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Adolescent Risk Perceptions of Health Risk vs Health Promotion Behaviors

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ABSTRACT

Adolescence is characterized by an increase in risky behaviors which threaten the health of adolescents and society. Decades of public health interventions have aimed to change how adolescents perceive risk in order to reduce risk-taking behaviors. Research has mainly focused on behaviors that harm the health of adolescents, however some risk-taking can serve to promote the health of adolescents, such as playing sports. The purpose of this thesis was to investigate how adolescents perceive different types of health risk behaviors, how they update those perceptions when given new information, and how risk perceptions are correlated with risky behavior in an experimental paradigm called the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). Adolescents (*N*=112) completed a likelihood estimation task in which they rated their estimates of experiencing both negative and positive outcomes of health risk and health promotion behaviors. They were given the opportunity to update their estimate after being told information about the actual likelihood of these risks. Adolescents also completed a risky decision-making task (BART) known to be associated with engagement in health risk behaviors (Lejuez et al., 2002). Results indicated that adolescents overestimated the likelihood of negative outcomes of health risk behaviors and underestimated the likelihood of positive outcomes of health risk behaviors, suggesting a healthy bias. They underestimated both outcomes for health promotion behaviors. Adolescents updated their risk perceptions after receiving new information, despite their initial biases. Health risk, but not health promotion risk perceptions were correlated with risk-taking in BART. The results shed light on the types of health perceptions that may contribute to adolescent risk-taking, and that adolescents are able to adjust their beliefs when presented with new information, which has implications for future health interventions.

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Chapter 1

Introduction

Adolescence is a period of physical, social, and cognitive development often characterized by increased risk-taking behavior (Steinberg, 2008). Health risk behaviors – such as binge drinking, drug use, reckless driving, and unsafe sexual practices – threaten the health and well-being of adolescents. As of 2020, the leading cause of death for adolescents ages 15-19 in the U.S. is accidents or unintentional injury (Centers for Disease Control and Prevention, 2021). Many accidents, such as motor vehicle crashes, can be attributed to engagement in risky behaviors (Carter et al., 2014; Ferguson, 2003; Shope & Bingham, 2008). As a result, public health interventions have focused on lowering adolescents' propensity for risky behaviors to improve health outcomes (Gibbons, et al., 2010; Jackson-Newson & Shelton, 2010; Romer, 2010). Decades of research have focused on uncovering the reason why risk-taking behavior increases between childhood and adolescence and then decreases in adulthood (Shuman et al., 2016; Steinberg, 2010; Tymula et al., 2012)

Much of the risk-taking behavior observed in adolescence has been attributed to dramatic changes in brain development that occur during this period (Blakemore & Robbins, 2012; Casey, 2015; Steinberg, 2010). Predominant neurodevelopmental theories of adolescent risky decision-making assert that an imbalance in the development of the brain's socioemotional system and cognitive control system explain heightened risk behavior in adolescence (Shulman et al., 2016; Steinberg 2008, 2010). A class of models – commonly known as the dual systems models – suggest that rapid changes in the socioemotional system lead to increased reward-seeking

behaviors, while the cognitive control system slowly and linearly matures throughout adolescence (Casey, 2015; Steinberg, 2008, 2010). The difference in timing of development in these brain networks creates a perfect storm of heightened reward-seeking and impulsivity reflected in adolescents' propensity towards risky behavior.

Furthermore, social context plays a significant role in risk-taking during adolescence. Studies have found that the brain regions sensitive to reward overlap with those that respond to social stimuli (Steinberg, 2008). Specifically, a functional magnetic resonance imaging (fMRI) study of adolescents found that reward-related brain regions, such as the ventral striatum and orbitofrontal cortex, were recruited in the presence of peers but not when alone, and activation of these regions predicted risk-taking in an experimental task (Chein et al., 2010). Another fMRI study found that greater activation of the anterior cingulate cortex (ACC) – a brain region associated with processing risk – was associated with greater conformity to risky peer influence during a risky driving simulation (Pei et al., 2020). Functional connections between the ventral striatum and ACC were associated with resistance against risky peer influence (Pei et al., 2020). In another risky driving study, adolescents took almost three times more risks in the presence of peers when compared to adults and children (Gardner & Steinberg, 2005). This body of research suggests that the presence of peers may result in greater sensitivity in the brain to rewarding outcomes of risky behaviors resulting in greater adolescent appeal and engagement in risky behaviors that negatively impact their health.

Adolescent Health Risk Perceptions

To combat negative health outcomes of adolescent risk behaviors, health intervention efforts typically focus on altering how adolescents perceive risks (Gibbons et al., 2009; Reyna & Farley, 2006). Risk perceptions can be defined as how susceptible one views themselves to the consequences of risky behavior (Ferrer & Klein, 2015). Typically, interventions attempt to alert adolescents to their vulnerability to the negative outcomes of these risky behaviors. This is supported by a body of research and theories of health behavior that perceived risk is a predictor of health behavior and behavior change (Brewer et al., 2007; Ferrer & Klein, 2015; Janz & Becker, 1984; Schmalzle et al., 2017; Sheeran et al., 2014).

Despite the efforts of health education programs to change the risk perceptions of adolescents, engagement in risk behaviors remains high. Research examining adolescent health risk perceptions and their associations with risk-taking behaviors has yielded inconsistent results. Some studies show that among adolescents, higher risk perceptions (i.e., perceiving a behavior to be riskier) correlates with lower participation in risk behaviors (Curry & Youngblade, 2006; Fryt et al., 2021; Reniers et al., 2015). A large meta-analysis examined 51 empirical studies of the relationship between adolescent risk perceptions and risk behaviors with long-term consequences, such as HIV or cancer (Larsman et al., 2012). The results were mixed; 12 studies suggested a negative relationship between risk perceptions and risk behavior (i.e., higher perceived risk was associated with lower involvement in risk behavior), 8 studies suggested a positive relationship (i.e. higher perceived risk was associated with higher involvement in risky behavior), and 12 studies found no relationship (Larsman et al., 2012).

The lack of consistency in the literature may be due to the use of different definitions and measures of risk perception and risk-taking. Meaning, not all studies utilize the same type of

questionnaire to measure risk perceptions. For example, some studies use probability assessments (how likely an outcome is to occur), some use perceptions of harm that could be caused by a risk behavior, and some simply ask people to rate how risky they perceive different behaviors to be (Millstein & Halpern-Felsher, 2003). General risk questionnaires ignore other factors that influence risk perceptions such as the perceived likelihood of potential outcomes (Slovic, 2000). Some studies show that the potential positive outcomes of risk behaviors are important predictors of participating in unhealthy risk behaviors (Goldberg et al., 2002, Parsons et al., 2000). The negative outcomes, however, are less predictive of risky behavior relative to the positive outcomes (Parsons et al., 2000), suggesting knowledge of negative consequences may have less of an effect on adolescents' propensity to engage in risky behaviors. More precise measures are needed to investigate adolescent risk perceptions across different types of behaviors and outcomes. Additionally, engagement in risk behavior was mostly self-reported, which can be limited in its generalizability to real-world risk-taking. Few studies have investigated the association between health risk perceptions and risk-taking in a risky decision-making experimental task, such as the Balloon Analog Risk Task (BART; Lejuez et al., 2002).

Additionally, the studies in the meta-analysis compared many different types of risk behaviors, such as sexual behaviors and alcohol/smoking behaviors (Larsman et al., 2012). Other empirical studies that examined risky driving found that lower risk perceptions (perceiving risk behaviors to be less risky) were associated with increased risky driving behaviors among adolescents (Carter et al., 2014; Rhodes & Pivik, 2011). The inconsistency within the extant literature suggests the relationship between risk perceptions and risk-taking among adolescents might be more complex than previously assumed, and that adolescents may feel differentially susceptible to different types of risk behaviors.

For decades, conventional thinking has perpetuated the idea that adolescents perceive themselves as invulnerable to risk more than adults, which was historically used as an explanation for the surge in adolescent risk-taking (Elkind, 1967). However, there is a lack of empirical evidence to support this claim. Research shows that adolescents actually overestimate their vulnerability to risk (Cohn et al., 1995; Fischhoff et al., 2010; Millstein & Halpern-Fisher, 2003; Reyna & Farley, 2006). Studies have found that adolescents are less likely to view themselves as invulnerable to risks than adults, and adolescents feel more vulnerable to negative outcomes of risk behaviors than adults (Cohn et al., 1995; Millstein & Halpern-Fisher, 2003). Furthermore, those who report engaging in risky behaviors feel they are at higher risk of experiencing negative outcomes than those who do not, which suggests adolescents are aware of the risks of engaging in unhealthy behaviors but choose to do so anyway (Johnson et al., 2002; Millstein & Halpern-Fisher, 2003).

The majority of this research compares adolescents to adults. When compared to their peers, research shows adolescents experience optimism bias, in which they view themselves as less vulnerable to the negative outcome of risks compared to their peers (Chapin, 2001). However, this is not unique to adolescents; adolescents and adults alike experience optimism bias (Reyna & Farley, 2006). This leaves the following question still unanswered: Why do adolescents still engage in risky behaviors if they are overestimating their susceptibility to negative outcomes? It is necessary to investigate other factors that may influence adolescent risk perceptions such as neurobiological factors, types of outcomes, and types of risk behaviors (health risk or health promoting).

Factors that Influence Health Risk Perceptions

Neurobiological Factors

It is important to understand the neurobiological underpinnings of health risk perceptions to optimize the effectiveness of health education. Schmalzle and colleagues (2013) conducted an fMRI study on individuals with both high and low personal risk perceptions while they viewed a TV report about the H1N1 pandemic. They found that the group with high risk perceptions (perceiving behaviors to be more risky) displayed inter-subject correlations in the anterior cingulate cortex, which is a brain region associated with threat appraisal and emotional responses (Schmalzle et al., 2013). The literature suggests that risks are perceived in the brain "as feelings" rather than analytically (Schmalzle et al., 2017; Slovic & Peters, 2006). In other words, when perceiving risk, people rely on "gut" feelings of fear or dread (Slovic & Peters, 2006). To corroborate this theory with psychophysiological data, Renner and colleagues (2012) used event-related potentials (ERPs), which measure the brain's electrophysiological response to a stimulus. They used ERPs to examine neural responses when people made decisions about whether a person was "HIV risky" or "HIV safe" (Renner et al., 2012). The results showed that there was only a 220-340 millisecond difference in the brain's response when making a decision about a person being risky or safe (Renner et al., 2012). The speed of neural responses suggests that risk perceptions may be based on intuitive feelings rather than rational or analytical processing. These neuroimaging studies provide us with insight into how risk information is being processed in the brain prior to decision-making and can even allow us to predict behavioral changes (Berkmann & Falk, 2013; Chua et al., 2011). However, the neural mechanisms of health risk perceptions are not fully understood. Additionally, these types of neuroimaging studies have not

been replicated in adolescents, so we do not know whether adolescents process risk information in similar ways in comparison to adults.

Outcomes

Risk perceptions may change depending on the valence of possible outcomes. In other words, people tend to make risky decisions differently when faced with a gain (positive outcome) versus a loss (negative outcome) (Kahneman & Tversky, 1979). Specifically, adults tend to prefer risk-taking to avoid losses rather than acquire gains (Kahneman & Tversky, 1979). Some studies show that adolescents are just as loss averse as adults (Rosenbaum et al., 2021; Van Leijenhorst et al., 2008; Weller et al., 2011). Other studies show that in risky gambling tasks, adolescents are less avoidant of disadvantageous decks of cards than adults, indicating they were not as loss avoidant (Cauffman et al., 2010; Smith et al., 2012). In the same task, adolescents played increasingly from advantageous decks of cards over the course of the task, indicating they sought out rewards (Cauffman et al., 2010). Thus, adolescents may be less sensitive to loss caused by risky behaviors and more driven by rewards of risky behaviors. These findings are consistent with adolescent brain development research that suggests adolescents' hypersensitivity to reward is a result of the rapid development of the dopaminergic reward systems of the brain (Blakemore & Robbins, 2012).

In the domain of health risk perceptions, adolescents may make decisions based on the perceived costs (negative outcomes) or the perceived benefits (positive outcomes) of risk behavior. One study of adolescents found that the perceived benefits of alcohol use were significantly more related to risky drinking behavior than the perceived costs (Goldberg et al.,

2002). Adolescents also perceived the positive outcomes of alcohol use to be more likely to occur than the negative outcomes (Goldberg et al., 2002). Similarly, another study found that the perceived benefits of unprotected sex were a better predictor of risky sexual behaviors relative to the perceived costs (Parsons et al., 2000). These findings suggest perceived benefits may play a major role in adolescents' decisions to engage in health risk behaviors.

Peer acceptance may be an especially salient perceived benefit of participating in risky behavior. Research shows peer acceptance plays a large role in adolescent decision-making (Blakemore & Robbins, 2012). The perceived benefits of risky behavior, such as peer acceptance, may outweigh the negative outcomes and drive participation in such activities (Benthin et al., 1993; Blakemore, 2018). Altogether, research is limited when it comes to directly comparing how risk perceptions change when the outcomes are positive versus negative. An understanding of how risk perceptions change depending on the valence of possible outcomes may potentially inform and restructure health inventions to maximize their effectiveness.

Health Risk Behaviors vs Health Promotion Behaviors

Adolescent risky decision-making research has historically focused on maladaptive health risk behaviors such as substance use and risky sexual behavior (Steinberg, 2008). However, some risks taken during adolescence may be beneficial or serve to promote the health of adolescents (Duell & Steinberg, 2021). For example, it is risky to take a challenging class, try out for a sports team, audition for a musical, or ask someone on a date (Duell & Steinberg, 2021). Like health risk behaviors, health promotion behaviors have associated positive and negative uncertain outcomes. In recent literature, these types of health promotion behaviors have

been referred to as “positive risks” under the criteria that they benefit the health or well-being of adolescents, have consequences mild in severity, and are socially acceptable or legal (Duell & Steinberg, 2019). We contend that the second criterion of having consequences mild in severity is not always true for health promoting risks. For example, a sports injury may lead to permanent disability, and rejection from peers may lead to isolation, depression, and suicidal thoughts or actions. We prefer to use the terminology of health promotion behaviors and distinguish them from health risk behaviors as they serve to benefit the adolescents' health and well-being and are socially acceptable. Studies show that health promoting risk-taking may improve academic engagement and mental health outcomes among adolescents (Duell & Steinberg, 2021). It is important to understand how health promotion behaviors are perceived in comparison to health risk behaviors to optimize health interventions that encourage participating in health promotion activities over maladaptive ones. An increased understanding may provide the opportunity to capitalize on adolescents’ desire for rewards and thrill by promoting healthy risks and diverting attention away from harmful risks.

The existing literature on health promotion behaviors is relatively new and still in the process of being explored. Work by Duell and Steinberg (2019) found that engagement in health risk behaviors was positively associated with engagement in health promotion behaviors among adolescents, suggesting they have a general propensity for risk regardless of type. Additionally, when investigating the psychological correlates of health risk versus health promotion behaviors among adolescents, engagement in both types of behaviors was associated with sensation seeking, but only health risk behaviors were associated with impulsivity and risk-taking in experimental tasks (Duell & Steinberg, 2020). Peer influence has been shown to play a role in both health risk and health promotion behaviors (Chierchia et al., 2020; Telzer et al., 2018).

Therefore, adolescents may be able to fulfill their desires for peer acceptance and sensation-seeking by engaging in health promotion behaviors.

Since research on risk perceptions of health promotion behaviors is limited, it is unknown whether they can be used to predict actual risk-taking. One study found that adolescents perceived risks of health promotion behaviors as lower than those of health risk behaviors (Fryt et al., 2021). Thus, adolescents may demonstrate a healthy bias against making decisions to engage in health risk behaviors over health promotion behaviors. The same study found that risk perceptions predicted engagement in health risk behaviors but not health promotion behaviors (Fryt et al., 2021). Health promotion risk perceptions have not been studied in association with risk-taking in experimental tasks. Additionally, few studies have separated risk perceptions by both type of behavior (health risk vs health promotion) and outcome (positive or negative). One study of late adolescents found that the perceived benefits of unprotected sex were a better predictor of risky sexual activity than the perceived benefits (or costs) of condom use (Parsons et al., 2000). In other words, the positive outcomes of *not* wearing a condom (health risk behavior) outweigh the positive outcomes of wearing a condom (health promotion behavior) when choosing to engage in unprotected sex. More research is needed to understand how adolescents differentially perceive health promotion and health risk behaviors in the context of different outcomes.

Lastly, little is known about the neuroscience of risky health promotion behaviors. A recent adolescent fMRI study showed that higher self-reported engagement in health promotion behaviors was uniquely associated with less neural tracking of expectant value in the dorsomedial prefrontal cortex (dmPFC) during risky decision-making (Duell et al., 2022). The dmPFC plays a role in deliberation and strategizing, so positive risk-taking correlating with

variability in this region may suggest adolescents who engage in health promotion behaviors may think more carefully about risky decisions (Duell et al., 2022). This was one of the first studies to associate neural activity with health promotion behaviors. Future research should continue to investigate the neural correlates of risk perceptions for health promotion behaviors.

Updating Risk Perceptions

A largely unexplored area of adolescent risky decision-making is how adolescents update their risk perceptions when presented with new information that may conflict with their initial biases. This is essentially the format of many health interventions; they aim to provide adolescents with information about the risks and consequences of certain negative health behaviors. However, few studies investigate how new information about the “true” risk changes adolescents' risk perceptions, if at all. Studies have found that people are more likely to update their beliefs when the information presented to them is desirable, or better than they expected than when the information was undesirable, or worse than they expected (Moutsiana et al., 2015; Sharot et al., 2011). This is known as unrealistic optimism, in which people maintain optimistic beliefs despite receiving disconfirming information (Weinstein, 1980). A study of people ages 9-26 found that younger people more inaccurately updated their beliefs when given undesirable information about their vulnerability to future adverse life events (Moutsiana et al., 2013). This suggests that adolescents may be resistant to incorporating information about the dangers of participating in risky behaviors into their beliefs.

On the other hand, adolescents are known to be heavily influenced by the opinions of their peers. The effect of social influence on adolescent risk-taking is supported by research that

shows adolescents participate in more risky behaviors when in the presence of peers (Gardner & Steinberg, 2005). Research also shows how peers influence adolescent risk perceptions. One study found that when young adolescents were provided ratings of risk from a social-influence group, they updated their risk preferences in the direction of that group (Knoll et al., 2015). Specifically, younger adolescents changed their risk rating more after seeing the risk ratings of teenagers than after seeing the risk rating of adults (Knoll et al., 2015). This suggests that when provided with information about how their peers perceive certain risks, adolescents may be more likely to change their risk perceptions. When creating health interventions, it may be more effective to provide information about the "true" risk of certain behaviors in the context of how their peers rate those risks. Additionally, Knoll and colleagues (2015) found that younger adolescents changed their risk perceptions the most of all age groups, so it may be beneficial for health interventions to target younger adolescents while their biases are still malleable.

Little is known about the neurological mechanisms of how humans update their beliefs. Studies suggest that belief updating when receiving favorable versus unfavorable information is processed differently in the brain, specifically in the left frontal-subcortical circuit of the brain (Moutsiana et al., 2015). The reduced tracking of estimation errors in the inferior prefrontal gyrus may explain selectivity in belief updating (i.e., updating beliefs more when information is favorable) (Sharot et al., 2011). However, both of these studies are in adults, whereas adolescents are still undergoing developmental changes in the prefrontal cortex (Blakemore & Choudhury, 2006). A recent fMRI study found that when given information about a social influence group's risk ratings that conflicted with their own beliefs, activity increased in the posterior middle frontal cortex, dorsal cingulate cortex, and inferior frontal gyrus in both adolescents and adults

(Knoll et al., 2020). More research is necessary to understand the neural mechanisms of updating risk perceptions when given new information.

The Current Study

Research Questions

Due to the gaps in the literature, this study aims to investigate adolescent risk perceptions for both health risk behaviors and health promotion behaviors and how adolescents change their perceptions of risks when provided with new information. Additionally, this study will investigate the association between both health risk and health promotion risk perceptions and risk-taking in an experimental task. The study aims to address the following research questions: (1) How do adolescents perceive health risk behaviors? (2) How do adolescents update their risk perceptions when presented with new information about the likelihood of these health risks occurring? (3) Do adolescents differ in (a) their perceptions of the likelihood of these risks occurring and (b) their updated perceptions when presented with new information based on the type of behavior (i.e., health risk and health promotion)? (4) How do initial risk perceptions of health risk and health promotion behaviors correlate with risk-taking in an experimental task (Balloon Analogue Risk Task) (Lejuez et al., 2002)? Answering these questions will not only guide structuring adolescent health interventions but also serve as preliminary evidence to support future neuroimaging studies.

Hypotheses

Hypotheses were generated to address each research question. For Research Question (1), it was hypothesized that adolescents will initially overestimate their vulnerability to health risks (Cohn et al., 1995; Fischhoff et al., 2010; Millstein & Halpern-Fisher, 2003; Reyna & Farley, 2006). For Research Question (2), it was predicted that participants will update their risk perceptions more when the information they receive is better than they expected and less when the information they receive when is worse than they expected per unrealistic optimism (Moutsiana et al., 2013, 2015; Sharot et al., 2011). For Research Question (3) it was anticipated that health risk and health promotion behaviors would be differentially perceived and updated following prior literature that suggests there are differential psychological correlates of negative and positive risk (Duell & Steinberg, 2020). Specifically, health promotion risk behaviors would be perceived as less risky (Fryt et al., 2021). Given the novelty of research surrounding health promotion behaviors, this hypothesis is largely exploratory. Lastly, for Research Question (4) it was hypothesized that initial health risk perceptions will be negatively correlated with risk-taking in the BART task. In other words, lower perceptions of risk will be associated with increased risk-taking behaviors in the BART task (Fryt et al., 2021; Reniers et al., 2016). However, it was anticipated initial health promotion risk perceptions would not be associated with risk-taking in the experimental risk task (Fryt et al., 2021; Duell & Steinberg, 2020).

Chapter 2

Methods

Participants

This investigation was part of a larger data collection effort that included a variety of studies designed by scientists affiliated with the Character Lab Research Network (CLRN). CLRN simultaneously rolled out multiple independent studies, and students were randomized to one of the studies running in their school. Students who were randomly assigned to this study included 112 adolescents (55% self-identified female). The participants were ages 13-19 years (M = 15.5, SD = 1.3) in grades 8-12 (M = 10.1, SD = 1.3). Parental consent and adolescent assent were obtained for participants under 18 through CLRN. Signed consent was obtained for participants 18 and older. Complete racial and ethnic data were reported by 48 of the 112 participants. See Table 1 for the demographic characteristics of the sample. Only a subset of participants completed the Balloon Analog Risk Task portion of the survey (N=62), so only those participants were included in analyses of that measure.

Table 1. Demographic Characteristics of the Sample

Sample Characteristics	*n*	%	*M*	*SD*
Gender				
Female	62	55		
Male	45	40		
Other	1	0.8		
Not reported	4	4		
Age			15.5	1.3
13	8	7		
14	13	12		
15	35	31		
16	25	22		
17	22	20		
18	4	4		
19	1	0.8		
Not reported	4	4		
Grade			10.1	1.3
8	12	11		
9	25	22		
10	29	26		
11	22	20		
12	20	18		
Not reported	4	4		
Race/Ethnicity [a]				
White	36	75		
Black	11	23		
Asian	0	0		
Hispanic	34	71		
American Indian/Alaska Native	1	2		
Hawaiian/Pacific Islander	0	0		
Multirace	0	0		
Home Language [a]				
English	21	44		
Spanish	27	56		

Note. N=112 for gender, age, and grade. N=48 for race/ethnicity and home language.

[a] Reflects data for only N=48 participants.

Procedure

This study was conducted on school computers during class time in participating schools throughout a two- to three-week testing window. On a predetermined testing day, a teacher proctor at each school administered the CLRN research activities to students. To introduce the study, teachers read a script that explained to students that all research activities were part of an educational research initiative at their school, that participation was voluntary, that they were not being graded, and that teachers would not see their answers. Teachers also instructed students to focus on their computers and not to look at classmates' screens. Upon logging into the CLRN platform, all students first viewed an assent screen that reiterated this information and, in addition, explained that parents would not see their responses and that their names and any other unique identifying information would not be shared with researchers. Students who agreed to participate were then directed to the survey.

The questionnaire specific to this study was a Qualtrics survey that contained a variety of questions about decision-making, risk-taking, and personality traits. During the survey, participants completed two tasks: the chat game and the balloon game (see Measures: Risk-Taking).

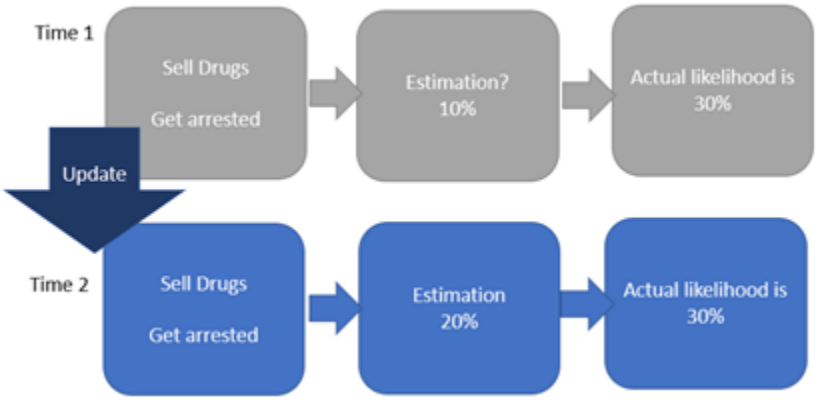
Measures

Health Risk Perceptions

Health risk perceptions were measured using a likelihood estimation task, adapted from Sharot and colleagues (2011). First, participants were asked a question such as, "*If you were to*

sell drugs, how likely is it that you will also get arrested?" Participants answered by dragging a slider anywhere from 0-100%. Then, participants were told the actual likelihood of that outcome occurring. Participants were told that the actual likelihood was calculated based on the experiences of a group of individuals their age. Participants estimated the likelihood of 24 situations that varied by type of behavior (health risk or health promotion) and outcome (positive or negative). After completing all 24 questions, participants completed the same task a second time to assess whether their likelihood estimations changed after being informed of the actual likelihood. Reference Figure 1 for an illustration of the likelihood estimation task and Appendix A for a full list of questions. The data from the likelihood estimation task was used to calculate the estimation error and the amount the participant updated their estimate. Estimation error was calculated by subtracting the actual likelihood from the participant's initial estimate. The amount updated was calculated by taking the absolute value of the second estimate subtracted from the initial estimate.

Figure 1. Illustration of Likelihood Estimation Task



Note. The figure above shows the flow of the likelihood estimation task that the participants completed. Time 1 indicates the first round of the task, and Time 2 indicates the second round of the task, after the actual likelihood was revealed. See Appendix A for the full list of questions in the Likelihood Estimation Task.

Risk-Taking

Risk-taking was measured using the Balloon Analog Risk Task (BART), adapted from Lejuez and colleagues (2002) (see Pei et al., 2020 for a complete description). In this task, participants can choose to inflate the virtual balloon for the chance to earn more in-game points or collect the points associated with the current state of the balloon. When presented with an image of a balloon, participants were prompted to press a button to either inflate or bank the balloon. Selecting "bank" would add the points to the game bank and start a new trial. Selecting "inflate" would increase the size of the balloon and the number of in-game points associated with the balloon. With every pump, the balloon is inflated, and the risk of the balloon popping increases, at which time the current points associated with the balloon are lost. The participants were told the balloon explodes at a random number of pumps unknown to the participant. The

maximum number of pumps was 12 for each trial. Risk-taking was operationalized as the average number of pumps the participant took on the trials in which the balloon did not explode across the 15 trials.

Data Analysis

R was used to clean, manipulate, and analyze the data. Descriptive statistics were calculated for each variable. Analyses followed a within-subjects 2(behavior type: health risk behavior or health promoting behavior) x 2(outcome type: positive or negative) experimental design. There were three dependent variables: 1) initial likelihood estimate 2) estimation error and 3) absolute value of the update. Three two-way ANOVA tests were run using R to determine the main effects and interaction effects of the categorical variables on the participants' initial estimates, estimation error, and absolute update. Tukey post hoc tests were run to investigate subsequent pairwise comparisons. To test whether health risk perceptions were related to risk-taking in the BART task, Pearson correlation tests were conducted. Correlation analyses only included participants who completed the BART task (N=62). Any potential outliers were Winsorized within three standard deviations of the mean for both the predictor and outcome variables (Dixon & Yuen, 1974). For each statistical test, the level of significance was set at α=0.05.

Chapter 3

Results

Descriptive Statistics

Across all types of behaviors and outcomes, the average initial likelihood estimate among the sample was 52.8 (*SD* = 27.7), which corresponds to a likelihood estimate of 52.8%. The average estimation error across all types of behaviors and outcomes was -2.09, indicating a slight underestimation relative to the actual likelihood (*SD* = 33.1). The average amount that adolescents updated their estimates was 21.5 (*SD* = 18.9), indicating that their perceptions of risk increased once they were provided with information on actual likelihood of the consequences. However, the average of each dependent variable varied greatly depending on the type of behavior and type of outcome. See Table 2 for descriptive statistics for each behavior type (health risk and health promotion) and outcome type (negative and positive).

Table 2. Descriptive Statistics of Initial Estimate, Estimation Error, and Update

Measure	HRB				HPB			
	Positive		Negative		Positive		Negative	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Initial Estimate	46.9	25.8	60.4	25.3	57.2	25.7	48.1	23.6
Estimation Error	-6.6	27.9	5.9	30.9	-0.2	33.6	-4.1	26.4
Update	21.6	17.7	17.0	19.7	22.8	19.9	19.0	18.0

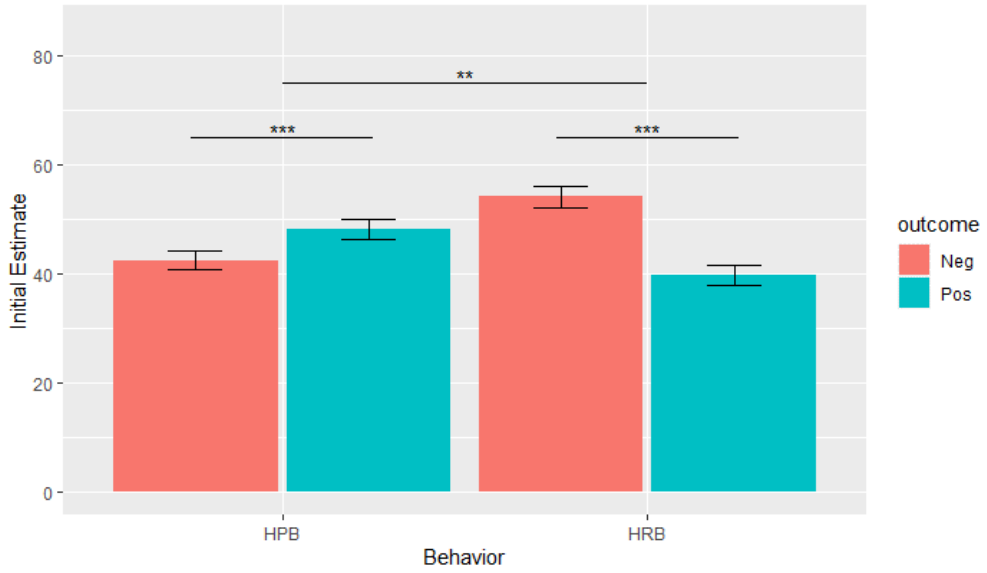
Note. HRB = Health Risk Behavior, HPB = Health Promotion Behavior. Negative and Positive refer to the outcome.

Differences in Initial Likelihood Estimates Based on Behavior and Outcome Type

A two-way ANOVA was used to test if the adolescents' initial likelihood estimates differed based on the type of behavior (health risk and health promotion) and type of outcome (positive and negative). The results revealed a statistically significant difference in average initial estimate by both type of behavior, $F(1)=7.08$, $p = .008$, and outcome, $F(1)=15.39$, $p < .001$. The interaction effect between type of behavior and outcome was also statistically significant, $F(1)=217.86$, $p < .001$ (See Table 3).

A Tukey post-hoc test revealed that adolescents estimated the outcomes of health risk behaviors to be more likely than health promotion behaviors on average. Additionally, negative outcomes were viewed as more likely to occur than positive outcomes. Adolescents demonstrated a healthy bias by viewing negative outcomes of health risk behaviors as more likely than positive outcomes. They also viewed the positive outcomes of health promotion behaviors as more likely than negative outcomes (See Figure 2). See Table 4 for all post-hoc comparisons.

Figure 2. Difference in Average Initial Estimates by Behavior and Outcome Type



Note. HRB = Health Risk Behavior, HPB = Health Promotion Behavior, Neg = Negative Outcome, Pos = Positive Outcome

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Table 3. ANOVA Results for the Effects of Behavior and Outcome on Initial Estimate

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	*Eta sq*
Behavior	4989	1	4989	7.08**	.008	.002
Outcome	10949	1	10949	15.39***	<.001	.005
Behavior x outcome	153549	1	153549	217.86***	<.001	.074

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Table 4. Tukey Post-hoc Comparisons of Behavior*Outcome on Initial Estimate

Comparison						95% Confidence Interval	
Behavior 1	Outcome 1	Behavior 2	Outcome 2	Mean Difference	p_{tukey}	Lower bound	Upper bound
HRB	-	HPB	-	2.72	.008	0.72	4.73
-	Positive	-	Negative	-4.02	<.001	-6.03	-2.01
HRB	Negative	HPB	Negative	17.84	<.001	14.12	21.56
HRB	Positive	HPB	Positive	-12.39	<.001	-16.11	-8.67
HRB	Positive	HRB	Negative	-19.13	<.001	-22.86	-15.41
HPB	Positive	HPB	Negative	11.10	<.001	7.38	14.82

Note. HRB = Health Risk Behavior, HPB = Health Promotion Behavior

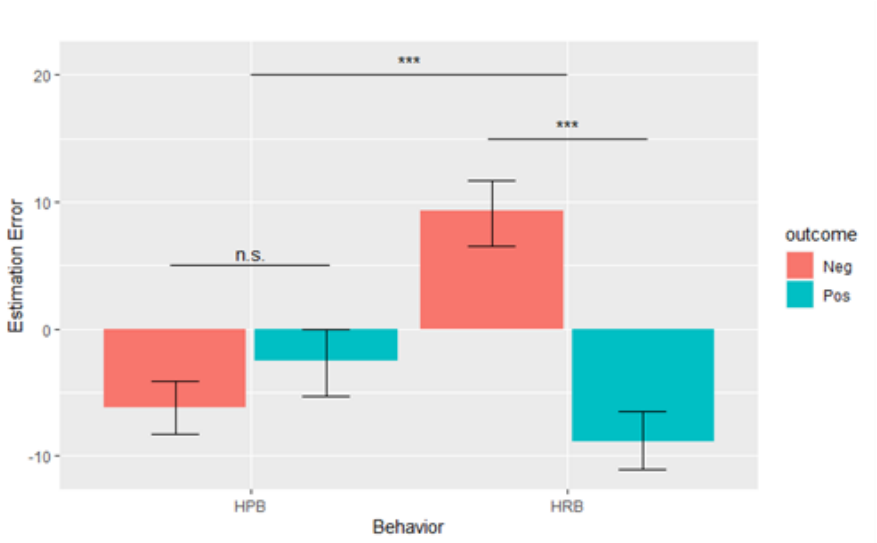
$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Differences in Estimation Error Based on Behavior and Outcome Type

A two-way ANOVA was used to test if the adolescents' estimation errors differed based on the type of behavior (health risk and health promotion) and type of outcome (positive and negative). The results revealed a statistically significant difference in average estimation error by both type of behavior, $F(1)=13.37$, $p < .001$, and outcome, $F(1)=33.16$, $p < .001$. The interaction effect between these two variables was also statistically significant, $F(1)=76.63$, $p < .001$ (See Table 5).

A Tukey post-hoc test revealed that on average adolescents had greater estimation errors for health risk behaviors than for health promotion behaviors. Additionally, adolescents had greater estimation errors when estimating the likelihood of negative outcomes than when estimating the likelihood of positive outcomes. On average, adolescents overestimated the likelihood of negative outcomes for health risk behaviors and underestimated the likelihood of positive outcomes of health risk behaviors, indicating a healthy bias. Adolescents also underestimated the likelihood of both negative and positive outcomes for health promotion behaviors on average. There were no significant differences in average estimation error for health promotion behaviors by outcome (See Figure 3). See Table 6 for all post-hoc comparisons.

Figure 3. Difference in Average Estimation Error by Behavior and Outcome Type



Note. HRB = Health Risk Behavior, HPB = Health Promotion Behavior, Neg = Negative Outcome, Pos = Positive Outcome

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Table 5. ANOVA Results for the Effects of Behavior and Outcome on Estimation Error

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	*Eta sq*
Behavior	14030	1	14030	13.37***	<.001	.005
Outcome	34795	1	34795	33.16***	<.001	.012
Behavior x outcome	80402	1	80402	76.63***	<.001	.027

*p<.05, **p<.01, ***p<.001

Table 6. Tukey Post-hoc Comparisons of Behavior*Outcome on Estimation Error

Comparison						95% Confidence Interval	
Behavior 1	Outcome 1	Behavior 2	Outcome 2	Mean Difference	p_{tukey}	Lower bound	Upper bound
HRB	-	HPB	-	4.57	<.001	2.12	7.02
-	Positive	-	Negative	-7.20	<.001	-9.65	-4.75
HRB	Negative	HPB	Negative	15.51	<.001	10.96	20.01
HRB	Positive	HPB	Positive	-6.37	.002	-10.91	-1.83
HRB	Positive	HRB	Negative	-18.13	<.001	-22.68	-13.59
HPB	Positive	HPB	Negative	3.74	.15	-0.80	8.29

Note. HRB = Health Risk Behavior, HPB = Health Promotion Behavior

*p<.05, **p<.01, ***p<.001

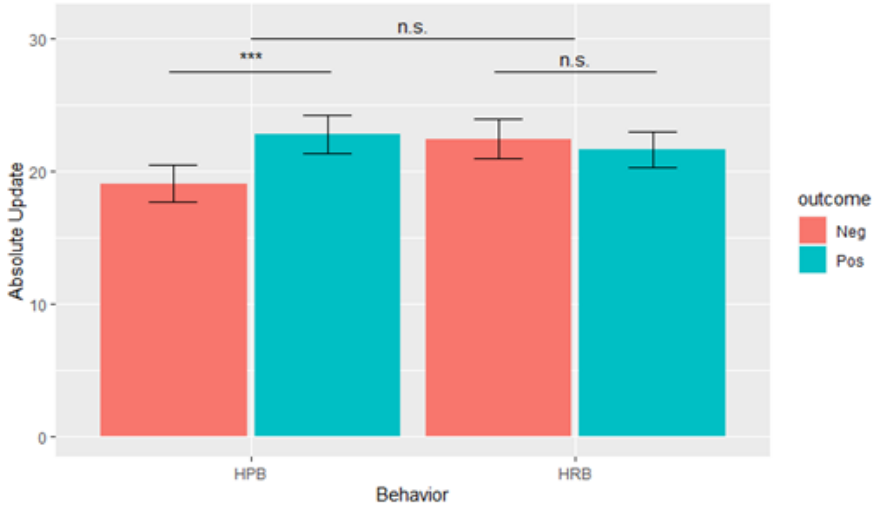
Differences in Update of Likelihood Estimates Based on Behavior and Outcome Type

Absolute Update of Likelihood Estimate

The absolute value of the difference between initial and final estimates was used to measure how much adolescents updated their likelihood estimates. A larger absolute value indicates a greater degree of belief updating. A two-way ANOVA was used to test if the degree to which adolescents updated their likelihood estimates differed based on the type of behavior (health risk and health promotion) and type of outcome (positive and negative). The results revealed a statistically significant difference in average absolute update by outcome, $F(1)=4.28$, $p = .04$. There was no statistically significant difference in average absolute update by behavior, $F(1)=2.31$, $p =.13$. The interaction between type of behavior and outcome for absolute update was statistically significant, $F(1)=9.85$, $p < .01$ (See Table 7).

A Tukey post-hoc test revealed that adolescents updated their likelihood estimates more when the outcomes of health promotion behaviors were positive than when the outcomes were negative (See Figure 4). See Table 8 for the full list of post-hoc comparisons.

Figure 4. Difference in Absolute Update by Behavior and Outcome Type



HRB = Health Risk Behavior, HPB = Health Promotion Behavior, Neg = Negative Outcome,

Pos = Positive Outcome

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Table 7. ANOVA Results for the Effects of Behavior and Outcome on Absolute Update of Likelihood Estimate

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	*Eta sq*
Behavior	922	1	922	2.31	.13	.001
Outcome	1521	1	1521	4.28*	.04	.002
Behavior x outcome	3497	1	3497	9.85**	.002	.004

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Table 8. Tukey Post-hoc Comparisons of Behavior*Outcome on Absolute Update of Likelihood Estimates

Comparison						95% Confidence Interval	
Behavior 1	Outcome 1	Behavior 2	Outcome 2	Mean Difference	p_{tukey}	Lower bound	Upper bound
HRB	-	HPB	-	1.11	.13	-0.32	2.53
-	Positive	-	Negative	1.50	.04	0.08	2.93
HRB	Negative	HPB	Negative	3.39	.006	0.74	6.03
HRB	Positive	HPB	Positive	-1.18	.66	-3.82	1.47
HRB	Positive	HRB	Negative	-0.78	.87	-3.42	1.87
HPB	Positive	HPB	Negative	3.79	.001	1.14	6.43

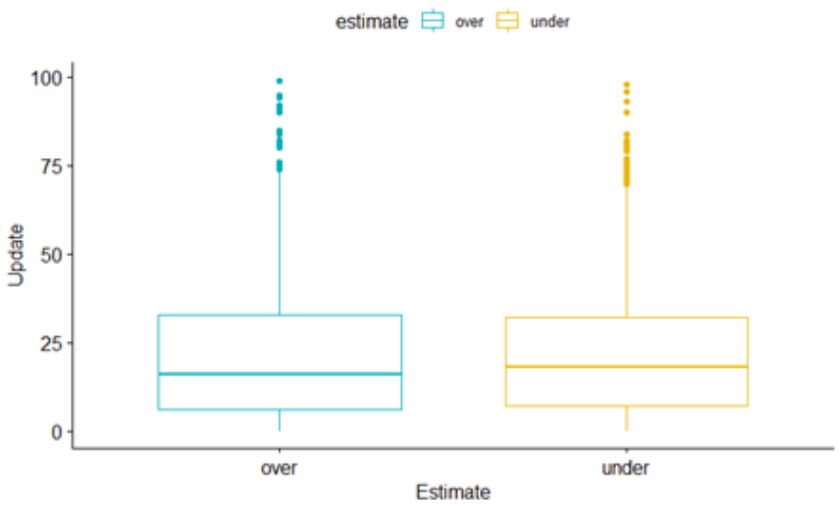
Note. HRB = Health Risk Behavior, HPB = Health Promotion Behavior

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Difference in Update of Likelihood Estimate Based on Initial Estimation Error

After categorizing participants based on whether they initially overestimated or underestimated the likelihood of events occurring, we ran an independent samples t-test to examine whether the two groups differed in the degree to which they updated their estimate. There was no statistically significant difference in absolute amount updated between those who initially overestimated and those who initially underestimated the outcomes of health behaviors, $t(2562.9)= 0.22$, $p = .82$ (See Figure 5).

Figure 5. Comparison of Absolute Update by Initial Estimation Error



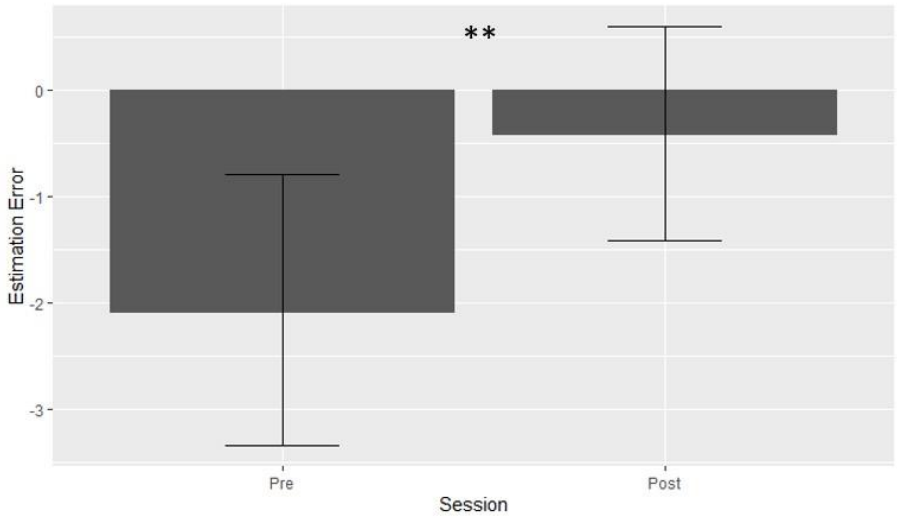
Note. The overestimate group was those who initially had a positive estimation error. The underestimate group was those who initially had a negative estimation error. The difference between the two groups was not significant, p =.82.

Update of Estimation Error

To measure the direction in which adolescents updated their risk perceptions, we ran a paired samples t-test between initial (pre) and final (post) estimation error. A final estimation error closer to zero would indicate they updated toward the actual likelihood. The results revealed that overall, there was a statistically significant difference in pre estimation error and post estimation error, indicating that adolescents updated their estimates towards the actual likelihood $t(2687)= 3.06$, p =.002 (See Figure 6). A three-way ANOVA test revealed that the interaction between session (pre vs post), behavior (heath risk behavior vs health promotion behavior), and outcome (positive vs negative) was significant, $F(1)=11.43$, $p < .001$. Figure 7

shows how adolescents updated towards the actual likelihood for each behavior and outcome type. See Table 9 for paired samples t-test results for each type of behavior and outcome.

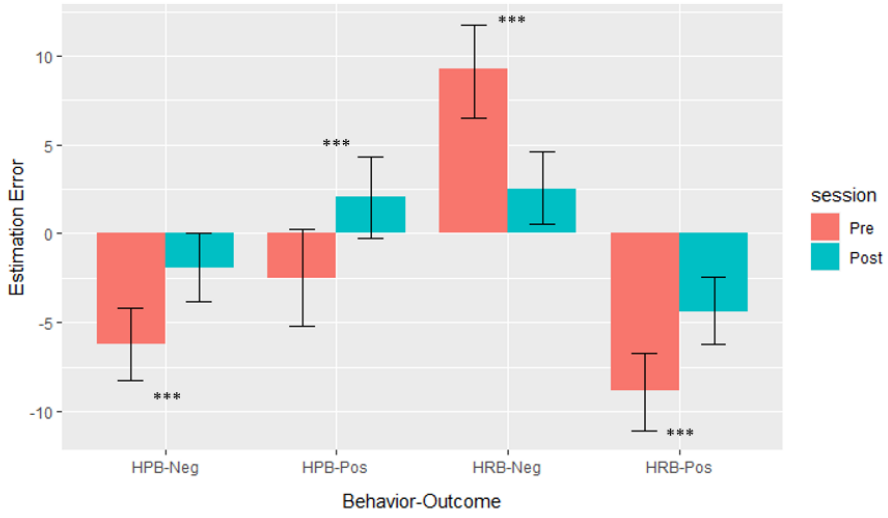
Figure 6. Comparison of Initial and Final Estimation Error Across All Behaviors and Outcomes



Note. Pre session indicates the first round of the likelihood estimation task. Post session indicates the second round of the likelihood estimation task, after the actual likelihood was revealed to participants.

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Figure 7. Comparison of Initial and Final Estimation Error for Each Behavior and Outcome Type



Note. HPB = Health Promotion Behavior, HRB = Health Risk Behavior, Pos = Positive Outcome, Neg = Negative Outcome. Pre session indicates the first round of the likelihood estimation task. Post session indicates the second round of the likelihood estimation task, after the actual likelihood was revealed to participants.

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

Table 9. Paired t-test Results for Comparison of Initial and Final Estimation Error for Each Behavior and Outcome Type

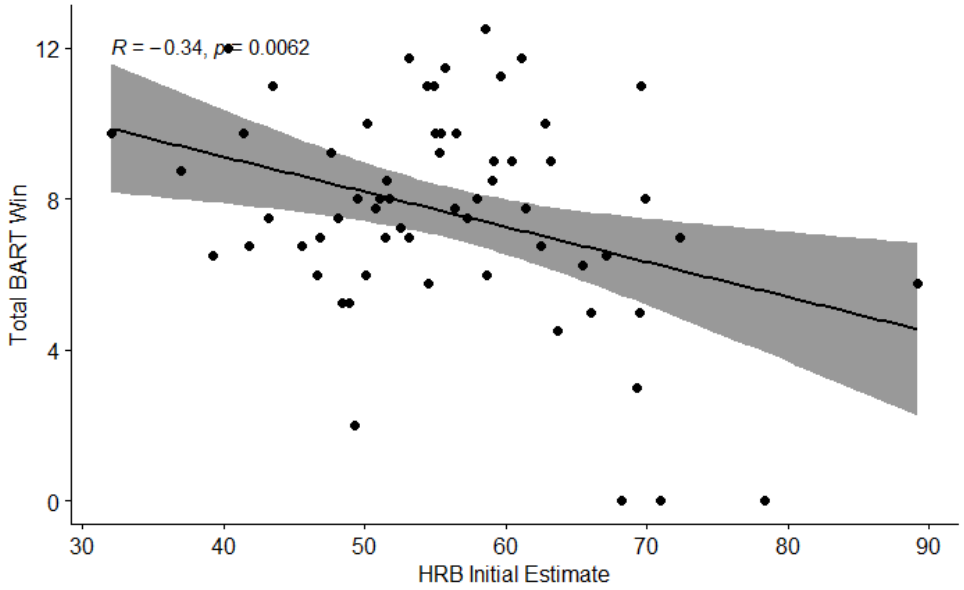
Behavior-Outcome	Pre		Post		*t*(671)	*p*	Cohen's
	M	*SD*	*M*	*SD*			*d*
HPB-Negative	-6.2	27.5	-1.9	25.2	4.338	<.001	0.167
HPB-Positive	-2.5	37.4	2.0	29.2	4.338	<.001	0.160
HRB-Negative	9.3	33.9	2.5	27.2	4.338	<.001	0.176
HRB-Positive	-8.9	29.9	-4.4	25.6	4.338	<.001	0.163

Note. "Pre" indicates the first round of the likelihood estimation task. "Post" indicates the second round of the likelihood estimation task, after the actual likelihood was revealed to participants.

Correlation Between Initial Risk Perceptions and Risk-Taking in the Balloon Analog Risk Task (BART)

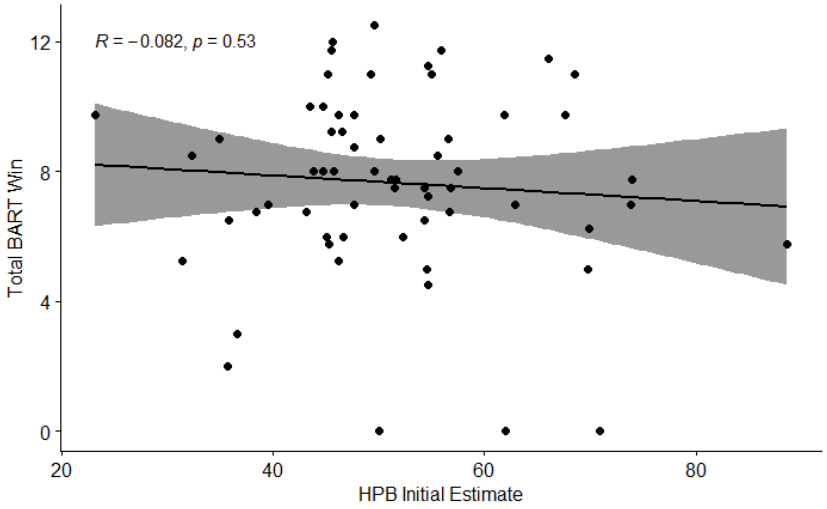
Pearson's correlation analysis revealed a statistically significant correlation between initial risk perceptions of health risk behaviors and risk-taking in the BART task, $r(60) = -0.34$, $p = .006$ (see Figure 8). There was no statistically significant correlation between initial risk perceptions of health promotion behaviors and risk-taking in the BART task, $r(60) = -.08$, $p = .53$ (see Figure 9). When health risk behaviors were separated by outcome type, there was a statistically significant negative association between estimates of positive outcomes and risk-taking and BART, $r(60) = -0.32$, $p = .01$. This indicates that those who perceived positive outcomes of health risk behaviors as less likely, took more risks in BART (See Figure 10). There was no signification relationship between estimates of negative outcomes of health risk behaviors and risk-taking in BART, $r(60) = -0.16$, $p = .23$ (See Figure 11).

Figure 8. Association between Initial Estimates of Health Risk Behaviors and Risk-Taking in the Balloon Analog Risk Task (BART)



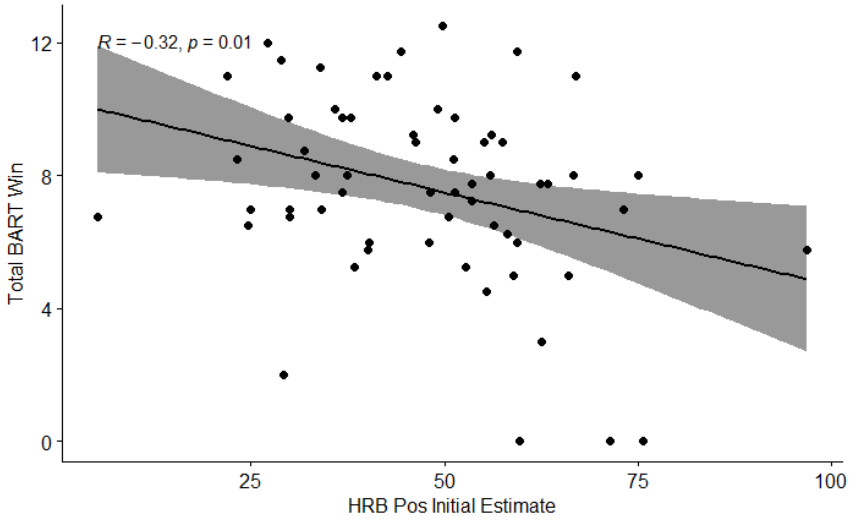
Note. N= 62. HRB = Health Risk Behavior. Total BART win represents the average number of pumps on trials in which the balloon did not explode. Pearson's product correlation was used to test the correlation between initial estimate and total BART win.

Figure 9. Association between Initial Estimates of Health Promotion Behaviors and Risk-Taking in Balloon Analog Risk Tak (BART)



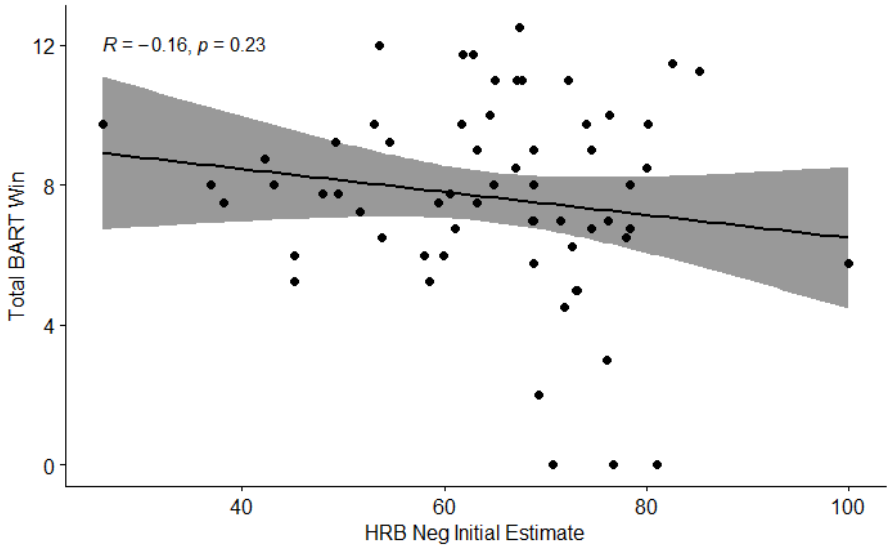
Note. N= 62. HPB = Health Promotion Behavior. Total BART win represents the average number of pumps on trials in which the balloon did not explode. Pearson's product correlation was used to test the correlation between initial estimate and total BART wins.

Figure 10. Association between Initial Estimates of Health Risk Behaviors with Positive Outcomes and Risk-Taking in Balloon Analog Risk Task (BART)



Note. N= 62. HRB = Health Risk Behavior, Pos = Positive Outcome. Total BART win represents the average number of pumps on trials in which the balloon did not explode. Pearson's product correlation was used to test the correlation between initial estimate and total BART wins.

Figure 11. Association between Initial Estimates of Health Risk Behaviors with Negative Outcomes and Risk-Taking in BART



Note. HRB = Health Risk Behavior, Neg = Negative Outcome. Total BART win represents the average number of pumps on trials in which the balloon did not explode. Pearson's product correlation was used to test the correlation between initial estimate and total BART wins.

Chapter 4

Discussion

The current study investigated how adolescents differentially perceive health risk and health promotion behaviors, how they update their risk perceptions when given new information, and how risk perceptions are associated with risk-taking in an experimental task. Results supported our hypothesis that adolescents would overestimate their vulnerability to negative outcomes of risk, indicating a healthy bias. On the other hand, they viewed health promotion behaviors differently than health risk behaviors. They generally underestimated the potential for positive outcomes of health promotion behaviors, highlighting a possible area for intervention. Furthermore, adolescents did not selectively update their beliefs based on their initial biases as hypothesized. Rather, adolescents updated their risk perceptions accurately when given information about the actual likelihood of these risks occurring – despite their initial biases – for both health risk and health promotion behaviors. Lastly, health risk, but not health promotion, perceptions were associated with risk-taking in an experimental paradigm, shedding light on the types of risk perceptions that may be associated with adolescent risk-taking.

The hypothesis that adolescents would overestimate their vulnerability to health risks was supported, but only for negative outcomes. Adolescents overestimated their likelihood of experiencing negative outcomes of health risk behaviors and underestimated their likelihood of experiencing positive outcomes of health risk behaviors. This suggests that adolescents may feel vulnerable to the harmful consequences of risky behavior, which has been demonstrated in previous literature (Cohn et al., 1995; Millstein & Halpern-Fisher, 2003). However, it contradicts the literature that suggests adolescents may view the positive outcomes of risk behavior as more likely than negative outcomes (Goldberg et al., 2002). A large confounding variable in this

relationship is experience with risk behaviors. Adolescents who report engaging in a health risk behavior more often may experience more positive consequences and fewer negative consequences and therefore perceive positive outcomes as more likely (Goldberg et al., 2002). Self-reported engagement in health risk behaviors was not surveyed in this study and should be considered in future research.

Furthermore, adolescents perceived health promotion behaviors differently than health risk behaviors. They viewed the positive outcomes of health promotion behaviors as more likely than those of health risk behaviors, and the negative outcomes of health promotion behaviors as less likely than those of health risk behaviors, which demonstrates a healthy bias. However, they generally underestimated the likelihood of positive outcomes of health risk behaviors. This reveals an important area for potential intervention. Educating adolescents about health promotion behaviors and directing them towards activities that may fulfill their sensation-seeking desires can serve as a model for future health interventions (Duell & Steinberg, 2020; D'Silva, 2001).

The hypothesis that adolescents would selectively update their risk perceptions was not supported. Regardless of their whether the information contradicted their initial beliefs, adolescents demonstrated a change in their risk perceptions toward the actual likelihood they were given. This contradicts findings from studies in which young people demonstrate asymmetric belief updating, or in other words, they update their beliefs less when information is undesirable (Moutsiana et al., 2013; Sharot et al., 2011). A possible explanation for this phenomenon is adolescents' cognitive flexibility. One study found that adolescents are flexible learners and tend to adopt unfamiliar information more than adults or children (Gopnik et al., 2017). The same still-developing neural circuitry that explains increased risk-taking in

adolescence may explain adolescents' propensity for flexible learning (McCormick & Telzer, 2016). Another study found that adolescents learned faster from reward-prediction errors than adults when completing a learning task (Hauser et al., 2015). This learning flexibility seems to decrease with age, so it is important to intervene early in adolescents to alter adolescent risk perceptions and improve health outcomes.

As hypothesized, risk perceptions of health promotion behaviors were not associated with risk-taking in BART. Previous research suggests that, unlike negative risk-taking, self-reported "positive" risk-taking was not associated with risk-taking in an experimental task (Duell & Steinberg, 2020). Engagement in health promotion behaviors has not been shown to share the same psychological correlates as health risk behaviors, such as impulsivity, reward sensitivity, and punishment sensitivity (Duell & Steinberg, 2020). This suggests that thinking about health-promoting risks may activate different neural processing networks associated with more long-term planning and strategizing (Duell & Steinberg, 2019, 2022). Future research should use neuroimaging techniques to examine the brain networks involved when evaluating health promotion behaviors.

Lastly, the results supported the hypothesis that health risk perceptions would predict risk-taking in BART. This is consistent with literature that shows adolescent health risk perceptions correlate with self-reported risk-taking (Curry & Youngblade, 2006; Fryt et al., 2021; Reniers et al., 2015), but this is one of the first studies to correlate adolescent health risk perceptions with risk-taking in an experimental paradigm like BART. This is an important finding because it demonstrates how health risk perceptions can potentially be used as a predictor for real-life risk-taking behaviors. Additionally, the current study separated health risk behaviors by type of outcome (positive or negative) when investigating the relationship between risk

perceptions and risk-taking in BART, which is something few studies have done. When separated by the outcome, those who viewed positive outcomes of health risk behaviors as more likely seemed to take fewer risks in BART, which is the opposite of what one might think. It contradicts findings from previous research studies that show perceived benefits (positive outcomes) are more predictive of risk-taking than perceived costs (negative outcomes) among adolescents (Goldberg et al., 2002; Parsons et al., 2000). However, some research suggests that when adolescents feel they have "nothing to lose" they tend to engage in more risky behaviors (Harris et al., 2002). This pessimistic attitude may explain why adolescents who viewed positive outcomes as less likely took more risks in BART. Pessimism, or negative expectations of the future, has been linked to negative health outcomes, such as depression, in adolescents (Zou et al., 2022). Additionally, adolescents are overly pessimistic about their risk of dying (Fischhoff et al., 2010). If adolescents are more pessimistic about their future, they may take more risks. The relationship between pessimism and risk-taking should be explored in future research.

Limitations

When interpreting these results, it is important to discuss the limitations of the study. First, a large portion of the sample preferred not to report racial and ethnic data, which limits the generalizability of the results. Additionally, in this study, adolescence was defined only by a specific age range (13-19). Most definitions include ages 10-19 as adolescence (World Health Organization, 2019). However, age is only a rough marker of adolescence, which can be also characterized by the onset of puberty (Jaworksa & MacQueen, 2015). Adding measures of pubertal development may have provided a more accurate definition of adolescence.

Future Directions

Peer influence has been shown to heavily influence engagement in health risk and health promotion behaviors in adolescence (Telzer, 2018). It would be worthwhile to investigate how peer influence affects how adolescents perceive risks for both types of behavior and how they update those perceptions. Additionally, factors such as affect and personality traits have also been shown to influence risk attitudes (Curry & Youngblade, 2006; Pavlíček et al., 2021; Slovic, 2006). Age and gender have also been shown to play a role in risk behaviors and risk perceptions (Knoll et al, 2015; Millstein & Halpern-Fisher, 2003; Reniers et al., 2016; Rhodes & Pivik, 2011). Future studies should investigate if and how age, gender, affect, and personality type influence adolescent risk perceptions and belief updating for health risk and health promotion behaviors.

Conclusions

To conclude, the current study presents novel findings about how adolescents perceive and update their perceptions of different types of risk behaviors. Few studies have compared adolescent health risk perceptions to risk-taking in an experimental task. This study provides the preliminary groundwork for future neuroimaging studies and implications for future health interventions. The results indicate that adolescents think differently about different types of risk, so health interventions must be precise about how information is presented. Promoting the benefits of health promotion behaviors, rather than informing them of the dangers of health risks, may be more effective in reducing harmful risk behaviors. Additionally, adolescents may not be as resistant to changing their beliefs as once thought, so early intervention is crucial to improve

health outcomes. Importantly, the results show that health risk perceptions do matter; they may be associated with adolescents' propensity to engage in risks.

Appendix A

Likelihood Estimation Task Survey Questions

If you were to start a conversation with someone you don't know, how likely is it that you will also have a successful conversation?
If you were to run for student council, how likely is it that you will also be elected?
If you were to exercise, how likely is it that you will also be healthy?
If you were to wear a helmet while riding a bike, how likely is it that you will also have no physical injuries?
If you were to take an Advanced Placement (AP) Class, how likely is it that you will also pass the AP class?
If you were to play sports, how likely is it that you will also make new friends?
If you were to brush your teeth, how likely is it that you will also have bleeding gums?
If you were to start a conversation with someone you don't know, how likely is it that you will also feel rejection?
If you were to volunteer for a charity, how likely is it that you will also have little time with friends?
If you were to get a flu shot, how likely is it that you will also get sick often?
If you were to participate in an academic competition, how likely is it that you will also sleep less than 8 hours?
If you were to try out for a school play, how likely is it that you will also be teased often?
If you were to drink alcohol, how likely is it that you will also feel happy?
If you were to smoke, how likely is it that you will also feel little anxiety?
If you were to use marijuana, how likely is it that you will also have more than 10 friends?
If you were to cheat, how likely is it that you will also have a high GPA?
If you were to bully others often, how likely is it that you will also have high self-esteem?
If you were to drive under the influence of alcohol, how likely is it that you will also fit in with your friends?
If you were to text while driving, how likely is it that you will also get into a car accident?
If you were to drink alcohol, how likely is it that you will also be embarrassed in front of friends?
If you were to use marijuana, how likely is it that you will also have memory problems?
If you were to bully others often, how likely is it that you will also get in trouble with your parents?
If you were to sell drugs, how likely is it that you will also get arrested?
If you were to eat fast food, how likely is it that you will also be overweight?

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ACADEMIC VITA

EDUCATION

The Pennsylvania State University **University Park, PA**
Schreyer Honors College | College of Health and Human Development *May 2023*
Bachelor of Science in Biobehavioral Health Dean's List 7/7 semesters
President Sparks Award, President's Freshman Award

MEDICAL & RESEARCH EXPERIENCE

Decision Neuroscience Lab **University Park, PA**
Lead Undergraduate Research Assistant *March 2021 – Present*

- Collaborate with Dr. Nina Lauharatanahirun on secondary data analysis of adolescent health risk perception for independent honors thesis
- Code and clean data using R and Qualtrics software for running studies and thesis project
- Administer and analyze ECG and ICG tests on human participants

Hershey Medical Center Emergency Medicine Research Associate Program **Hershey, PA**
Student Intern *Summer 2021*

- Shadowed attending and resident physicians for over 50 hours in Emergency Department
- Screened patients entering Emergency Department for potential clinical trial candidates

LEADERSHIP & SERVICE

Penn State IFC/Panhellenic Dance Marathon (THON) **University Park, PA**
Volunteer, Committee Member *September 2019 – Present*

- Raise over $100,000 each year with my organization to support children and families affected by childhood cancer as a part of the world's largest student-run philanthropy
- Serve on committee that provides sustenance to over 700 dancers and thousands of attendees during the 46-hour dance marathon

Delta Gamma, Alpha Chi Chapter Sorority **University Park, PA**
Director of Public Relations, General Member *February 2020 – Present*

- Manage three social media platforms to communicate within and outwardly promote the chapter
- Advocate for the visually impaired community through philanthropy: Service for Sight

Penn State University Department of Biobehavioral Health & Chemistry **University Park, PA**
Undergraduate Teaching Intern, Learning Assistant *August 2020 – December 2021*

- Collaborated with professional and graduate staff to promote student learning in an undergraduate general chemistry course and first-year seminar
- Coached students during office hours to reinforce course content and develop effective study strategies

Schreyer Honors College Orientation (SHO TIME) **University Park, PA**
Communications Team Lead, Mentor *August 2020 – August 2021*

- Mentored 20 first-year-students through two-day welcome program and maintained connections throughout their first semester
- Led team of 12 orientation mentors to motivate and inspire best mentoring practices