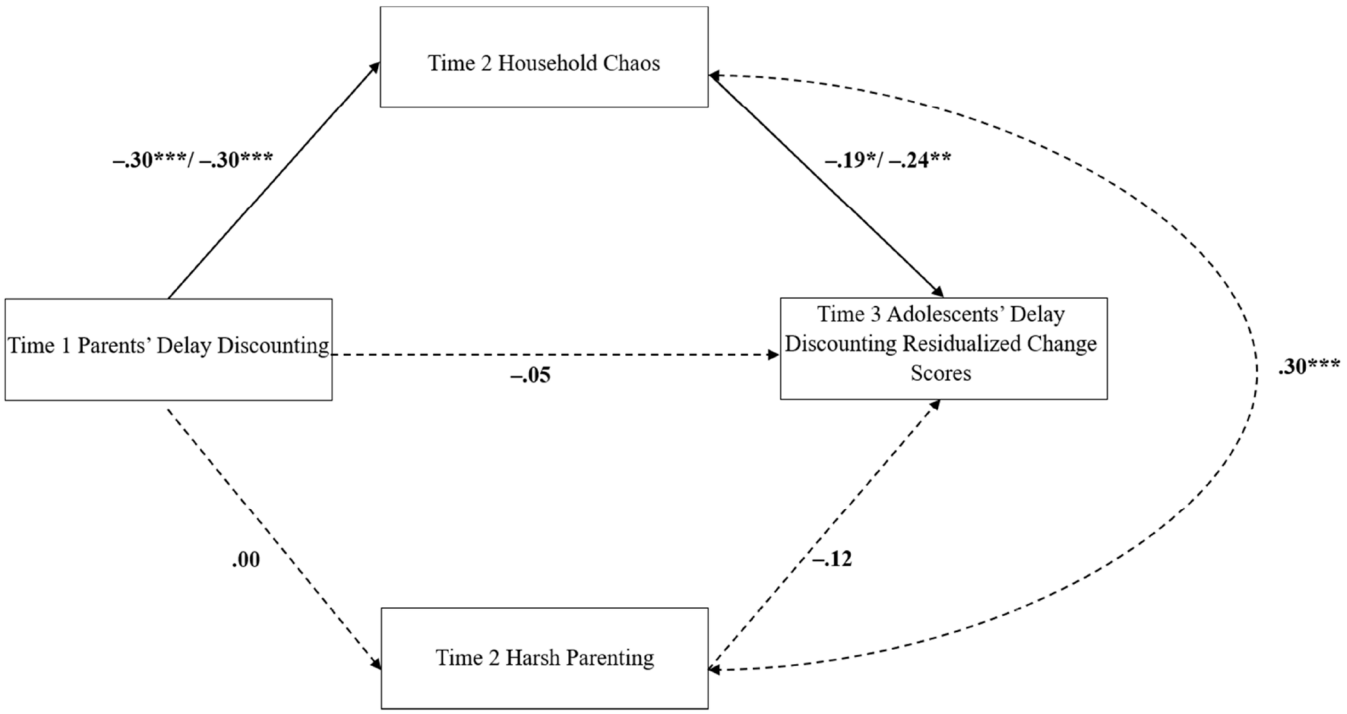

Figure 1.

Parallel mediation model of the indirect effect from parents' delay discounting at Time 1 to adolescents' delay discounting Time 3 residualized change scores through Time 2 household chaos. Dashed lines indicate paths that were trimmed from the final model. Full model estimates are presented preceding the slashed line, whereas final model estimates are presented following the slashed line. Standardized coefficients are presented. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 1.

Descriptive statistics and correlations of Parents' and Adolescents' Delay discounting, Household Chaos, and Harsh Parent-Adolescent Relationship Quality

Variables	1	2	3	4	5	*M (SD)*	Range
1. Time 1 Parents' Delay discounting (AUC)						.57 (0.16)	.17–.74
2. Time 1 Adolescents' Delay discounting (AUC)	.29**					.50 (0.19)	.01–.74
3. Time 2 Harsh Parenting	.01	−.02				2.03 (0.61)	1.00–3.83
4. Time 2 Household Chaos	−.29**	−.12	.29**			2.42 (0.52)	1.25–3.75
5. Time 3 Adolescents' Delay discounting (AUC)	.20*	.60**	−.18*	−.27**		.58 (0.15)	.08–.74
6. Time 3 Adolescents' Delay discounting (AUC) Residualized Change Scores	.08	.00	−.17	−.23*	.80**	.00 (0.12)	−0.34–0.24

Note: Composite scores of harsh parenting and household chaos were computed using an average of parent and adolescent reports at Time 2. Time 3 adolescents' delay discounting residualized change scores were calculated by controlling for their baseline delay discounting.

* $p < .05$,

** $p < .01$.