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Adolescent risk behavior: Differentiating reasoned and reactive risk-taking

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Abstract

Although explanatory models of adolescent risk behavior have predominantly focused on adolescents' limited ability to self-regulate impulsive and/or reward-driven behavior (reactive risk behavior), recent arguments suggest that a significant proportion of adolescent risk behavior may actually be strategic and planned in advance (reasoned risk behavior). The present study evaluates hypothesized predictors of reasoned versus reactive risk behavior using self-reported and neurocognitive task data from a large, diverse adolescent sample (N = 1,266 participants; N = 3,894 risk behaviors). Participants' mean age was 16.5 years (SD = 1.1); 56.9% were female, 61.9% White, 17.1% Black, 7.0% Hispanic, and 14.1% other race/ethnicity; 40% were in 10th grade, 60% in 12th grade. As hypothesized, reasoned risk behavior (compared to reactive risk behavior) was associated with higher levels of sensation seeking, better working memory, greater

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Authors' Contributions

JM conceived of the study, conducted the statistical analysis, and wrote the initial draft of the manuscript. OO assisted in study conception and writing. DK and EH designed and executed the survey. EH organized data preparation and assisted in study conception and writing. DK assisted in study conception and writing. All authors read and approved the manuscript.

Data Sharing Declaration

The investigators are committed to sharing the data generated through this research, however, data collection is currently ongoing and is not currently publically available. Under the terms of our grant, we intend to make data available to the wider research community within 12 months following the completion of data collection. This includes all self-report, neurocognitive, and imaging parameters which will be included in the database, along with demographic information that does not risk confidentiality

Conflicts of interest

The authors declare no conflict of interests.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Ethical approval

The study has been granted ethical approval by the University of Michigan Institutional review Board.

Informed consent

Informed consent was obtained from parents of all minor participants included in the study. Minor participants also provided assent to participate. Participants age 18 and older provided informed consent to participate.

future orientation, and perceiving risk behavior to be more beneficial than risky. These results support the distinction between reasoned and reactive risk behavior as meaningful subtypes of adolescent risk behavior and challenge prevailing frameworks that attribute adolescent risk behavior primarily to poor response inhibition.

Keywords

Risk behavior; Sensation seeking; Future orientation; Working memory; Risk/benefit appraisal

Introduction

Adolescents' engagement in risk behavior results in substantial mortality and morbidity. In the U.S., approximately ten thousand 15- to 19-year-olds die every year, mostly from preventable causes related to risk behavior (Heron, 2017; Murphy et al. 2017). Unintentional injury, for example, the leading cause of deaths among adolescents, includes motor vehicle accidents (i.e., risky driving), poisoning (including drug and alcohol overdoses), and drowning. Another 2 million adolescents experience serious injuries each year due to similar causes (Centers for Disease Control and Prevention [CDC] 2016). Understanding the etiology of adolescent risk behavior is essential to inform intervention and prevention strategies to reduce unnecessary morbidity and mortality during this period of life.

Explanatory models of adolescent risk behavior continue to evolve. During the past decade, the dual systems model (Casey et al. 2008; Steinberg 2008) has been a dominant framework for conceptualizing the mechanisms underlying adolescent risk behavior. This approach hypothesizes that adolescents' elevated rates of risk behavior stem from a mismatch between reward-driven behavior and the ability to self-regulate, owing to a structural and functional maturational imbalance between two neural systems, cognitive control and incentive processing. The cognitive control system exerts functions such as decision making, judgment, and response inhibition (Casey and Jones 2010), whereas the incentive processing system responds to emotionally arousing and rewarding stimuli (Van Leijenhorst et al. 2010). According to the dual systems model, the incentive processing system matures earlier than the cognitive control system, leading to imbalances between reward-driven behavior and the ability to self-regulate such behavior (Casey et al. 2008; Steinberg 2008).

Reasoned and Reactive Risk Behavior

Recent work has suggested that the dual systems model should be refined to reflect two evident subtypes of adolescent risk behavior: reasoned and reactive risk behavior (Gibbons et al. 2009; Reyna and Farley 2006; Romer et al. 2017). Reasoned risk behavior is premeditated, with adolescents purposefully choosing to engage in activities they know to be risky in order to gain some benefits they believe to be associated with those activities. This behavior is exploratory, but it can also be adaptive in its support of the development of independence and self-sufficiency. In contrast, reactive risk behavior occurs in the moment; it is impulsive, driven by a developmental or individual deficit in response inhibition (Romer et al. 2017). A given type of risk behavior can be either reasoned or reactive. For example, alcohol use may be reasoned (an adolescent attends a party knowing there will be alcohol

and intending to drink) or reactive (an adolescent impulsively engages in alcohol use when the opportunity arises, but did not purposely seek out alcohol or plan in advance to drink). Romer et al. (2017) argue that the dual systems model explains reactive risk well but does not fully encompass the mechanisms underlying reasoned risk.

Whereas reactive risk behavior reflects lower executive capability to regulate prepotent responses, reasoned risk behavior seems to result from increased reliance on relatively more mature executive functioning that enables adolescents to engage in purposeful behavior. Reasoned risk behavior is thought to increase with age—as executive function improves and adolescents accrue experience with various risk behaviors that allows them to forecast potential consequences and engage in behaviors more purposefully in pursuit of perceived benefits (Gibbons et al. 2009; Pomery et al. 2009). Working memory is a particularly important component of executive function in this regard.

Working Memory

Working memory refers to the ability to temporarily store and manipulate a limited amount of goal-relevant information in order to execute complex cognitive tasks (Miller and Cohen 2001). Because working memory capacity is limited, successful deployment of working memory capacity requires strong executive attention to attune to the most goal-relevant information in the environment and suppress attention to other, distracting information (Engle 2002). Khurana and colleagues have argued that poorer working memory in adolescents is related to decreased ability to suppress momentary urges and shown that lower working memory abilities are related to a range of adolescent risk behaviors including early sexual debut (Khurana et al. 2012) and drug use (Khurana et al. 2013).

Working memory is particularly relevant to the distinction between reasoned and reactive risk behavior. Working memory supports retrieval and maintenance of explicit attitudes and self-regulatory goals, which in turn support self-monitoring of behavior and engagement in more goal-directed versus impulsive actions (Hofmann et al. 2008). As adolescents gain experience in taking risks, those with better working memory capabilities may be able to integrate their experiences (e.g., the positive or negative consequences that have resulted from a given behavior) to drive more strategic future behavior such as reasoned risk behavior (Romer et al. 2017). Those with worse working memory capacities may conversely be more likely to engage in reactive risk behavior. In a college student sample, Hinson et al. (2003) found that both individual differences in working memory and experimentally manipulated levels of working memory load were related to more impulsive decision making (preferring more immediate over longer-term rewards) in a delayed discounting task.

Response Inhibition

Response inhibition is the ability to suppress a prepotent behavioral response in favor of a behavior that is more contextually appropriate or goal-oriented. Lower response inhibition abilities in adolescents are associated with more engagement in risky behaviors, including risky driving (Ross et al. 2015), early onset cigarette smoking (Mashhoon et al. 2018), and alcohol use (Henges and Marczinski 2012). Poor response inhibition is also a prospective predictor of risk behavior in adolescence, such as early engagement in alcohol use (Peeters

et al. 2015). Dual systems models attribute the majority of adolescent risk behavior to failure of response inhibition resulting from ineffective top-down regulation by the cognitive control system of prepotent responses driven by the incentive processing system (Casey et al. 2008; Steinberg 2008). The reasoned/reactive risk behavior framework views poor response inhibition as a primary driver of reactive risk only (Romer et al. 2017).

Sensation Seeking

Sensation seeking is a personality characteristic that involves a drive to pursue novel and exciting situations (Zuckerman 2007). Sensation seeking increases in early adolescence, peaks in mid-adolescence (~age 15), and declines in late adolescence (Harden and Tucker-Drob 2011; Steinberg et al. 2008). In addition to such developmental differences, individual differences in sensation seeking are positively correlated with risk behavior in adolescents (Crawford et al. 2003; Quinn and Harden 2013). One reason why high sensation-seeking adolescents engage in more risk behavior may be that they perceive the benefits of risk behavior to outweigh its risks, given their attraction to thrills and excitement (Maslowsky et al. 2011a). Sensation seeking is positively correlated with working memory performance during adolescence, perhaps due to puberty-induced increases in hormones supporting brain development and increasing sensation-seeking drives (Khurana et al. 2012; Romer et al. 2011). Romer et al. (2017) argue that simultaneous development of sensation seeking and executive functions such as working memory may underlie increased engagement in reasoned risk behavior across adolescence.

Risk/Benefit Appraisal

Reyna and Farley's (2006) characterization of reasoned risk includes deliberate consideration of the benefits versus risks of a particular behavior before planning to engage in it. Perceived benefits of a potential behavior may motivate adolescents to engage in reasoned risk behavior by planning that behavior in advance, engaging both cognitive and self-regulatory abilities to strategically engage in behavior that they believe likely to yield rewards. Although the adolescent cognitive system is not fully mature, adolescents are highly capable of the calculation and self-organization necessary to engage in reasoned risks (Luciana 2013; Reyna et al. 2015). Adolescents' overreliance on computing risk versus benefit tradeoffs of behavior has led some to characterize adolescents' decision making as hyperrational in comparison with the decision making of adults, who are more likely to rely on an intuitive or "gist" sense that a behavior is risky (Reyna et al. 2015). Adolescents' perceived benefits predict risk behavior independently of perceived risks (Goldberg et al. 2002), and adolescents in whom perceived benefits of risk behavior outweigh perceived risks report more risk behavior (Maslowsky et al. 2011a). Further, in one study, adolescents who perceived the benefits of risk behavior as outweighing its risks engaged in more reasoned risks and were better at identifying rewarding situations in two gambling tasks (Maslowsky et al. 2011b).

Future Orientation

Future orientation is the ability to set future plans and goals such as educational goals, health goals, career aspirations, or life milestones (Zimbardo and Boyd 1999). Future orientation involves thinking about one's future goals and formulating plans for how to achieve them

(Nurmi 1991). Levels of future orientation increase with age across adolescence (Steinberg et al. 2009). The role of future orientation in behavior is often understood through the lens of expectancy-value theory, which posits that individuals modify their behavior according to future outcomes that they expect to result from their behavior (Wigfield and Eccles 2000). The likelihood of an outcome and how much an individual values that outcome predict the individual's engaging in behavior to seek that outcome. Therefore, individuals are more likely to engage in behavior that they believe will lead to likely outcomes that they value highly and less likely to engage in behavior that they believe will yield less likely and/or more undesired outcomes (Johnson et al. 2014). Adolescents with higher future orientation generally engage in fewer risk behaviors such as substance use, sexual risk taking, and violent weapon-related behaviors (Johnson et al. 2014; Steiger et al. 2017; Stoddard et al. 2011). This may be because future-oriented adolescents are more strategic in choosing risk behaviors that are potentially most beneficial to them while least threatening to their future plans, and thus more likely to take reasoned risks when they do take risks.

Current Study

The majority of the work suggesting a distinction between reasoned and reactive risk behavior in adolescence consists of review articles and theoretical pieces (e.g., Reyna and Farley 2006; Romer et al. 2017). An important next step is to test this hypothesis empirically. The present study tests theoretically hypothesized predictors of reasoned versus reactive risk behavior among adolescents and whether their associations with type of risk behavior vary by age. The study focuses on common risk behaviors associated with significant morbidity and mortality among U.S. adolescents, including substance use, drowsy driving, distracted driving, unprotected sex, physical fighting, and risking serious injury (CDC 2017; Miech et al. 2018). The study examines predictors of whether risk behaviors are reasoned (planned ahead of time) or reactive (in-the-heat-of-the-moment). Engagement in more reasoned, rather than reactive, risk behavior is expected to be associated with higher levels of sensation seeking, higher levels of perceived benefits versus risks of risk behavior, better working memory, better inhibitory control, and higher levels of future orientation.

Methods

Participants

Participants were from the Adolescent Health Risk Behavior (AHRB) study, a study designed to characterize behavioral and cognitive correlates of adolescents' risk behavior trajectories. The AHRB study includes a nonprobability sample of 10th and 12th grade students recruited from nine public school districts across eight Southeastern Michigan counties, using a quota sampling approach to increase diversity. Parental consent and adolescent assent for participation were obtained. Study procedures were approved by the University of Michigan Institutional Review Board. Eligible participants were initially contacted by mail and provided with a study brochure and an informed consent document that could be signed and returned to the students' schools. Of 5,009 eligible participants contacted by mail through their schools, 2,278 students (45.8%) provided parental consent

by returning consent forms to their schools, and 2,017 of those who had parental consent (88.5%) participated. Data were collected in schools during school hours or after school via self-report surveys administered using computer-assisted self-interviewing (CAI Illume version 5.1.1.18300). The surveys assessed engagement in risk behavior and a range of related psychosocial constructs. Upon completion of the protocol, participants were compensated with $50 cash for their time.

Of the 2,017 study participants, 1,720 (85.2%) responded to the risk behavior section of the survey. Nonresponse was due primarily to not finishing the survey during the allotted time. Those who did not respond to the risk behavior section were significantly more likely to be male, in 10th grade, non-White, and with lower parental education than those who completed the section. Of those who responded to the risk behavior survey, 1,329 (77.3%) reported that they had participated in at least 1 of 15 risk behaviors in the last 12 months; these participants were therefore administered the follow-up items on reasoned/reactive risk that are the focus of the present study; 1,266 (95%) of them provided valid data on both their risk behaviors and follow-up questions regarding reasoned versus reactive risk (see Measures, below) and were thus included in the present analysis. The participants' mean age was 16.5 years (SD = 1.1); 56.9% were female, 61.9% were White, 17.1% Black, 7.0% Hispanic, 14.1% other race/ethnicity, 40% were in the 10th grade, and 60% in the 12th grade. Study participants reported an average of about 3 risk behaviors each (M = 3.1 risk behaviors per participant, SD = 2.3). Data were restructured such that each individual risk behavior constituted one observation; therefore, the analytic sample for the present study was N = 3,894 behaviors. Analyses were adjusted for clustering at the individual level, described below.

Measures

Reasoned versus reactive risk.—Reasoned versus reactive risk was assessed with the following item: "When you have [done behavior], how often did you plan on doing it ahead of time, as opposed to doing it without planning it ahead of time?" (Maslowsky et al. 2011b). This item was administered as a follow-up to each risk behavior that the respondent endorsed in the 15-item risk behavior measure (below). Responses were measured on a 4-point scale indicating whether the behavior was "never," "almost never," "almost always," or "always" planned ahead of time. Higher scores on the dependent variable indicated more reasoned risk; lower scores indicated more reactive risk.

Risk behavior.—Engagement in each of the following 15 risk behaviors in the past 12 months was assessed: using cigarettes, e-cigarettes, alcohol, marijuana, amphetamines, street drugs (including cocaine, heroin, ecstasy, and LSD), narcotics, or sedatives; riding with an alcohol-impaired driver; distracted driving (e.g. texting while driving); driving while under the influence of alcohol; drowsy driving; having unprotected sex; physical fighting; and risking serious injury to oneself.

Substance use.: Substance use behaviors (cigarettes, e-cigarettes, marijuana, alcohol, amphetamines, narcotics, sedatives, street drugs) were assessed with the following items: "On how many occasions (if any) have you [smoked cigarettes/used an electronic vaporizer

such as an e-cigarette/used marijuana or hashish/had any alcoholic beverage to drink—more than just a few sips/taken prescription amphetamines without a doctor telling you to/taken prescription narcotics without a doctor telling you to/taken prescription sedatives without a doctor telling you to/used illicit or street drugs] during the last 12 months?" Responses were reported on a 7-point scale ranging from 1 = "0 occasions" to 7 = "40 or more occasions." These items were identical to those used in annual national Monitoring the Future surveys (Miech et al. 2018).

Driving behaviors.: Driving behaviors (riding with an alcohol-impaired driver, distracted driving, drowsy driving) were assessed with the following item: "During the last 12 months, on how many days did you… [ride in a car or other vehicle driven by someone (not including your parent) who had been drinking alcohol/ text or email while driving a car or other vehicle/ drive a car or other vehicle while drowsy or sleepy]. Responses were on a 6-point scale ranging from 1 = "0 times" to 6 = "6 or more times."

Physical fighting.: Physical fighting was assessed via the item "During the last 12 months, how many times have you gotten into a serious physical fight at school, home, or work?" on an 8-point scale ranging from 1 = "0 times" to 8 = "12 or more times." Driving behavior and physical fighting items were adapted from the Youth Risk Behavior Surveillance System (CDC 2017). The adaptations consisted of modifying the time frame of reporting from the past 30 days to past 12 months and specifying "not including your parent" in the riding with an impaired driver item.

Unprotected sex.: Unprotected sex was assessed with the item "During the last 12 months, have you had unprotected sexual intercourse?" Unprotected sex was defined in the item instructions as "having vaginal, oral, or anal sex without using a condom." Response options were "yes" or "no."

Risking serious injury.: Risking serious injury was assessed with the item "On how many occasions have you risked serious injury to yourself in the last 12 months" on a 7-point scale ranging from "0 occasions" to "40 or more." "Risking serious injury" was defined as "doing something that did or could have caused you to be hurt so badly you had to go to the emergency room. Some examples may include riding a bicycle without a helmet; diving into water without knowing how deep it was; riding a skateboard in traffic. Do not include participation in organized sports."

For purposes of the present analysis, all risk behavior responses were dichotomized such that those who indicated "0 occasions" or "0 times" were coded as not engaging in the behavior and those who reported any occasions were coded as engaging in the behavior.

Risk/benefit appraisal.—For each risk behavior in which the respondent had engaged at least once in the past 12 months, the respondent was asked, "To what extent are the benefits of [behavior] greater than the risks associated with it?" on a 4-point scale: 1 = "risks are much greater than benefits," 2 = "risks are somewhat greater than benefits," 3 = "benefits are somewhat greater than risks," 4 = "benefits are much greater than risks." This measure was

adapted from the Risk Assessment subscale of the Benthin Risk Perception measure (Benthin et al. 1993).

Future orientation.—Future orientation was measured with the 15-item Future Orientation Scale (Steinberg et al. 2009). Based on the work of Harter (1982), this scale is formatted to minimize social desirability by presenting respondents with a series of statement pairs separated by the word "BUT." Respondents are instructed to choose the statement that best describes them and then instructed to indicate the extent to which the descriptor is true: "really true for me," or "sort of true for me." Example items include "Some people take life one day at a time without worrying about the future BUT Other people are always thinking about what tomorrow will bring" and "Some people have trouble imagining how things might play out over time BUT Other people are usually pretty good at seeing in advance how one thing can lead to another." Each item is scored on a 4-point scale, with higher scores indicating stronger future orientation. The mean of all items was used for analysis. The scale has previously shown good reliability and significant negative correlations with risk behavior in adolescent and adult samples (α = .80; Steinberg et al. 2009), and it also showed good reliability in the present sample, α = .77.

Sensation seeking.—Sensation seeking was measured with the Brief Sensation Seeking Scale (Hoyle et al. 2002), an 8-item self-report measure of sensation seeking derived from the 40-item Sensation Seeking Scale (Zuckerman et al. 1978). Responses are given on a 5-point scale ranging from 1 = "strongly disagree" to 5 = "strongly agree." A mean score was computed for analysis, with higher scores indicating greater sensation seeking tendencies. The scale has demonstrated adequate reliability in adolescent, adult, and clinical samples (α = .70 – .74), including the present sample, α =.75, and it has been used in previous studies examining a variety of risk behaviors in adolescents (Hoyle et al. 2002; Maslowsky et al. 2011a), with negative correlations observed with risk behavior.

Working memory.—Working memory performance was assessed using a computer-administered digit span task. The digit span is designed to assess working memory by measuring the number of digits that a participant is able to correctly recall (Woods et al. 2011). In this task, random digit lists presented on a computer screen are adaptively increased and decreased to repeatedly sample the lower and upper bounds of a participant's digit span. For the duration of 14 trials, a participant sees a sequence of digits (starting with 2 digits), where each digit is presented for 1 second. A visual signal is presented for the duration of 1 second, after which the participant is asked to recall the digit sequence in reverse and type the answer into a presented textbox (e.g., if "74" is presented, the participant should then type "47"). If the participant correctly enters the reversed sequence, the participant moves up to the next level, where the length of the sequence is increased by 1 digit. If the participant fails to enter the correct sequence, the same level is presented again. If the participant makes two consecutive errors, the sequence is moved down one level. Digit span in the present study reflects the maximum number of digits that participants were able to recall before making two consecutive errors.

Response inhibition.—Response inhibition was assessed via a computer-administered go/no-go task (Durston et al. 2002; Heitzeg et al. 2010). Participants viewed a series of letters one at a time and were instructed to press a button as quickly as possible in response to go-trial stimuli (letters other than X), but not to respond to no-go trial stimuli (the letter X). Participants completed 5 blocks of 49 trials each, consisting of 75% go and 25% no-go trials presented in pseudorandomized order. Response inhibition was indicated by the number of "false alarms," or responding on a no-go trial. A higher score indicates poorer response inhibition.

Sociodemographic covariates.—Sociodemographic covariates, reported by each participant, included the participant's age in years, race/ethnicity (White, Black, Hispanic or Latino, other race/ethnicity), and average parent education. Parent education was the average of mother's and father's highest educational attainment measured on a 6-point scale ranging from 1 = "completed grade school or less" to 6 = "graduate or professional school after college." For participants with only one parent, that parent's educational attainment was used.

Analysis

Data were analyzed using Mplus version 8 (Muthén and Muthén 1998-2017). Due to the ordinal scale of the dependent variable, ordinal logistic regression analysis was used to examine the associations between each of the independent variables and reasoned/reactive risk. Two models were estimated. Model 1 estimated the main effects of all predictors of interest and covariates in predicting reasoned versus reactive risk. Model 2 included all predictors of interest, covariates, and interactions between age and each of the five predictors of interest: risk/benefit appraisal, future orientation, sensation seeking, working memory, and response inhibition. All predictors were mean centered prior to computing the interaction terms. Because some participants contributed more than one risk behavior to the dataset, the model adjusted for clustering at the participant level by specifying individual ID as the cluster variable in Mplus. Missing data were handled using full information maximum likelihood, which retains all participants in the dataset and uses all available data provided to estimate relationships, thereby limiting bias that might be introduced by dropping a participant from the analysis due to item-level missingness.

Results

Table 1 provides descriptive statistics and correlations of the independent variables among the participants (N = 1,266). Table 2 provides descriptive statistics on the individual risk behaviors reported by participants (N = 3,894 behaviors), including each type of behavior and its rating on the reasoned/reactive risk scale. The most common risk behavior was alcohol use (20.4% of reported risk behaviors), followed by driving while sleepy (12.5%) and distracted driving (11.0%). The least common risk behavior types were use of amphetamines, street drugs, narcotics, and sedatives (0.6%–1.1% of reported risk behaviors). About three quarters of risk behaviors were rated as reactive ("never planned ahead of time" [52.7%] or "almost never planned ahead of time" [20.5%]), while

approximately a quarter of risk behaviors were rated as reasoned ("almost always planned ahead of time" [17.2%] or "always planned ahead of time" [9.6%]).

Table 3 presents the results of the ordinal logistic regression examining predictors of reasoned/reactive risk behaviors. In Model 1, sensation seeking was a significant positive predictor, such that youths higher in sensation seeking were more likely to engage in reasoned risk taking (OR = 1.24, 95% CI = 1.10–1.39, $p < .001$, indicating 24% higher odds of reasoned risk behavior for each one-unit increase in sensation seeking). Risk/benefit appraisal was a significant predictor (OR = 1.60, 95% CI = 1.49–1.71, $p < .001$), indicating that perceiving benefits as greater than risks of a behavior was associated with a higher likelihood of reasoned risk taking. Youths with higher scores on the working memory task were more likely to engage in reasoned risk (OR = 1.05, 95% CI = 1.00–1.09, $p < .05$), as were youths with higher levels of future orientation (OR = 1.46, 95% CI = 1.18–1.81, $p < .001$) and older youths (OR = 1.17, 95% CI = 1.09–1.27, $p < .001$). Response inhibition was not a significant predictor of reasoned/reactive risk behavior. Race/ethnicity, sex, and parent education were not significantly associated with reasoned versus reactive risk taking.

In Model 2, interaction terms between age and each of the five predictors of interest were added. The pattern of results among the main effects was the same as in Model 1. One of the five interactions tested was significant: the interaction of response inhibition with age (OR = 0.99, 95% CI = 0.98–.99, $p < .01$). This interaction reflects a significant negative association between response inhibition and reasoned/reactive risk at older ages and a nonsignificant relationship at younger ages. Plotting the interaction term revealed that among youth ages 17 and older, lower scores on the response inhibition measure (indicating better response inhibition) were associated with increased likelihood of reasoned risk behavior. However, the effect was quite small (OR = .99) and therefore should be interpreted accordingly.

Discussion

Research based on dual systems models of adolescent risk behavior has described multiple intertwined neural and behavioral systems underlying adolescents' risk behavior. It is increasingly evident that these multiple systems can produce both reasoned (purposeful and premeditated) and reactive (impulsive, heat-of-the-moment) risk behaviors. The present study has examined predictors of engaging in risk behaviors that are reasoned as opposed to reactive. As hypothesized, the results show that adolescents who indicated that their risk behaviors were more often reasoned than reactive had higher levels of sensation seeking, better working memory, were more future oriented, and perceived risk behavior to be more beneficial than risky.

Consistent with previous work (Maslowsky et al. 2011b), the present study shows that higher levels of sensation seeking were associated with increased probability of engaging in reasoned versus reactive risk behavior. Sensation seeking is one of the most robust personality trait correlates of adolescent risk behavior (Crawford et al. 2003; Quinn et al. 2013). Recent examinations of the mechanisms by which sensation seeking is related to risk behavior suggest that the relationship is not a direct one in which adolescents with high levels of sensation seeking look for and then blindly participate in risk behaviors. Rather, it

appears that sensation seeking is related to putting oneself into more situations that offer the opportunity for risk behavior but not necessarily engaging in every risky opportunity (Boyer and Byrnes 2009). Romer et al. (2017) have argued that reasoned risk behavior is underpinned by concurrent developments in sensation seeking and working memory that enable the purposeful selection of risk behaviors most likely to yield rewards rather than engaging in more frequent risk behaviors less purposively.

The present study indeed found that better working memory performance was associated with higher likelihood of reasoned risk behavior. Previous studies have linked working memory with less engagement in high-risk behaviors. For example, Khurana et al. (2015) observed that stronger working memory ability at mean age 13 predicted less sexual risk taking 2 years later in a community sample of adolescents. The present finding that both sensation seeking and working memory were positively associated with reasoned risk behavior is consistent with previous suggestions that relatively mature working memory affords progressively more purposeful risk taking by allowing adolescents to hold goal-relevant information in mind and choose behaviors, some “risky,” that move them closer to their goals (Khurana et al. 2012).

The present study found that a more positive future orientation was related to higher probability of engaging in reasoned risk behavior. Previous studies have shown future orientation to be related to engaging in a lower number of risks. In the present examination of subtypes of risk, future orientation was related to an increased likelihood that the risk behaviors in which an adolescent does engage are reasoned rather than reactive. Thus it may be more precise to say that future orientation is related to selecting more reasoned risks that are seen as beneficial but not too threatening to future plans while opting out of other risk behaviors to avoid their negative consequences. Several previous studies have demonstrated that future orientation is associated with less engagement in more extreme versions of risk behavior that have potentially severe negative consequences. Robbins and Bryan (2004) found that adjudicated adolescents with positive future orientation reported fewer alcohol problems than did those with low future orientation, despite similar levels of alcohol use in the two groups. In a sample of urban male adolescents, Culyba et al. (2018) found that future orientation was related to lower likelihood of threatening or injuring someone with a weapon, behaviors that carry potentially severe consequences, but not related to likelihood of physical fighting, a less severe behavior. In another study, adolescent males who were less future-oriented were more likely to engage in problem gambling but not more likely to engage in gambling behavior generally (Donati et al. in press), and similar findings have been obtained in a mixed-sex sample (Cosenza and Nigro 2015). Adolescents with more positive future orientation report fewer delinquent peers (Jackman and McPhee 2017), which may indicate that when they do take risks they are in the company of peers who are less likely to escalate those risks to dangerous levels. Another possibility is that adolescents who are more future oriented are less likely to engage in reactive risk behavior. Chen and Vazsonyi (2011) found that the effect of impulsivity on levels of risk behavior over time was weaker for adolescents with high levels of future orientation. Future-oriented adolescents may be more motivated to inhibit reactive risk behaviors in order not to jeopardize their long-term goals.

Finally, the present results show that perceiving risk behaviors to be more beneficial than risky is associated with reasoned risk taking. This study builds on previous research in which perceiving the benefits of risk behavior as outweighing its risks was associated with more frequent risk behavior (Boyer and Byrnes 2009; Maslowsky et al. 2011a). Adolescents who take more reasoned risks may find the benefits of risk behavior more intrinsically rewarding due to their higher levels of sensation seeking. This is consistent with previous research in which the relationship between sensation seeking and higher levels of risk behavior was mediated by the perception that the benefits of risk behaviors outweighed their risks (Maslowsky et al. 2011a). Furthermore, given advanced executive function abilities, adolescents who take reasoned risks may be better able to seek out and engage in behaviors that are more beneficial to them.

Theoretical Implications

For the past decade, the dual systems model has prevailed as the dominant explanatory and theoretical framework in research on adolescent risk behavior. However, recent critiques have noted that while the dual systems model explains reactive risk behavior well, it is less applicable to reasoned risk behaviors. In particular, Romer et al. (2017) and Reyna and Farley (2006) have provided extended arguments for the existence of reasoned and reactive risk behavior as two distinct subtypes. However, there have been few empirical studies of the hypothesized predictors of reasoned versus reactive risk. Whereas dual systems models view risk behavior as the product of unregulated, in-the-moment impulses, the present study provides evidence that adolescents who are more future oriented and who perform better on at least one indicator of executive function—working memory—engage in premeditated, reasoned risks. These adolescents are also more likely to report that the benefits of risk behaviors outweigh their risks. And among older adolescents, increased ability to inhibit responses was linked with higher likelihood of engaging in reasoned risk behavior. In other words, it seems that some adolescents may purposely use their skills in response inhibition, working memory, and future orientation to engage in risk behavior from which they stand to gain some perceived benefits. Although the present study did not involve neuroimaging, the results are consistent with neuroimaging studies that have shown that adolescents who frequently engage in risk behavior show more neural maturity, as indicated by greater white matter integrity in frontal brain regions that support executive function, rather than less mature pathways as the dual systems model might predict (Berns et al. 2009; Kwon et al. 2014).

One potential explanation for reasoned risk behavior in adolescence may be that what is “risky” is in the eye of the beholder. Researchers have typically defined risk behaviors as those that could potentially result in negative health or legal outcomes for adolescents. However, adolescents may have different perceptions of what is “risky.” Blakemore and Mills (2014) have argued that adolescents weigh social risk more heavily than potential health or legal risks in their decision making. Blakemore (2018) argues that adolescents are fundamentally motivated to avoid social rejection by their peers, and they may engage in behaviors with potential negative health or disciplinary consequences in order to do so. Adolescents may purposely seek and engage in behaviors that adults see as risky but that adolescents view as likely to yield peer approval or at least enable them to avoid peer

rejection. In other words, behavior that adults view as risky may actually be adaptive in the context of a larger developmental goal of learning to function as an independent adult in a complex social world.

In sum, the present evidence suggests that the dual systems model should be expanded to accommodate reasoned risks as well as reactive risks. Age seems to be a key factor in differentiating reasoned and reactive risk behavior. Older adolescents were more likely to report reasoned risk behavior in the present study. The characteristics linked with reasoned risk behavior, including future orientation, working memory performance, and response inhibition, generally improve with age. We also observed a small but significant interaction between age and response inhibition such that older adolescents with better response inhibition abilities were more likely to engage in reasoned risks. Older adolescents may be more able and more motivated to pursue reasoned risks.

Practical Implications

Differentiating reasoned and reactive risk behaviors has practical implications for interventions aimed at preventing adolescent risk behavior or minimizing its associated harms. One common practical approach to preventing and reducing risk behavior has been to teach refusal skills, helping adolescents to say no to a risky behavior when the opportunity to engage in that behavior presents itself (e.g., Maruska et al. 2016). One assumption inherent in the refusal skills approach is that risk behaviors happen in the heat of the moment; they are not planned ahead of time. Prevention approaches emphasizing refusal skills may be helpful in the case of reactive risks, but they are less likely to prevent reasoned risks. The refusal skills approach may be most effective for reactive behaviors that involve some interpersonal exchange where refusal skills could be exercised, such as unprotected sex or riding with an alcohol-impaired driver.

A second common strategy for preventing adolescent risk behavior is the health education approach, which focuses on providing information about how risky a given behavior is. This approach was illustrated by the famous “This is your brain on drugs” advertising campaign, originally run in the 1980s and revamped in 2016 by the national nonprofit organization Partnership for Drug-Free Kids. It likened drugs’ effects on the brain to that of cracking and frying an egg. The health education approach remains a common strategy in current programming (Lennox and Cecchini 2008; Sloboda et al. 2008). An implicit assumption of the health education approach is that adolescents are not aware of the health risks involved in their behavior. However, evidence indicates that adolescents are indeed aware of and may even overestimate their risks (Fischhoff et al. 2010). The present results as well as those of previous studies demonstrate that adolescents are also attuned to benefits of risk behavior. Perceiving benefits to outweigh risks positively relates to engagement in risk behaviors (Maslowsky et al. 2011a). Further, benefits predict risk behavior independently of perceived risks (Goldberg et al. 2002).

For preventing reasoned risks, instead of emphasizing potential immediate harms associated with risk behaviors, one promising approach may be to emphasize “risks in benefits” (RIBs), or the long-term risks that are sometimes inherent in behaviors that yield short-term benefits (Goldberg et al. 2009). For example, adolescents’ initial experiences of using substances

may be so enjoyable (benefits) that they find themselves using them more and more often and subsequently becoming addicted (risks in benefits). Failing to appreciate the risks in benefits is related to increased future risk taking among adolescents. Interventions to enhance the salience of RIBs may reduce the likelihood that individuals will take risks with their health (Goldberg et al. 2009). Emphasizing short-term, highly salient risks that adolescents value now may be more effective than, or complementary to, messaging that focuses on more abstract, longer term risks such as a smoker's likelihood of developing lung cancer.

Strengths, Limitations, and Future Directions for Research

This study has several notable strengths. The sample was large, and it included adolescents from diverse racial/ethnic backgrounds. The study examined a wide range of risk behavior types, including substance use, risky driving behaviors, risky sexual behavior, and risking physical injury to oneself. Finally, the study included both neurocognitive and self-report measures, increasing the validity of the distinction drawn between reasoned and reactive risk behaviors in adolescence.

However, this study also has several limitations. The participants, though diverse, were from one Midwestern state, and the sample was therefore not representative of the U. S. national population. The data were collected in schools, which did afford access to a large, diverse sample. However, some participants did not complete the survey in the allotted time during the school-based data collection and therefore were not included. Future studies of adolescent risk behavior should include measures of reasoned versus reactive risk in order to allow for further investigations of these risk subtypes in a variety of adolescent populations. Finally, the data are cross-sectional. In future research, longitudinal data will be instructive for understanding both the trajectories of reasoned and reactive risk behaviors across development and the consequences of each type of risk behavior. Future research should examine whether reasoned risk behavior is associated with fewer negative consequences than reactive risk behavior.

Conclusion

Although prevailing approaches suggest that adolescents engage in risk behavior due to limited ability to self-regulate, adolescent risk behavior can also be well reasoned, calculative, and planned. Adolescents who engage in such reasoned risks exhibit high sensation seeking coupled with better working memory and positive future orientation. These findings have important implications for how adolescent risk behavior is seen and understood in society. The results imply that risk-taking adolescents are not purely unregulated and emotion driven, but are also capable of channeling their maturing cognitive abilities and their drive for novel sensations into behaviors that achieve a desired benefit; their risk taking is planned more than one quarter of the time. Understanding that adolescents' risk behaviors may be premeditated should inform how we structure the adolescent experience to promote exploration while minimizing potential harms.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Descriptive statistics and correlations among independent variables

	1	2	3	4	5	6	7
1. Sensation seeking	1.00						
2. Risk/benefit appraisal	0.02	1.00					
3. Future orientation	−.25**	−.13**	1.00				
4. Working memory	−.004	−.05	.04	1.00			
5. Response inhibition	.04	.06	−.14**	−.16**	1.00		
6. Parent education	.01	−.09**	.13**	.05	−.14**	1.00	
7. Age	.03	−.001	.10**	.02	.02	.04	1.00
M	3.24	1.82	2.78	5.46	41.19	4.17	16.48
SD	0.68	1.02	0.35	1.98	18.35	1.12	1.11
Minimum	1	1	1.53	1	3.3	1	14
Maximum	5	4	3.75	15	93.3	6	19

* $p < .05$,

** $p < .01$

Table 2:

Descriptive statistics of risk behaviors ($N = 3894$)

	N	% of all behaviors
Behavior Type		
Alcohol	796	20.4
Driving while sleepy	488	12.5
Distracted driving	428	11.0
E-cigarettes	422	10.8
Marijuana	377	9.7
Risking serious injury to oneself	343	8.8
Unprotected sex	311	8.0
Cigarettes	210	5.4
Ride with a drunk driver	205	5.3
Physical fighting	143	3.7
Driving while under influence of alcohol	48	1.2
Amphetamines	41	1.1
Street Drugs	30	0.8
Narcotics	30	0.8
Sedatives	22	0.6
Reasoned/reactive risk		
Never planned ahead of time	2054	52.7
Almost never planned ahead of time	798	20.5
Almost always planned ahead of time	669	17.2
Always planned ahead of time	373	9.6

Table 3:

Ordinal logistic regression predicting reasoned/reactive risk (N = 3894)

	Model 1				Model 2			
	B	**OR**	**95% CI of OR**	***p***	**B**	**OR**	**95% CI of OR**	***p***
Sensation seeking	0.08	1.24	1.10 - 1.39	<.001	0.08	1.23	1.10-1.39	<.001
Risk/benefit appraisal	0.25	1.60	1.49 - 1.71	<.001	0.26	1.62	1.51-1.74	<.001
Future orientation	0.07	1.46	1.18 - 1.81	<.001	0.07	1.46	1.18-1.81	<.001
Working memory	0.04	1.05	1.00 - 1.09	<.05	0.03	1.04	0.99-1.08	ns
Response inhibition	−0.04	1.00	0.99 - 1.00	ns	−0.04	1.00	0.99-1.00	ns
Race/ethnicity (ref= White)								
Black	−0.02	0.91	0.72 - 1.13	ns	−0.02	0.91	0.73-1.14	ns
Hispanic	0.01	1.08	0.79 - 1.49	ns	0.02	1.14	0.83-1.57	ns
Other race/ethnicity	−0.03	0.85	0.68 - 1.04	ns	−0.03	0.84	0.68-1.04	ns
Parent education	0.012	1.02	0.95 - 1.09	ns	0.02	1.03	0.96-1.10	ns
Age	0.09	1.17	1.09 - 1.27	<.001	0.09	1.17	1.08-1.26	<.001
Sex	−0.01	0.95	0.82 - 1.11	ns	−0.01	0.96	0.82-1.12	ns
Age*Sensation seeking					0.01	1.02	0.90-1.15	ns
Age*Risk/benefit appraisal					0.04	1.04	0.97-1.10	ns
Age*Future orientation					−0.03	0.86	0.67-1.11	ns
Age*Working memory					−0.02	0.98	0.94-1.03	ns
Age*Response inhibition					−0.07	0.99	0.989-0.998	<.01

Note. Sensation seeking, risk/benefit appraisal, and future orientation were measured via self-report. Working memory and response inhibition were measured via cognitive tasks.