Examining the Role of Physiological Arousal in Laboratory Risk-Taking in Social and Non-Social Contexts

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Submitted in partial fulfillment of the
requirements for the degree of Masters of Arts, Psychology

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Abstract

Current theoretical models attribute the rise in risk-taking during adolescence to heightened activity in reward processing brain regions when in the presence of social and non-social rewarding stimuli. However, non-rewarding, but very salient stimuli, have also been shown to increase activity in reward processing brain regions and could, in theory, also increase risk taking propensity in adolescents. To examine this, we had participants complete a risk-taking task under "standard" conditions as well as under one of three experimental conditions: virtual peer observer with positive social feedback (positive social), virtual peer observer with neutral social feedback (negative social), and with triple the potential rewards (non-social positive). The study's sample consisted of 59 mainly young adult participants (M_{age} = 20.69, *SD* = 5.08), where 22 identified as men and 37 identified as women. A multi-level model revealed no overall effect of exposure to the experimental context on risk-taking. Greater skin conductance was, unexpectedly, associated with less risk-taking. When examining each context in separate models, exposure to the non-social showed associations with increased risk-taking, whereas the positive social context did not. Negative social contexts showed a pattern of means suggesting that exposure to such contexts may be associated with increased risk-taking, but our models may have been underpowered and were unable to detect this effect. These findings suggest that the salience of a context may be an important factor to consider when exploring what drives adolescent risk-taking.

Keywords: adolescence; risk-taking; peers; social; arousal; skin conductance

Acknowledgments

I would like to thank my supervisor, Dr. Elizabeth Shulman, for her endless support, guidance, and expertise during every step of this thesis research. I appreciate and value her dedication and the knowledge she has passed along. I would also like to thank my committee members, Dr. Teena Willoughby and Dr. Cheryl McCormick, as well as my external examiner, Dr. Louis Schmidt, for all of the insightful feedback and suggestions they have offered me. I am grateful for all of the time they allocated to this process. I also would like to thank the research assistants in the lab for all of their support and for their help collecting and cleaning the data for my thesis research.

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Adolescence is a transitional period of development that is marked by a rise in substance use, unsafe sex, risky driving, and other risky behaviors that offer an immediate reward or benefit, at the risk of a potential consequence (Steinberg, 2010; Duell et al., 2018; WHO, 2021). Current theoretical models attribute this rise in risk-taking during adolescence to a fast-maturing and reactive neural network of brain regions that are sensitive to environmental rewards (Steinberg, 2010), especially in the presence of peers (Chein et al., 2011). Indeed, for adolescents – and to a lesser extent, young adults – the presence of peers seems to heighten activity in the reward network and increase risk-taking, even absent overt peer pressure (Chein et al., 2011). The effect of peers on the reward network suggests that arousal of this network may be a key mechanism by which peers influence risk-taking in adolescence. However, the brain regions involved in this network are not only responsive to rewarding input; they are also sensitive to non-rewarding input (Horvitz, 2000). In an effort to clarify whether (a) arousal increases risk-taking, (b) whether positive arousal due to peer presence affects risk-taking differently than positive arousal due to increased potential monetary gains, and (c) whether the effect of peer-induced arousal depends on its valence (positive or negative), this study examined the effect of experimentally manipulated social contexts on adolescents' and young adults' laboratory risk-taking and whether any such effects were attributable to physiological arousal.

Social Contexts and Risk Taking

During adolescence, peers tend to have a strong influence on risk-taking behaviors (Prinstein et al., 2001; Fergusson, Swain-Campbell & Horwood, 2002; Simons-Morton, Lerner & Singer, 2005; Gardner & Steinberg, 2005; Chein et al., 2011; Centifanti, Modecki, MacLellan & Gowling, 2016). For instance, in a study by Fergusson, Swain-Campbell, and Horwood

(2002) researchers found that having deviant peers (e.g, engaged in problematic use of substances, were suspended from school, or were in trouble with the law) was associated with increased risky behaviors, such as crime and substance use. Given the longitudinal design of this study, researchers examined how participants' susceptibility to deviant peers changed with age. They found that younger participants (14-15) were most vulnerable to deviant peers whereas older participants (20-21) were least vulnerable, suggesting that peers have more influence in adolescence. Furthermore, in a study by Gardner and Steinberg (2005) researchers examined the effects of peers on risk-taking in adolescents and adults using a computerized laboratory task where participants had to decide if they would stop a car as it approached a yellow light. Participants either completed the task independently or in the presence of two similarly aged peers, who each took turns completing the task. Peers were informed that they could provide advice to participants and that participants could use the advice if they wanted to. It was found that, compared to adults, adolescents in the peer condition took more risks (ran more yellow lights) than those completing the task alone. Altogether, these findings highlight the influence that peers can have on risky behaviors and demonstrate that this peer effect seems to be the strongest in adolescence.

The Dual Systems Model of adolescent risk-taking (Casey et al., 2008; Steinberg, 2008) posits that adolescent risk-taking is driven by an imbalance between a socioemotional system and a cognitive control system. The socioemotional system is made up of neural structures that are essential for processing rewarding stimuli (e.g, the amygdala, the ventral striatum, and the orbitofrontal cortex; Galvan et al., 2013; Steinberg, 2008). The cognitive control system is made up of neural structures that are essential for controlling impulses (e.g, the lateral prefrontal cortex and parietal cortex; Steinberg, 2008). Given that the socioemotional system matures more rapidly than the cognitive control system, this system is much more reactive in adolescence, particularly in social contexts. Therefore, based on this model peers influence risk-taking in adolescents by increasing the activation of the fast-maturing socioemotional system, at a time when the cognitive control system is not able to override these reward sensitive drives (Shulman et al., 2016; Steinberg, 2008).

There is a large body of research that lends support to the dual systems model (Galvan, 2010; Chein et al., 2011; Smith, Chein & Steinberg, 2014; Weigard, Chein, Albert, Smith & Steinberg, 2014; Shulman et al., 2016). For instance, Chein et al. (2011) proposed that a social context may increase risk taking in adolescents by increasing activity in the ventral striatum and orbitofrontal cortex, brain areas linked to the anticipation of rewards. To test their theory, the researchers measured brain activity in a sample of adolescents, young adults, and adults who completed a risk-taking task alone and while being observed by a familiar peer. The risk-taking task entailed driving a car to the end of a road as fast as possible, to get the greatest number of tokens. While driving, participants had to decide whether they would run through traffic lights (saving time but risking a collision) or stop and await a green light (wasting time but no risk of collision). It was found that in the presence of peers, adolescents took more risks (i.e., ran more lights), which was associated with greater ventral striatum and orbitofrontal cortex activation, compared to older participants. Notably, the positive association between reward processing brain regions and risk-taking in the adolescent group was only observed in the presence of peers. Older participants did not differ in levels of neural activity or risk taking, when alone or with a peer. Furthermore, researchers found less activity in adolescents' cognitive control regions (e.g, lateral prefrontal cortex), relative to adults when these groups were in the presence of peers. Together, these findings support the dual systems model by showing that the presence of peers encourages adolescent risk-taking through the activation of brain areas that are related to reward processing and that the cognitive control system is less able to override these drives.

In line with the findings by Chein et al. (2011), there are numerous other neuroimaging and behavioral studies showing increased reward sensitivity during adolescence, particularly in the presence of peers. For instance, Smith, Steinberg, Strang, and Chein (2015) found that in the presence of familiar peers, adolescents displayed greater activity in the ventral striatum compared to adults while receiving rewards. Additionally, Smith et al., (2018) found increased activity in the striatum (involved in reward processing) and anterior insula (involved in affective processing) when adolescents were in the presence of neutral anonymous peers, compared to when alone. Furthermore, O'Brien, Albert, Chein, and Steinberg (2011) demonstrated that in the presence of familiar peers adolescents tended to choose small immediate rewards instead of large future rewards more often than those who completed the task alone. Together, these findings suggest that social contexts in which a familiar peer (who presumably likes the adolescent) or a neutral peer are present produce a rewarding or pleasurable experience in adolescence that can, in turn, intensify their preference for additional rewards.

However, what complicates this view is that heightened activity in the socioemotional system has also been observed in response to non-rewarding social stimuli, suggesting that activity in the ventral striatum may also be associated with the processing of negative social stimuli. Specifically, in a study by Pfeifer et al. (2011), researchers examined longitudinal changes in neural activity in response to various facial emotions (e.g, neutral, angry, fearful, sad, and happy) from late childhood (10 years) to early adolescence (13 years). Neuroimaging scans revealed increased neural activity in the ventral striatum in response to facial emotions from childhood to adolescence. This rise in neural activity overtime was especially pronounced for sad and happy facial expressions. In line with the findings by Pfeifer et al. (2011), heightened activity in the socioemotional system, specifically a rise in dopaminergic activity, has been observed in response to non-rewarding stimuli (e.g, unpleasant sounds, pain, and aversive smells) in animal studies (Horvitz, 2000). Considering the effect of non-rewarding stimuli on the dopamine levels in the socioemotional system, Horvitz (2000) proposes that it is not the valence of the stimuli that influences activity in this system, but the arousing quality of the stimuli. These findings challenge the traditional view proposed by the dual systems model, which posits that heightened sensitivity to rewards explains why adolescents engage in risky behaviors when in the presence of peers. Instead, these findings suggest that a mechanism sensitive to salient/arousing stimuli (whether it be positively or negatively valanced) may help explain why adolescents take more risks with peers.

Effect of Salient Contexts on Physiological Arousal

The autonomic nervous system (ANS) is sensitive to salient stimuli. It is made up of two subsystems (Porges, 1992). First, there is the parasympathetic nervous system (PNS), which promotes rest and restoration by stabilizing heart rate, sweat, and pupil dilation (Porges, 1992). Second, there is the sympathetic nervous system (SNS), which promotes the use of energy to cope with challenges or threats in the environment by increasing heart rate, sweat, and pupil dilation (Murray-Close, 2013). These systems interact with one another, and with a number neural structures to produce different levels of arousal in response to salient environmental cues, including social cues (Stroud et al., 2009). For instance, when exposed to a negative social experience, such as social rejection, the body’s instinctive response is to prepare for action by activating the SNS (e.g, the fight or flight response; Thayer & Brosschot, 2005). However, when encountering a stressful or salient event, this response is inhibited through the top-down control of the prefrontal cortex over midbrain areas, which reduces SNS activity and, in turn, increases PNS activity (Thayer & Brosschot, 2005). In other words, suppression of the SNS and activation of the PNS in response to social rejection may help explain observed linkages between negative affect and increased PNS activity (Gunther Moor et al., 2010). For example, researchers found that following unexpected social rejection, participants (aged 18-25) exhibited a reduced heart rate (Gunther Moor et al., 2010), which is consistent with increased PNS and/or suppressed SNS. Furthermore, PNS activity (i.e, reduced heart rate) following social rejection has been associated with adaptive self-regulatory processes involving the prefrontal cortex (Thayer & Brosschot, 2005; Thayer & Lane, 2009; Somerville, Heatherton, Kelley, 2006; Gunther-Moor et al., 2010). Taken together, these findings support the model that young adults should demonstrate reduced SNS activity and increased PNS activity, following social rejection.

Complicating this picture, the relationship between social rejection and increased PNS activity observed in young adults (18-25) may differ for adolescents (Cacioppo, Tassinary, & Bernston, 2007; Gunther Moor et al., 2010). This difference may be because the prefrontal cortex is still maturing in adolescence (Gogtay et al., 2004) in comparison to young adults, as are the connections between prefrontal regions and midbrain regions (Jetha & Segalowitz, 2012). Because of this immaturity, the ability of adolescents to regulate physiological reactions to immediate social stressors may not be as effective as that of adults (Blakemore & Mills, 2014). This reduced ability to regulate physiological arousal may make it challenging for adolescents to return to homeostasis by suppressing SNS and upregulating PNS activity. Consistent with this view, research demonstrates that in adolescence social contexts elicit strong emotional reactions (Crone & Dahl, 2002; Stroud et al., 2009), that are poorly managed by self-regulatory abilities (Nelson et al., 2005). As a result, adolescents may be more likely to display greater SNS activity when experiencing social rejection from peers compared to adults who are more likely to display greater PNS activity (Cacioppo, Tassinary, & Bernston, 2007; Gunther Moor et al., 2010).

Social rejection is not the only salient experience that adolescents and young adults can experience. Social acceptance is also considered to be a salient experience, especially for adolescents (Silk et al., 2012, Hare et al., 2008). However, there is considerably less research examining physiological responses to this type of stimuli. At the neural level, positive social stimuli, such as happy faces, have been associated with increased activity in midbrain regions such as the amygdala (Hare et al., 2008). Furthermore, adolescents have shown increased activity in the ventral striatum in response to receiving positive social feedback from peers (ex: being liked; Davey et al., 2010). However, based on these studies, it is not clear whether this socially induced neural activity actually translates to increased SNS activity.

Studies examining the association between positive social contexts and physiological arousal are not always consistent in their results. For instance, in a study by Butterfield et al. (2021), researchers examined adolescents' physiological arousal in responses to peer feedback using a novel laboratory paradigm where participants listened to neutral (ex: a statement indicating the participants' height or other aspect unrelated to the peer relationship), positive (ex: a statement indicating a positive quality, such as being fun or other aspect related to the peer relationship), and negative (ex: a statement indicating a negative quality, such as being too sensitive or other aspect related to the peer relationship) feedback from a familiar peer. Negative feedback was associated with greater physiological arousal (measured using skin conductance levels) compared to positive or neutral feedback. These results are in keeping with research by Silk et al., (2012) whereby participants showed greater physiological arousal (measured using pupil dilation) when experiencing rejection compared to acceptance by peers in a computerized social networking task.

However, other research has produced different patterns of results with respect to the relation between social rejection, social acceptance, and physiological arousal. For instance, researchers examined participants physiological arousal and emotional reactions after experiencing either social rejection or social acceptance during a ball tossing game with two other virtual peers (CyberBall task; Iffland, Sansen, Catani, and Neuner, 2014). Participants in the acceptance condition received passes from peers 1/3 of the time and those in the rejection condition received no passes from peers. Increases from baseline skin conductance levels did not differ between the two conditions. However, when heart rate was used as an index of arousal, participants in the rejection condition showed increased heart rates and those in the acceptance condition showed reduced heart rates during the task. Furthermore, only participants in the social exclusion condition reported a change in emotions, specifically an increase in self-reported anger in response to the manipulation compared to before the manipulation. These mixed findings demonstrate that the effect of positive social contexts on physiological arousal is not well-understood. Furthermore, it is unknown whether or how adolescents and adults differ in their physiological responses to positive social contexts.

Similar to positive and negative social stimuli, non-social but highly rewarding stimuli are also thought to be particularly salient during adolescence (Galvan et al., 2006; Galvan, 2010). Non-social rewards – or the anticipation of receiving them – may influence physiological arousal differently in adolescents than in adults. Both heart rate and subjective feelings of excitement were positively associated with the expected amount of money to be earned from a gamble in a sample of young adults (18-26 years; Wulfert et al., 2008). Moreover, researchers found that positive experiences (e.g, completing an optimally challenging task) were associated with moderate levels of SNS activation, whereas negative experiences (e.g, completing a challenging task under stress) was associated with higher levels of SNS activation (Peifer et al., 2014). Together, these findings suggest that non-social, but rewarding events increase SNS activation, but perhaps not more than negative events. However, the latter two studies only involved participants aged 18-34 years old. It remains unclear whether levels of SNS activation would differ between adolescents and adults experiencing non-social, but highly rewarding stimuli. Extant evidence provides reason to hypothesize that it might. For example, in neuroimaging studies, adolescents evince greater activation in the socioemotional system when receiving large rewards (but not small or medium rewards) compared to adults or children (Galvan, 2006). This finding (and others like it; Galvan, 2010, Van Leijenhorst et al., 2010; Van Duijvenvoorde et al., 2014) taken together with the theory that salient stimuli evoke physiological arousal (Critchley, 2002) suggest that adolescents should experience greater SNS activity than adults in response to non-social rewarding stimuli.

Socially Induced Physiological Arousal and Risk-Taking Behaviors

Physiological arousal is an adaptive mechanism evolved to motivate behavior in response to environmental stimuli and may play a crucial role in influencing risk-taking behavior (Porcelli & Delgado, 2017; Jamieson & Mendes, 2016). The effect of physiological arousal on reward processing brain regions can influence one's tendency to engage in risk-taking behaviors (Porcelli & Delgado, 2017). This influence is because risk-taking is characterized by both the possibility of rewards and aversive outcomes, and that one's tendency to approach reward or avoid aversive outcomes can be influenced by the levels of arousal that they induce (Porcelli & Delgado, 2017, Fowles, 1988; Beauchaine & Sylvers, 2005). Consistent with this view is that arousal resulting from negative social experiences (i.e, negative social arousal) may reduce reward-seeking behaviors in adults (Kumar, Berghosrt, Nickerson, Dutra, Goer, Greve & Pizzagalli, 2014) and increase reward-seeking behaviors in adolescents (Galvan & McGlennen, 2011). Although these studies did not directly compare risk-taking behavior between adolescents and adults, they are consistent with findings by Jamieson and Mendes (2016) who did so. Specifically, they examined whether experiencing social stress would differentially influence risk-taking behaviors and risk perceptions in youths and adults. Youths (ages 15 to 19) and adults (ages 25 to 40) completed the hot version of the Columbia Card Task (Figner et al., 2009) in a social stress condition (i.e., give a speech and do a math task in front of two peers) and a non-stressed condition (i.e., give a speech and do a math task independently). The goal of the Columbia Card Task was to accumulate as many points as possible by flipping over cards from an array. Gain cards that were flipped gave participants a number of points, while loss cards ended the trial and cost a significant amount of points. Participants flipped over cards until they chose to move to the next trial or until they flipped a loss card. The average number of cards flipped was used as a measure of risk-taking (the more cards flipped represented more risk-taking). Cardiovascular responses during the social manipulation were compared to a baseline resting period and the effect of change (from baseline) in cardiovascular activity on risk-taking in the Columbia Card Task was calculated. Adolescents in the social stress condition displayed greater arousal compared to adults in the same condition. Additionally, the increased arousal of adolescents was associated with increased risk-taking behavior. In contrast, for adults, greater levels of arousal were associated with reduced risk-taking behavior. These findings suggest that adolescents and adults are both influenced by negative social contexts, but their cardiovascular reactions to these contexts differ – adolescents exhibit a greater stress response than adults.

Moreover, the relation between cardiovascular responses to stress and risk-taking differs for adolescents and adults. For adolescents, greater stress predicts greater risk-taking; for adults, greater stress predicts less risk-taking.

Positive social contexts may also be associated with different physiological reactions and risk-taking tendencies in adolescents and adults. At the neural level, adolescents have shown increased activation of the ventral striatum in response to receiving positive social feedback from peers (ex: being liked; Davey et al., 2010). Furthermore, when in the presence of a familiar peer (who presumably likes the participant), adolescents showed greater ventral striatum activation than adults, and ventral striatal activation was positively associated with risk-taking (Chein et al., 2011). Together, these findings suggest that positive social contexts are more intensely rewarding for adolescents than for adults, which may explain why adolescents – and not adults – take more risks in the presence of friends.

Similar to social experiences, non-social, highly rewarding stimuli are also associated with stronger ventral striatal activation (Smith et al., 2018) in adolescence and may in turn influence risk-taking in adolescents differently than in adults. Indeed, the effect of non-social, highly rewarding stimuli on risk-taking was examined in a study by Figner et al. (2009), who also simultaneously measured levels of skin conductance, an index of physiological arousal. In this study, participants completed two versions of a risk-taking task. The hot version was designed to engage the socioemotional system by giving participants immediate feedback on rewards earned and the cold version was designed to engage the cognitive control system by only giving participants reward feedback at the end of all trials. Adolescents took more risks than did adults in the hot version of the task but did not differ from adults in risk-taking levels on the cold version of the task. Additionally, the hot version of the task, which was designed to be more engaging, was associated with heightened skin conductance. Although these findings indicate that highly exciting contexts increase both arousal and risk-taking, it is unclear whether the rise in arousal is driving risk-taking behavior.

Current Study

The growing body of work examining peer effects on risk-taking find that in adolescence the presence of peers is associated with increased risk-taking, an effect that is not found in adults. However, the mechanisms explaining why adolescents engage in more risk-taking in the presence of peers compared to adults are still not well understood. As such, this study's overarching objective was to examine the effect of salient contexts on risk-taking and whether physiological arousal mediated the effect of salient contexts on risk-taking. The dual systems model posits that the rise in risk-taking during adolescence occurs as a result of an imbalance between the fast-maturing socioemotional system and the slow maturing cognitive control system (Steinberg, 2010). This imbalance results in more activation of the socioemotional sensitivity system (Smith et al., 2018), particularly in the presence of peers, which is in turn associated with more risk-taking (Chein et al., 2011). However, activation of the socioemotional system is also associated with negative social events, suggesting that this system is likely responsive to salient stimuli, rather than just positively valanced stimuli (Horvitz, 2000). Therefore, the salience of a context may drive risk-taking in adolescence, because sensitivity to salient environmental information, like rewards and social cues, is heightened during this period of development. Considering that the autonomic nervous system is especially sensitive to salient stimuli and plays an important role in motivating behaviors (Porges, 1992), it can provide an objective index of sensitivity to various contexts.

The present study was designed to investigate how risk-taking differs as a function of the context in which it is carried out, and to examine whether differences in risk-taking across contexts can be explained by differences in physiological arousal. To manipulate the context in which risk-taking occurred, participants were randomly assigned to one of three conditions: positive social, negative social, or highly rewarding non-social. Participants in the positive social condition received positive feedback from a peer (e.g, 5/5 rating). Participants in the negative social condition received negative feedback from a peer (e.g, 3/5 rating). Participants in the highly rewarding non-social condition had the chance to earn three times more rewards than the standard condition. Participants' physiological arousal in response to these contexts were assessed using tonic Skin Conductance Levels (SCLs). Participants in each of the context conditions completed two versions of a risk-taking task. The exposure version of the risk task entailed either being watched by a peer (positive social and negative social) or receiving large rewards (non-social) and the non-exposure version entailed either being alone or receiving the base number of rewards.

This study was designed to test five hypotheses. First, we could test the hypothesis that risk-taking would differ across the three conditions. Similar to past research showing increased risk-taking in salient contexts (Chein et al., 2011; Figner et al., 2009), it would be expected that participants completing the exposure version of the risk task (ex: peer present or high rewards) would take more risks than those completing the non-exposure version of the task. Second, we could test the hypothesis that the relationship between the three conditions and physiological arousal would be positive. In line with the view that the salience of stimulus is positively related to the neural or physiological reactivity to the stimulus (Horvitz, 2000; Critchley, 2002), it would be expected that social and non-social contexts would be associated with greater physiological arousal than standard contexts. Third, we could test the hypothesis that the relationship between physiological arousal and risk-taking would be positive. Consistent with findings by Jamieson and Mendes (2016) demonstrating a positive association between physiological arousal and risk-taking, it would be expected that participants with heightened physiological arousal would engage in more risk-taking. Fourth, this study could test the hypothesis that physiological arousal would have a mediating role of on the relationship between salient context conditions and risk-taking. In line with previous findings showing that increased arousal following a social manipulation was associated with greater risk-taking (Jamieson & Mendes, 2016), it would be expected that participants completing a risk-taking task in the social and non-social conditions as opposed to the standard, would show heightened arousal and in turn heightened risk-taking. Fifth, this study was designed to test whether the hypothesized effects above differed for adolescents and adults. However, due to a pause in data collection because of the COVID-19 pandemic, we were unable to collect enough data from adolescents to test age differences.

Method

Participants

Data were collected from a sample of 73 participants, aged 12-29 years (M_{age} = 20.52, *SD* = 4.95). Data from 16 participants were excluded from analyses due to errors in the physiological recording (e.g, sensor displacement during data collection or errors in data recording). Thus, the final sample consisted of 57 participants, aged 12 – 29 years (M_{age} = 20.51, *SD* = 5.03). Of these participants, 22 identified as men and 35 as women, 59.6% reported being White, 3.5% reported being Black, 19.3% reported being Asian, 5.3% Indigenous, 1.8% Latin American, 3.5% Arab, and 3.5% chose not to report their ethnicity. Additionally, when looking at father's highest level of education, 14.1% had less than a high school diploma, 28.1% had a high school diploma, 17.5% had a trades/college diploma, 21% had some or a complete university degree, 8.8% had some or a graduate/professional degree, and 5.3% did not report any information. When looking at mother's highest level of education, 16.1% had attained less than a high school diploma, 12.5% had a high school diploma, 33.3% had a trades/college diploma, 22.9% had some or a complete university degree, 12.3% had some or a graduate/professional degree, and 1.8% did not report any information. Finally, only 10 participants reported taking medication daily. Of these participants, two did not specify the type of medication, one took a vitamin supplement, two took birth control, four took medication to treat mental health disorders, and one took Advil.

The sample is a convenience sample. Participants were recruited from the local community using flyers distributed to local businesses and posted on local community boards, online advertisements in local buy-and-sell websites, through in-person promotion at community events and at a local college campus, and through outreach to the staff in local high schools.

Procedures

Consent was obtained from participants aged 16 and over. For participants younger than 16, the participant's informed assent was obtained as well as the informed consent of a legal guardian. Participants aged 18 and over received $25 and younger participants received $15 for their participation. University students had the option to receive course credit in lieu of payment. To encourage sustained motivation throughout the tasks, participants were informed that they would earn a bonus prize if their performance was above that of the average participant. In reality, all participants earned a bonus prize. For the bonus prize, participants were presented with two options (1) choose a $5 gift card from their choice of vendor (out of three popular vendors), or (2) gamble for a chance to win $100 in gift cards from these same vendors (5% chance of winning).

Participant's physiological responses were recorded while they completed a series of computerized questionnaires and behavioral tasks. The study session lasted approximately two hours and was divided into two phases. During the first phase, two research assistants prepared participants for the recording of physiological data and physical measurements were taken. During the second phase, one research assistant guided participants through a series of computer-based questionnaires and tasks. The series of computer-based questionnaires and tasks included measures that are not included in this thesis. Thus, only the relevant measures are described in the measures and procedures sections.

Upon arriving at the lab, the participant was instructed to use the washroom, as having a full bladder can influence physiological recordings (Fagius & Karkuvaara, 1989). The participant was provided with unscented wipes to clean his/her hands, as soap can interfere with the quality of physiological data (Morgan, 2017). Next, the main research assistant applied two Electrodermal Activity (EDA) sensors to the participant's non-dominant hand. Participants then had a 5-minute rest period. To make sure that the sensors were recording properly, the main research assistant instructed the participant to take a seat at the computer and informed them that they would remain seated there for the rest of the study period. The participant was instructed to press the bell on their left-hand side to summon the research assistant when instructed to do so or if they had questions. The participant was instructed to press the space bar to begin the first computer task, which consisted of a 5-minute rest period during which they watched a video of slow-moving stars while physiological data were collected that could serve as the participants' "baseline" level of physiological arousal. Following the stars video, the participant completed a series of questionnaires and computerized tasks.

Upon completing the study, participants were debriefed about the goal of the study. If the participant had experienced a deception, the research assistant revealed the deception and queried whether the participant had believed it. The Research Ethics Board of the university at which data were collected approved all study procedures.

Measures

For the present analysis, relevant measures included a risk-taking task (completed twice by each participant), recordings of physiological arousal, and experimental condition. The experimental manipulation involved varying the context in which each run of the risk-taking was completed.

Experimental Condition: Manipulation of the Social Context. The Virtual Peer Rating Paradigm (VPRP) was developed to manipulate the context in which the risk-taking task was completed, such that each participant could be randomly assigned to either the positive social, negative social, or non-social but highly rewarding experimental condition (see Figure 1). To manipulate the context in which risky decision making occurred, we designed a paradigm whereby the participant created a personal profile similar to that found on social media. First, the research assistant took a photograph of the participant (a head shot) in front of a grey backdrop. This picture was then uploaded and incorporated into a blank profile template. The participant then completed his/her profile by answering a series of questions (see Figure 1). Upon completing the profile, the participant was asked to confirm that he/she/they was satisfied with the entries before proceeding. Next, the participant rated three identically formatted social profiles of same-sex, similarly aged strangers ("peers") based on how much they wanted to meet the peer (see Appendix A). Ratings ranged from 1 to 5 stars (1 = they did not want to meet the peer to 5 = they did want to meet the peer).

After rating the three peer profiles, participants completed a second 5-minute rest period during which they watched the same video of slow-moving stars as in the first baseline. This second baseline period was used to record an updated resting level of cardiac and skin conductance activity. After the 5-minute rest period, participants were randomly assigned to one of three experimental conditions: (1) positive social, (2) negative social, or (3) non-social.

Positive and negative social conditions. In the positive and negative social conditions, participants were informed that one of the three profiles that they had rated was actually that of another study participant who was currently participating in the same study in a nearby testing room. Participants were shown the following instructions:

"We didn't tell you about this earlier, but one of the three profiles you saw was from another study participant who, like you, is currently completing the tasks in our other testing space. For now, we will refer to this other participant just as your "peer". But you will see which profile was his/hers shortly, and you will meet him/her in person at the end of the next set of tasks. You and your peer will switch off playing decision-making games in which you can win tokens based on your choices. You will play two different games and your peer will play two different games (not the same ones as you). For your games, you will play each one twice, once with the peer watching remotely (he/she will be able to view your screen), and once without the peer watching. The order (peer watching or not) is selected at random by the computer. You will know when the peer is watching because his/her picture will appear in the corner of the screen. When he/she is not watching, there will be a red "X" over his/her picture. For the peer's games, in the rounds in which you are watching his/her play, you will mark on a paper form whether you would have made the same or different decisions from the peer. After your peer has

completed all the games, you two will meet in person to discuss the games and provide feedback on the games to the experimenter."

Next, the participant viewed the peer profile, which, importantly, included the peer's star-rating of the participant's profile. For participants in both conditions, the "real" peer was the high status profile. To manipulate the valence of the peer context, participants in the positive social condition received the best possible rating from the peer (5 out of 5 stars; see Figure 2); whereas participants in the negative social condition received an ambiguous rating from the peer (3 out of 5 stars; see Figure 2).

Non-social condition. In the non-social condition, participants did not receive any feedback on their social profile (see Figure 2) and no mention was made of any other participant currently completing the study.

Risk Taking. Participants completed two runs of an adapted version of the BART-Youth (Lejuez et al., 2003), which was used to gauge participants' propensity to take risks. In this computerized task, participants were presented with a series of 30 deflated balloons. The instructions explained that participants could click to pump air into the balloon to earn tokens (one click equals one pump), and that pumping too much air into the balloon would result in an explosion (the average explosion point was 20 pumps, but participants were not given this information). Each pump of air earned the participant 0.05 tokens (or 0.15 tokens if they were in the non-social, exposure condition). When participants were satisfied with the number of tokens they had accumulated, they could click the 'collect' button to transfer the tokens to a permanent reserve and proceed to the next balloon. If a balloon popped before the participant collected the tokens, all tokens accumulated in the temporary reserve were lost. When this happened, a new trial began, and a new balloon was displayed on the screen (see Appendix B for the exact instructions). The adjusted mean number of pumps (average number of pumps on unexploded balloons) was used to measure risk-taking (Lauriola et al., 2014). Only unexploded balloons were used, as there is no way to know when participants would have stopped inflating balloons that exploded.

Exposure. All participants completed two runs of the BART-Y, once under standard laboratory conditions (unobserved by the peer and receiving the standard reward value per pump) and once under exposure to their condition. The order of the two runs of the BART-Y was counterbalanced across participants. This design allowed for a within-subject estimation of the effect of exposure to experimental context on risk-taking. For participants in the social conditions, participants were told:

"As a reminder, here is what you will be doing for the next little while. The computer has selected you to play your games first, so you will play your first game twice (two runs). During one of the runs, your peer will be watching you. During the other run, your peer will not be watching you. After you have completed both your first run, it will be time for you to watch your peer play a different game. While you are watching them play their game, you will be judging their decisions, and writing down on a piece of paper if you would have made the same decisions. Once you have finished watching your peer play their game, the process will repeat. Except you will be playing a new game, and your peer will be playing a new game. Once all of the games are finished, you will be meeting with your peer to discuss the decisions that each of you made."

To increase the credibility of the virtual peer deception, the secondary research assistant entered the testing room while the primary research assistant was guiding the participant through the above instructions. The secondary research assistant stated that there was an issue with the peer's computer upstairs and that they would go fix it. The primary research assistant said that they would wait for the issue to be resolved before connecting the participant to the game. When the secondary research assistant returned, the primary research assistant proceeded to "connect" the participant to the risk-taking task. During the exposure run, the peer's profile picture appeared in the bottom right corner of the screen. In the standard run, the picture of the peer was crossed out (covered with a red X) to remind the participant that the peer was not observing their performance.

For participants in the non-social condition, exposure was manipulated by having participants complete the BART-Y while receiving triple the rewards (0.15 tokens) or the base rewards (0.05 tokens) per pump. Between each run of the BART-Y, participants were told that they would observe a past participant complete two different tasks.

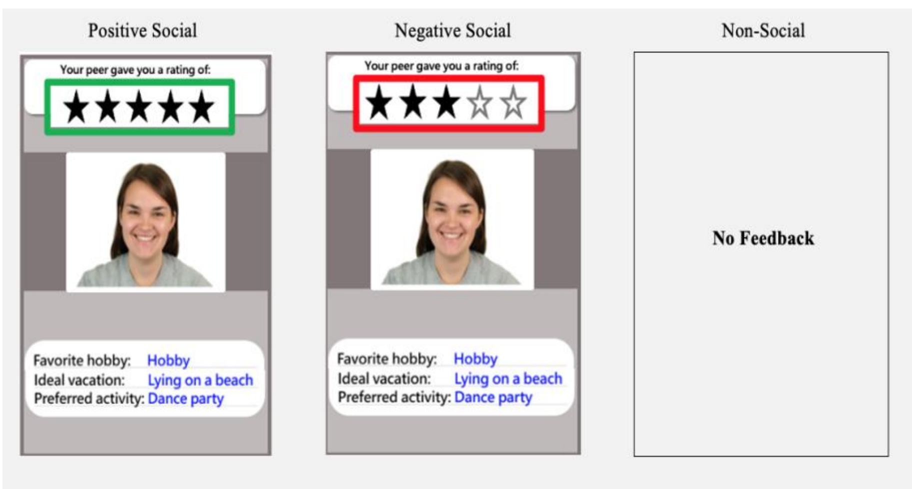


Figure 1. Virtual Peer Rating Paradigm. Participants create a profile and proceed to rate three identically structures profiles, but of three same-sex and same-age peers. Participants are then assigned to one of three conditions (a) positive, where they received a 5/5 rating from the high-status peer's profile they rated, (b) negative, where they receive a 3/5 rating from the high-status peer's profile the rated, or (c) non-social where they do not received ratings from a peer. Participants in these conditions then complete the BART-Y twice, once under low arousal (no peer or base token value) and high arousal (peer monitoring performance or base token value).

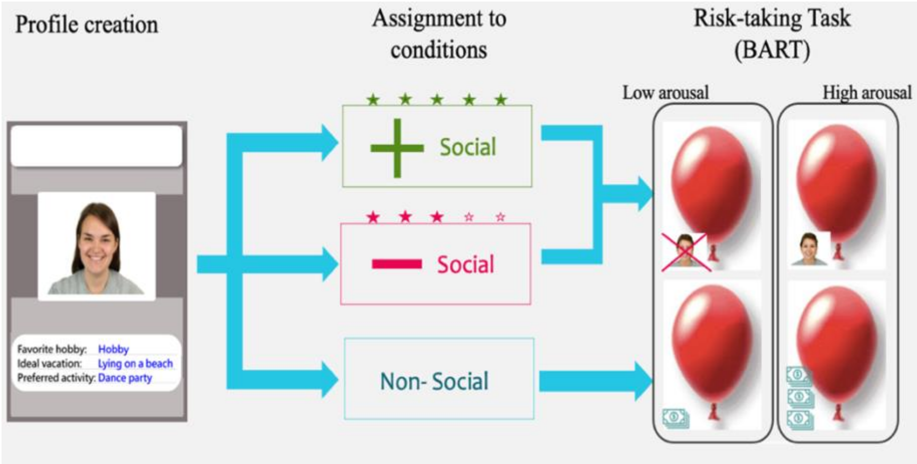


Figure 2. Social profile feedback by experimental condition. Participants received one of the three types of feedback depending on the experimental condition that they were assigned to. Those in the positive social condition received a rating of 5/5 stars. Those in the negative social condition received a rating 3/5 stars. Those in the non-social condition did not receive any feedback.

Physiological Arousal. To gauge physiological arousal during the two runs of the BART-Y, we measured electrodermal activity, (i.e, skin conductance). Skin conductance was assessed using two disposable 3.58cm x 2.54cm Ag/AgCl sensors with a chloride wet gel concentration of 0.5%. These sensors were applied to the hypothenar and thenar eminences of the participants' non-dominant hand and connected to the MindWare mobile unit using two 1.5 DIN touch-proof wires. Each wire was taped in a service loop to protect against any tugging during data collection. Raw skin conductance was acquired using a wireless data transmission to the BioLab software (version 3.3.1) at 500 samples per second. A 500-block size rolling filter was applied in the calibration settings and the data was automatically scaled to microsiemens (uS), with a threshold of 0.05 uS.

To assess physiological arousal during the BART-Y, we used the average tonic skin conductance levels (SCL), calculated excluding skin conductance responses (SCRs). SCL was also collected while participants completed the BART. High Tonic SCLs are indicative of higher arousal (Braithwaite, Watson, Jones, and Rowe, 2013). For each participant two tonic SCL statistics were obtained: (a) the tonic SCL in the exposure run of the risk task, (b) tonic SCL in the non-exposure run of the risk task. From these statistics, the square root of the average tonic SCL across both runs was computed and the deviations from each individual's own mean across both runs (centered score) was used in the analyses.

The skin conductance data for all tasks were processed and cleaned using Mindware's Electrodermal Activity Analysis Application (version 3.2.2). Two independent raters processed the data. Unfortunately, technical problems arose in the remote accessing of the data, so only one rater's data were used for the present analysis.

For the two runs of the BART-Y, electrodermal data were cleaned using a time-based setting that divided the tasks into 60 second epochs. Key components of the electrodermal waveform were identified and all artifacts were removed. Artifacts consisted of changes in the waveform that were (a) physiologically impossible (sharp drops or increases in the signal) or (b) due to participant movement, both of which did not represent a real physiological response. Two steps were taken to ensure that artifacts were accurately identified. First, a video recording of the participant completing the task was matched to each 60 second epoch. This video allowed confirmation that a change in the waveform was attributable to participant movement. Second, during data collection, the secondary research assistant noted (within the recording) if the participant moved or reacted in a way that could have produced a change in the waveform (e.g., if the participant yawned, coughed, or sneezed). These notes were referenced when cleaning the data.

Demographic Variables. Several demographic variables were collected for purposes of descriptive analysis.

Age. Self-reported age was used both as a continuous variable and as a categorical one, whereby 1 = adolescents (12-20 years; M_{age} = 15.64, *SD* = 2.56, *n* = 25) and 0 = young adults (21 – 29 years; M_{age} = 24.41, *SD* = 2.63, *n*= 34).

Gender. Self-reported gender was coded as a discrete variable whereby females = 1 and males = 0.

Race/Ethnicity. Race/ethnicity (self-reported) was coded as a discrete variable whereby White =1 and non-White = 0. This choice was necessary given the smaller number of participants recruited.

Socio-economic status (SES). Parents' highest level of education, coded from 1 (some grade school) to 10 (professional or graduate degree) was used as a proxy for SES (Aarø et al., 2009).

Plan of Analysis

To examine whether the effect of exposure (exposure = peer observation or high reward; non-exposure = peer non-observation or standard reward) on risk-taking under different context conditions (positive social, negative social, and non-social) could be explained by changes in skin conductance, a series of multi-level models were estimated using MPLUS (version 7.31; Muthén & Muthén, 1998-2015). Risk-taking (average adjusted pumps on the BART-Y) was the outcome variable in the regression examining the direct effect, indirect effect and path b of the mediation model. Skin Conductance was the outcome variable in the regression examining path a of the mediation model. Each participant completed the risk-taking task twice, once with exposure to condition and once without. Physiological arousal (average tonic skin conductance level) was obtained for each run. To compare participants' risk-taking scores and physiological arousal levels on each run of the BART-Y, without losing information (e.g, using a difference score), a multi-level model was used (Peugh, 2010). The exposure variable and physiological arousal variable were within-subject variables and included as level 1 predictors in the multi-level model. Order of the run (exposure vs standard first or second) also was included as a within-subject control variable. Context condition, which was randomly assigned to participants, was a between-subjects variable. To examine differences in each context condition we ran three separate models that included the exposure by run (interaction). A chi-square difference test was used to assess model fit, as this test is the standard for comparing nested models. Sixteen participants were excluded from all analyses due to missing skin conductance data on both runs of the BART-Y. As such the analytic sample consisted of 57 participants. Participants with missing skin conductance data were not more or less likely to engage in risk-taking in the exposure (t (72) = -.44, p = .661) or non-exposure condition (t (72) = .78, p = .431) than those with complete data. To limit the impact of other missing data on parameter estimates, full information maximum likelihood was used.

Results

Descriptive Statistics

Table 1 provides the participants' demographics, within each of the three experimental conditions (non-social, positive social, and negative social). The three conditions did not differ in size, gender ratio, and age, indicating that random assignment was successful. The current sample included more adults than adolescents (see Table 1).

Table 1.

Demographic Characteristics per Condition.

	Conditions							
	Non-Social		Positive Social		Negative Social		Total	
	N	(%)	N	(%)	N	(%)	N	(%)
Age Range								
12-14 years	5	23.8	2	9.5	2	13.3	9	15.8
15-17 years	3	14.3	5	23.8	1	6.7	9	15.8
18-22 years	6	28.5	6	28.7	6	40.1	18	31.6
23-30 years	7	33.4	8	38.2	6	40	21	36.9
Sex								
Men	9	42.9	7	33.3	6	40	22	38.6
Women	12	57.1	14	66.7	9	60	35	61.4
Race								
White	13	61.9	11	55	10	71.4	34	61.8
Non-White	8	38.1	9	45	4	28.6	21	38.2

Note: Non-social $N = 21$, positive social $N = 21$, negative social $N = 15$; Total $N = 57$.

Multivariate Assumptions

Table 2 provides the spread values for variables of interest. There was one participant who had outlying values for skin conductance (greater than 1.5 times the inter-quartile range).

Given that this outlier was not identified as an extreme outlier (greater than 3 times the interquartile range), this participant's data were retained in the sample (Hoaglin, Iglewicz, 1987).

Table 2.

Descriptive Statistics for Variables of Interest.

Condition	Variable		*M*(*SD*)	*Skewness*	*Kurtosis*
Non-social	Risk-Taking				
(*N* = 22)		Exposure	10.19(4.49)	0.07	-0.73
		No exposure	9.85(3.73)	-0.04	-0.66
		Across conditions	10.02(3.80)	-0.29	-0.85
	Arousal				
		Exposure	10.34(6.49)	1.36	1.67
		No exposure	10.28(6.31)	1.49	2.59
		Across conditions	10.31(6.37)	1.44	2.12
Positive social	Risk-Taking				
(*N* = 21)		Exposure	10.96(3.28)	0.53	1.29
		No exposure	11.44(3.15)	0.48	0.40
		Across conditions	11.20(2.93)	0.48	1.89
	Arousal				
		Exposure	11.56(7.23)	1.61	2.91
		No exposure	11.52(6.56)	1.67	3.26
		Across conditions	11.77(6.97)	1.62	2.94
Negative social	Risk-Taking				
(*N* = 15)		Exposure	11.86(4.20)	0.42	-0.76
		No exposure	11.36(3.68)	0.63	0.05
		Across conditions	11.61(3.68)	0.35	-0.38
	Arousal				
		Exposure	11.05(5.93)	1.15	0.33
		No exposure	10.62(6.52)	1.14	0.39
		Across conditions	10.83(6.21)	1.15	0.38

Note: Non-social listwise *N* = 21, positive social listwise *N* = 21, negative social listwise *N* = 15*;* Risk-taking = average adjusted pumps on unexploded balloons, Arousal = average Tonic SCLs

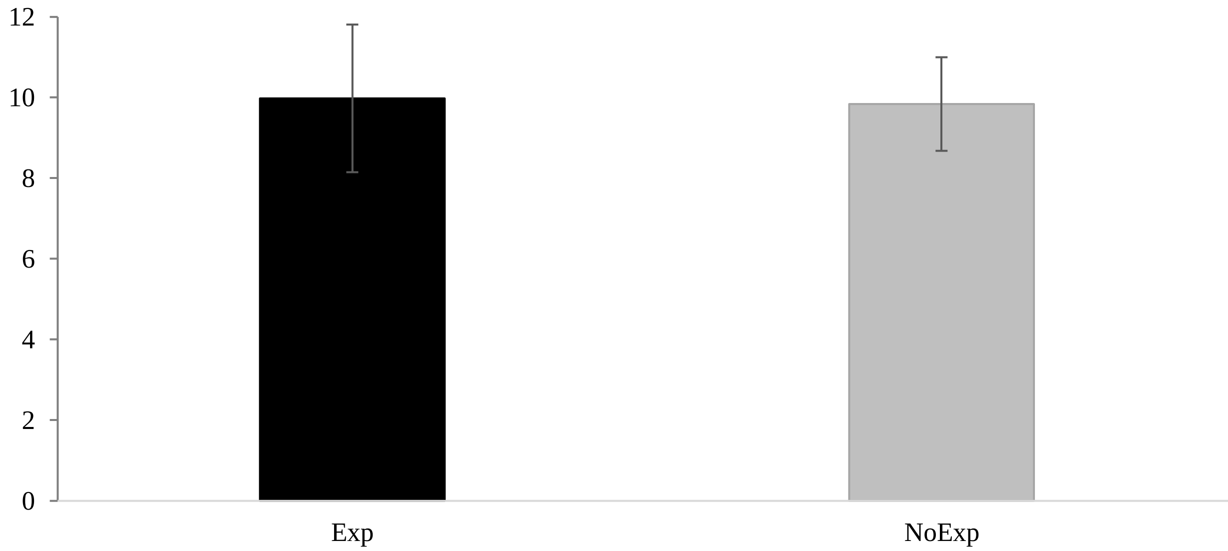
Multi-Level Modeling Analyses

Unconditional Model. In an unconditional model (with no predictors), 71% of the variance in risk-taking was between subjects.

The Effect of Exposure on Risk-Taking. To examine whether completing the risk-taking task under exposure to the condition specific stimulus (ex: peer or to high rewards) could help explain within subject variance in risk-taking, the second step added exposure as a within subject predictor. Adding exposure to the model did not improve its fit ($\Delta\chi^2$ (1) = 0.03, $p > 0.05$), meaning that exposure alone had no significant effect on risk-taking ($b = 0.05$, $SE = 0.39$, $p = 0.893$). Specifically, in the non-exposure run participants pumped on average 10.85 times compared to 10.90 times in the exposure run. This finding is inconsistent with my prediction that risk taking would be higher in the exposure than in the non-exposure run.

The Effect of Exposure on Risk-Taking, Controlling for Run order. To examine whether completing the risk-taking task under exposure could help explain within subject variance in risk-taking, while controlling for run order, the third step added exposure as a within subject predictor and run order as a within subject control. Adding run to the model improved its fit ($\Delta\chi^2$ (2) = 22.68, $p < .01$). Run order significantly predicted risk-taking ($b = 1.92$, $SE = 0.30$, $p < 0.01$). The first time that participants completed the risk task they pumped the balloons on average 9.92 times. The second time participants completed the risk task they pumped the balloons on average 1.92 times more than the first time.

Figure 3.
Mean Adjusted Pumps by Exposure, Controlling for Run Order.



Notes: This figure depicts the effect of exposure on risk-taking (mean adjusted pumps). The error bars represent the 95% Confidence Interval.

The Effect of Exposure on Skin Conductance, Controlling for Run Order. To examine whether exposure to the condition specific stimulus (ex: peer or to high rewards) could help explain within subject variance in skin conductance (path a), I ran a model where exposure was added as a within subject predictor, run order as a within subject control, and skin conductance as the outcome variable. There was no significant within subject differences in skin conductance when participants were under exposure (peer present or high rewards) compared to non-exposure (b = 0.04, SE = 0.03, p = 0.111) to experimentally manipulated context, when controlling for run order. Specifically, participants under non-exposure showed average tonic skin conductance levels of 3.20 compared to 3.24 when under exposure. This finding is inconsistent with my prediction that exposure would be associated with greater skin conductance levels.

The Effect of Skin Conductance on Risk-Taking, Controlling for Exposure Type and Run Order. To examine whether skin conductance could explain any of the within subject variance in risk-taking (path b), the fourth step involved using a model in which skin conductance was added as a predictor, run order as a control, and risk-taking as the outcome. Adding skin conductance improved the fit of the model ($\Delta\chi^2$ (3) = 30.50, p < 0.01). In contrast to my original prediction, however, average tonic skin conductance levels were negatively related to risk-taking (b = -4.15, SE = 1.68, p = 0.013), meaning that the higher participants' physiological arousal (higher skin conductance), the fewer risks they took (fewer pumps, on average, on the BART-Y).

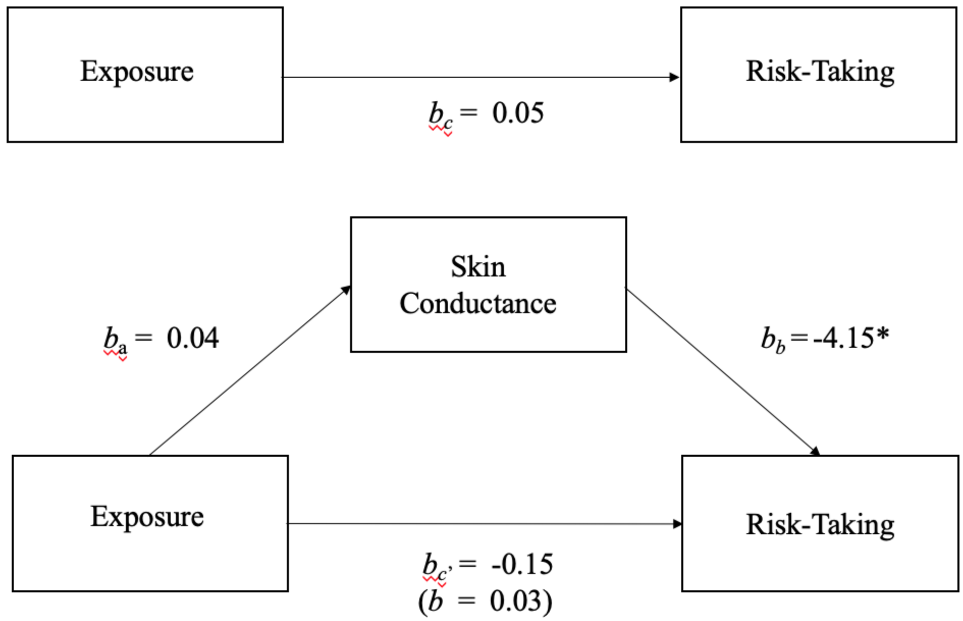
The Indirect Effect of Exposure on Risk-Taking Through Skin Conductance, Controlling for Run Order. To examine whether skin conductance mediated the relationship between exposure and risk-taking, the fifth step involved running a model that tested the indirect effect of exposure on risk-taking through skin conductance, controlling for run order. Although this model resulted in improved fit ($\Delta\chi^2$ (7) = 32.25, p <.01), there was no significant indirect effect (b = -0.15, SE = 0.14, p = 0.30; see Figure 4). Thus, contrary to my predictions, exposure to experimentally manipulated context did not influence risk-taking through changes in skin conductance.

The Total Effect of Exposure, Run, and Skin Conductance on Risk-Taking.

To examine the total effect of exposure on risk-taking, exposure, run, and skin were added as a within subject predictor and risk-taking as the outcome variable. Although this model resulted in improved fit ($\Delta\chi^2$ (3) = 30.50, p <.01), there was no significant total effect of exposure on risk-taking (b = 0.03, SE = 0.29, p = 0.91; see Figure 4).

Figure 4.

Mediation Model of the Relationship Between Exposure, Skin Conductance, and Risk-Taking



Notes: This figure depicts the mediation model. b_c is the direct effect, b_a is path a, b_b is path b, $b_{c'}$ is the indirect effect, and the total effect is in parentheses. All significant effects are marked with an asterisk. Run was controlled for, for each effect.

Table 3.

Mediation Model Coefficients

		b	SE	p
Path a				
	SKIN on EXP	0.04	0.03	.129
	SKIN on RUN	-0.10	0.03	.000
Path b				
	PUMPS on SKIN	-4.15	1.68	.013
	PUMPS on RUN	1.50	0.25	.000
Direct Effect				
	PUMPS on EXP	0.05	0.39	.893
Indirect Effect				
	PUMPS on Path a * Path b	-0.15	0.14	.288
Total Effect				
	PUMPS on EXP	0.033	0.29	.908
	PUMPS on RUN	1.50	0.26	.000
	PUMPS on SKIN	-4.15	-1.68	.013

Notes: PUMPS = risk-taking, SKIN = skin conductance, EXP = exposure. The rows in grey indicate which variables were controlled for.

Effect of the Interaction Between Exposure Type and Run Order on Risk-Taking. In the sixth step, I included exposure by run order (interaction) as a level 1 predictor. Including the interaction term between run order and exposure allowed me to test whether the effect of exposure on risk-taking differed as a function of run order. Adding the interaction term improved the fit of the model ($\Delta\chi^2$ (4) = 37.46, $p < 0.1$), as there was a significant interaction between run order and exposure ($b = 4.15$, $SE = 1.76$, $p = 0.018$). This result indicated that, for participants who completed the exposure run followed by the non-exposure run, being in the exposure condition (first) was associated with less risk-taking ($b = -2.04$, $SE = 0.80$, $p = 0.011$) than the non-exposure condition (second). For participants who completed the non-exposure run followed by the exposure run, being in the exposure condition (second) was associated with more risk-taking (4.15 more pumps) than the non-exposure condition (first). In other words, pooling across condition, participants took more risks in the exposure run, but only when it was completed second. Additionally, the negative relationship between skin conductance and risk-taking remained significant in this model ($b = -4.15$, $SE = 1.68$, $p = 0.014$).

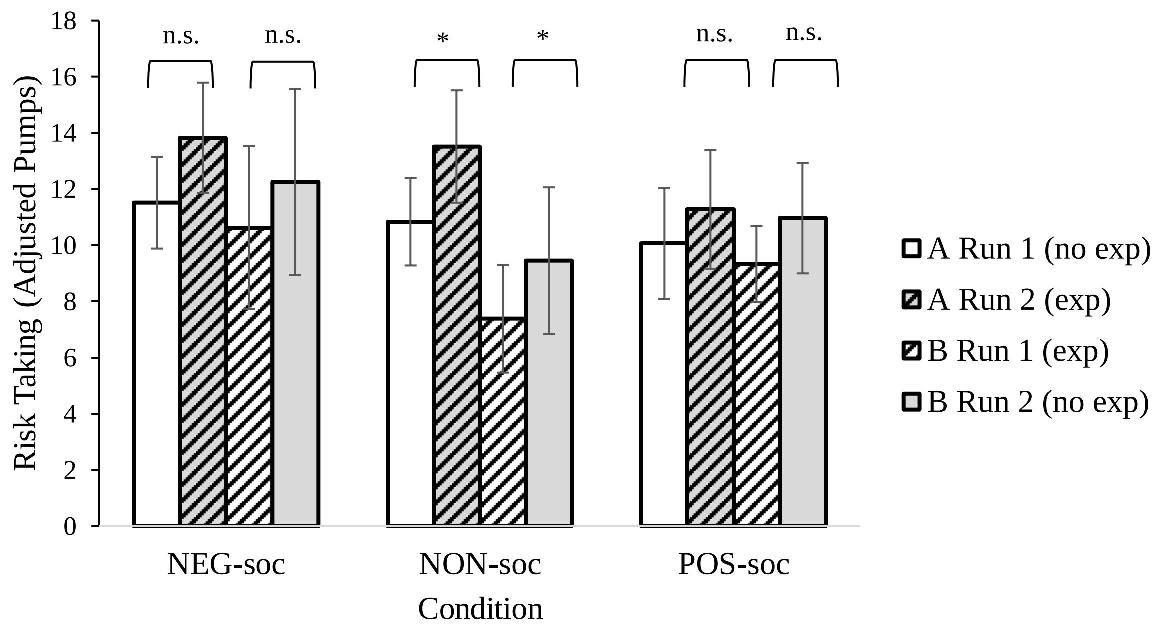
Examining the Interaction Between Exposure Type and Run, in Each Condition. We wanted to investigate whether the interaction between run order and exposure on risk-taking was further moderated by condition (non-social, negative social, and positive social), but we lacked the statistical power to conduct the analysis reliably. Instead, we ran (underpowered) models separately by condition to explore whether the interaction was significant ($p < .05$) or close to significant ($p < .10$) in each condition (see Figure 5).

Non-Social. To examine whether the interaction between run order and exposure on risk-taking was present in the non-social condition and how skin conductance relates to risk-taking, we ran a model that included skin conductance, exposure, run order, and exposure type by run order (interaction) as predictors. The model showed a significant interaction between run order and exposure (*b* = 7.39, *SE* = 2.84, *p* = 0.009). For participants who completed the exposure run followed by the non-exposure run, completing the exposure run first was associated with less risk-taking (*b* = -3.40, *SE* = 1.31, *p* = 0.009) than the non-exposure run (second; see Figure 5). For participants who completed the non-exposure run followed by the exposure run, being in the exposure condition (first) was associated with more risk-taking (7.39 more pumps) than the non-exposure condition (second). Additionally, the effect of skin conductance on risk-taking remained significant in this model, even when controlling for the effect of exposure type, run order, and the interaction (*b* = -6.39, *SE* = 1.31, *p* = 0.009). Although this finding is significant, it contradicts the prediction that increased arousal would be related to more risk-taking. Instead, it suggests that the higher participants' arousal (higher skin conductance), the fewer risks they took.

Negative Social. To examine whether the interaction between run order and exposure on risk-taking was present in the negative social condition and how skin conductance relates to risk-taking, we ran a model that included skin conductance, exposure, run order, and exposure type by run order (interaction) as predictors. The model showed no significant interaction between run order and exposure (*b* = 6.05, *SE* = 3.41, *p* = 0.076; see Figure 5). Participants who completed the exposure run first did not engage in significantly more or less risk-taking than those in the non-exposure run (b = -2.30, SE = 1.46, *p* = 0.115; see Figure 5). Although the interaction between run order and exposure was not significant, the pattern of results of the means suggests that we may have been underpowered to detect an interaction effect. For example, participants seem to have engaged in more risk-taking on the second run compared to the first run, regardless of whether the peer was present of absent (see Figure 5). The difference in mean levels of risk-taking between the first and second run appears even more pronounced when the non-exposure run is followed by the exposure run. In this model, there was a negative relationship between skin conductance and risk-taking that reached trend levels of significance (b = -5,65, SE = 3.30, p = 0.087).

Positive Social. To examine whether the interaction between run order and exposure on risk-taking was present in the positive social condition and how skin conductance relates to risk-taking, we ran a model that included skin conductance, exposure, run order, and exposure type by run order (interaction) as predictors. The model showed a non-significant interaction between run order and exposure (b = -0.92, SE = 2.34, p = 0.69). Participants who completed the exposure run first did not engage in significantly more or less risk-taking than those in the non-exposure run (b = -0.11, SE = 1.13, p = 0.846; see Figure 5). Participants who completed the non-exposure run first did not engage in significantly more or less risk-taking than those in the exposure run (b = -1.14, SE = 1.33, p = 0.392; see Figure 5). This finding suggests that the participants took similar levels of risks when the peer was present and when the peer was absent, regardless of the order or the runs. Additionally, there was no significant effect of skin conductance on risk-taking (b = -3.00, SE = 1.97, p = 0.128). This contradicts the prediction that the social manipulation would result in more arousal and in turn more risk-taking.

Figure 5.
Mean Risk Taking Split by Run Order (A = Non-Exposure, B = Exposure).



Notes: This figure depicts the interaction between the run and exposure variables for each context condition. The error bars represent the 95% Confidence Interval. The white background indicates the first run, the gray background indicates the second run, the stripes indicate the exposure to experimental context.

The Effect of Run on Skin Conductance. Given that a negative association between skin conductance and risk-taking was found, a post hoc analysis examining the effect of run on skin conductance was performed. The goal was to examine whether the order in which participants completed the runs influenced their physiological arousal. Run was added as a within subject predictor and skin conductance was the outcome variable in this model. Run was negatively associated with skin-conductance (b = -0.01, SE = 0.03, p = .000), meaning that the participants had higher levels of physiological arousal on their first run, compared to their second run of the risk-taking task.

The Between Context Conditions Difference in Skin Conductance. To examine whether there were significant differences in levels of skin conductance between the three salient when completing the exposure version of the task on run 1, a one-way Analysis of Variance

(ANOVA) was performed where outcome variable was skin conductance and the independent variable was exposure to the salient context condition on run 1, which had three levels, the positive social, negative social, and high reward non-social. The high reward non-social condition was used as the comparison group for the first contrast to see if skin conductance differed between the high reward non-social condition and the social conditions. The positive social condition was used as the comparison group for the second contrast to see if the positive social condition differed from the negative social condition. The analysis revealed that there were no significant mean differences between the salient context conditions on skin conductance ($F(2,28) = .63$, $p = .543$). To examine whether there were significant differences in levels of skin conductance between the three salient when completing the exposure version of the task on run 2, a one-way Analysis of Variance (ANOVA) was performed where outcome variable was skin conductance and the independent variable was exposure to the salient context condition on run 2, which had three levels, the positive social, negative social, and high reward non-social. The high reward non-social condition was used as the comparison group for the first contrast to see if skin conductance differed between the high reward non-social condition and the social conditions. The positive social condition was used as the comparison group for the second contrast to see if the positive social condition differed from the negative social condition. The analysis revealed that there were no significant mean differences between the salient context conditions on skin conductance ($F(2,22) = 1.16$, $p = .333$).

Discussion

The dual systems model proposes that young adult risk-taking can be attributed in part to increased sensitivity of the socioemotional system, particularly in salient context (Steinberg, 2010). Although it was hypothesized that participants would take more risks under exposure to salient contexts, no effect of exposure on risk-taking was found. Moreover, it was hypothesized that participants' tonic skin conductance levels would be positively associated with risk-taking, but instead we found a negative association between skin conductance and risk-taking. Finally, skin conductance did not mediate the association between exposure and risk-takin. The current study also explored whether the effect of exposure on risk-taking differed based on whether participants completed the risk-taking task in a positive social context (5/5 rating from a virtual peer), a negative social context (3/5 rating from a peer), or a non-social context (3 times more rewards than the base amount of 0.05 tokens). Despite our predictions that the effect of exposure on risk-taking would not differ based on the type of context, our findings revealed that participants in the non-social condition engaged in more risk-taking (i.e, more pumps) under exposure. For participants in the negative social condition, findings revealed no significant differences in levels of risk-taking when under exposure or non-exposure version. However, the pattern of results of the means suggest that we may have been underpowered to detect a significant effect. For example, participants seem to have engaged in more risk-taking on the second run compared to the first run, regardless of whether the peer was present or absent (see Figure 3). The difference in mean levels of risk-taking between the first and second run appears even more pronounced when the non-exposure run is followed by the exposure run. Conversely, participants in the positive social conditions did not show differences in risk-taking when under exposure versus no-exposure. Overall, our findings were not consistent with the dual systems model's reasoning that adolescent risk-taking is partly attributable to rewarding contexts.

The absence of a significant effect of exposure on risk-taking does not align with the dual systems model and previous research showing that for young adults the presence of peers (Gardner & Steinberg, 2005) and high rewards (Figner et al., 2009) are associated with more risk-taking. Although the imbalance between the fast-maturing socioemotional system and slow maturing cognitive control system is smaller in young adults than in adolescents, it is still present, and is thought to explain why risk-taking is still observed in this age group, especially in salient contexts. This idea is supported by Gardner and Steinberg (2005) who found that the effect of peers on risk-taking was greatest in adolescents (13-16 years) but was still observed in young adults (18-22 years). Similarly, Figner et al. (2009) found that in more reward salient contexts, both adolescents (14-16 years) and young adults (17-19 years) took more risks than adults (20 years and over). The current study does not align with this past research, as there was no effect of (presumably) salient contexts on risk-taking in our young adult sample. Instead, this study's findings are more similar to Chein et al.'s (2011), who did not observe an effect of peers on risk-taking in young adults (19-22 years) and adults (24 and over years), only in adolescents (14-18 years).

One potential explanation for the current study's findings is that because young adults are less sensitive to social stimuli than are adolescents, they may require a more salient social manipulation of exposure to elicit changes in risk-taking (Blakemore & Mills, 2014). In the Gardner and Steinberg's (2005) study, the social manipulation involved having participants complete a risk task in the presence of two unfamiliar peers (physically present) who could make comments on whether the participant should make riskier or safer choices throughout the task. Conversely, in the current study participants completed a risk task in the presence of one unfamiliar peer (virtually present) who was not able to communicate with the participant. This result is similar to Chein et al.'s (2011) study that involved having participants complete a risk-task in the presence of two familiar peers (virtually present), who were instructed to state that they could see participants play, but not to give comments on their performance. Therefore, a context in which a peer is present and does not provide any form of encouragement or pressure may be enough to elicit changes in risk-taking for adolescents, but not for young adults. It is also possible that because young adults are less sensitive to the effects of virtual peers compared to physically present peers (Paek, 2009), using a virtual unfamiliar peer to manipulate the social context in the current study may not have been a strong enough manipulation for our sample. Given that the effect of peers on risk-taking may differ based on the type of peer (ex: familiar versus unfamiliar and physically present versus virtually present), future research should compare which type of peer has a greater effect on risk-taking. Moreover, future research should examine whether the effect of certain types of peers on risk-taking changes in the transition from adolescence to young adulthood.

It is possible that the null effect of exposure on risk-taking occurred because participants did not believe that they were actually interacting with a peer. A total of 36 participants were assigned to the positive social or negative social conditions. Of these participants, 20 reported that they did not believe that the peer was real. However, at the end of the study participants were required to complete a task in which they were given 100 additional tokens. Participants had to decide how many of these 100 tokens they were going keep and how many they were going to give to their peer. They were able to give as few as 0 tokens or as many as 100 tokens (in increments of 10). However, only 1 participant chose to give 0 tokens to the ‘fake’ peer. The other 19 participants gave between 10 and 100 tokens to the peer, whom they (purportedly) did not believe was real. Because giving tokens to a person you do not believe exists is irrational, participants’ self-report of belief in the deception may not be valid. Nonetheless, the number of participants that reported not believing the peer manipulation raises concern about the believability and strength of the social manipulation and could serve as a potential explanation for why there was no effect of exposure on risk-taking.

Another explanation is that the manipulation of reward in the non-social condition was not strong enough to elicit changes in risk-taking when completing the exposure run. The current study's manipulation of exposure, in the non-social condition, involved increasing the number of tokens accumulated in the exposure version of the risk-task by three times more than the amount accumulated in the non-exposure version of the task. Despite this increase, it is possible that the value of the rewards was not large enough to elicit a change in risk-taking behavior in the study's sample. Research by Galvan et al. (2006) found that adolescents reacted faster when receiving large rewards in a gambling task, and not when receiving small or medium rewards. However, adults showed faster reaction times to large rewards, followed by slightly slower reaction times to medium rewards, and even slower reaction times to small rewards. These findings suggest that adults may behave differently in response to large, medium, or small rewards, whereas adolescents may only behave differently in response to large rewards, compared to small and medium rewards. Thus, it is possible that tripling the size of the rewards from 0.05 to 0.15 did not produce a large enough difference between the two versions of the risk-task to elicit an effect of exposure on risk-taking in our sample.

When examining the relationship between exposure and skin conductance (path a), no significant effect was found. Therefore, participants did not differ in their levels of arousal when under exposure (e.g. peer present or high reward) compared to under no exposure (e.g. peer absent or base rewards). This finding does not align with past research showing greater physiological arousal when under exposure to salient contexts (Cacioppo, Tassinary, & Bernston, 2007; Gunther Moor et al., 2010; Hare et al., 2008; Silk et al., 2012). Instead, the current study's findings are more aligned with past findings showing no significant increases in skin conductance levels from baseline when experiencing social acceptance and social rejection during the CyberBall task (Iffland, Sansen, Catani, and Neuner, 2014). One possible explanation for the null effect of exposure on skin conductance is that our sample was less influenced by the manipulation of context than expected. Although research shows that adolescents are more sensitive to salient contexts (Blakemore & Mills, 2014), the current study's sample mainly consisted of young adults, who are better able to self-regulate physiological responses in response to environmental stimuli (Thayer & Brosschot, 2005). For instance, past research shows that 18- to 25-year-old participants evinced reduced heart rate following social rejection (Gunther Moor et al., 2010). Therefore, because our sample consisted mainly of young adults it is possible that exposure did not have a very strong effect on skin conductance given young adults improved ability to regulate arousal to salient contexts.

When examining the relationship between skin conductance and risk-taking, we found that greater skin conductance predicted less risk-taking in our sample. Therefore, the more physiologically aroused participants were, the fewer risks they took (ex: pumped less air into balloons). This result does align with the original prediction that heightened physiological arousal would explain less risk-taking in adolescents. However, the current study's sample consisted of young adults and the negative relationship between physiological arousal and risk-taking obtained appears consistent with existing research showing that increased physiological arousal reduces rewards seeking behaviors in adults (Kumar et al., 2014). Furthermore, increased physiological arousal, measured using cardiovascular activity, was related to less risk-taking in adults and more risk-taking in adolescents (Jamieson & Mendes, 2016). In line with these past findings is research showing that increased stress (measured using cortisol levels) can inhibit reward processing in adults (Berghorst, Bogdan, Frank & Pizzagalli, 2013; Bogdan & Pizzagalli, 2006). Hence, it is possible that we obtained a negative relationship between skin conductance levels and risk-taking because our sample consisted mainly of young adults, who appear to be less sensitive to rewards when experiencing high physiological arousal. Once the sample is large enough, I plan to assess whether the effect of exposure on risk-taking differs in adolescents compared to adults and whether these different effects can be explained by different levels of physiological arousal (the current sample is too small to test this).

Given that a negative association between skin conductance and risk-taking was found, an analysis examining the association between run and skin conductance was performed to examine if perhaps the order of the runs could help explain why a negative association between skin conductance and risk-taking was found. This analysis revealed that participants had greater levels of arousal on the first run and lower levels of arousal on the second run. This suggests that perhaps on run one, participants are more aroused because the task is perceived as novel and challenging. In turn, participants may engage in less risk-taking because they are still getting habituated to the task. Conversely, on the second run of the task, participants' lower arousal may reflect being habituated to the task or even bored because they are completing the same task a second time. In turn, they engage in more risk-taking because they are more comfortable testing the limits of the task and/or they are seeking to increase their arousal by taking risks (ex: need for arousal theory; Hebb, 1955).

When examining whether physiological arousal mediates the relationship between exposure and risk-taking, no significant effect was found. This is inconsistent with previous research showing that exposure to salient contexts, such as social stress, can increase arousal thereby increasing risk-taking in adolescents, and reducing risk-taking in adults (Jamieson &

Mendes, 2016). Considering that participants did not show differences in arousal levels when under exposure compared to no exposure, it is possible that another factor led to reduced arousal and in turn more risk-taking. For instance, if participants did not believe the social manipulation or lost motivation during the study, it is possible that out of boredom (which is associated with low arousal; Bench & Lench, 2013) participants' arousal levels did not differ between the exposure and non-exposure run. Thus, in turn the rise in risk-taking associated with low arousal, may be attributable to boredom or lack of motivation, not exposure to the experimental manipulation. As such, future research should aim to ensure that participants remain engaged throughout the study as a way of limiting the effect of boredom.

A post hoc analysis revealed an interaction whereby run (first or second) moderated the effect of exposure on risk-taking. Participants engaged in more risk-taking (ex: pumped more air into balloons) on their second run of the risk task, regardless of whether they completed the exposure run (ex: exposed to the peer or high rewards) or the non-exposure run (ex: not exposed to the peer or high rewards). One potential explanation for this finding is that participants' levels of risk-taking were influenced by observing the peer (for those in the social conditions) or past participant (for those in the non-social condition) engage in a risk-taking task (Columbia Card Task) before completing the second run of the BART-Y. This finding appears consistent with the Social Learning Theory (Bandura, 1977), which posits that individuals attend to the behaviors of important individuals around them (ex: models) and subsequently imitate these observed behaviors. Experimental studies have shown that individuals are more likely to smoke, drink alcohol, and engage in risky decision making in the presence of peers who are also smoking, drinking, or engaging in risky decision making, even when peer pressure is not involved (Harakeh & Vollebergh, 2012; Larsen, Engels, Granic, & Overbeek, 2009; Reidijk & Harakeh, 2018). In the current study, it is possible that the peer or past participant served as a model that participants proceeded to imitate. Given that this study's finding suggests that watching a peer or past participant engage in risk-taking may in turn alter one's own levels of risk-taking, it would be important for future research to ensure that the exposure run and non-exposure run are counterbalanced, as was done in the current study.

Notably, when exploring the interaction between run and exposure on risk-taking, different patterns emerged depending on the context condition that participants were randomly assigned to. However, the pattern of results of the means suggests that we may have been underpowered to detect effects.

Non-Social Condition. For the non-social condition, participants took more risks in the high reward run (exposure) compared to the low reward run (non-exposure), when the exposure run was completed second. When the tasks were administered in this order, the greater number of pumps observed when under exposure may have occurred because participants realized that each pump was worth more tokens than pumps in the previous run. In turn, participants were more motivated to take risks for these larger rewards. This finding suggests that the salience of rewards could affect risk-taking when the exposure run comes after the non-exposure run. This finding is consistent with past research whereby both adolescents (14-16) and young adults (17-19) took more risks than adults (20 and over) in reward salient contexts compared to non-salient contexts (Figner et al., 2009).

Moreover, this pattern of findings may be attributable to framing effects. Framing effects occur when individuals make different decisions based on whether options are presented in a positive or negative way. The framing effect in decision-making is explained as the result of quick and automatic emotion-based or intuitive thoughts over controlled and slow analytic or executive thoughts (De Neys, 2006). Specifically, when options are presented as potential gains, individuals tend to make safer and less risky decisions. Conversely, when options are presented as potential losses, individuals tend to make riskier decisions. The Asian disease problem is a classic example of the framing effect (Tversky and Kahneman, 1981). In this example individuals are informed about an unfamiliar Asian disease and are told that the United States needs to prepare for an outbreak in which 600 people are estimated to die. They are presented with two programs framed in a positive way (A = “200 people will be saved” and B = “1/3 probability that 600 people will be saved and 2/3 probability that no people will be saved”) and two programs framed in a negative way (C = “400 people will die” and D = “1/3 probability that nobody will die and 2/3 probability that 600 people will be saved”). Although all programs have the same estimated number of survivors, individuals tended to choose the low-risk option (A) out of the two positive options and the high-risk option (C) out of the two negative options. This pattern where individuals tend to choose low-risk options when options are framed positively and the high-risk option when options are framed negatively can be observed in the current study. When participants completed the exposure run-first they were earning the high reward value (gains) and engaging in less risk-taking. When they completed the non-exposure run, they were presented with the low reward value (three times less tokens per pump; loss) and engaged in more risk-taking. However, the current study is not a perfect parallel to the framing effect model given that the low reward option does not represent a loss (individuals still earn something). Additionally, in the BART-Y, when rewards are high so too are the potential losses (e.g, each pump results in a larger token value, but if the balloon pops, participants risk losing this larger reward). Thus, based on the current study we cannot know whether it is the potential gains or losses driving behavior. Nonetheless, past research has demonstrated that when options were presented as gains (ex: you can earn points) participants engaged in less risk-taking, whereas when options were presented as losses (ex: you can lose tokens), participants engaged in more risk-taking (De Martino, Kumaran, Seymour, and Dolan, 2006). Thus, the framing effect provides a potential explanation as to why participants in the non-social condition descriptively engaged in more risk-taking in the non-exposure run, relative to the exposure run, when the non-exposure run was second.

When examining the relationship between skin conductance and risk-taking for the non-social condition we found a negative relationship, such that low levels of skin conductance predicted more risk-taking. This finding does not align with past research in which a positive relationship between skin conductance levels and increased risk-taking among adolescents and young adults was found (Figner et al., 2009). Instead, our findings seem to align with the optimal level of arousal theory which posits that when levels of arousal are low, individuals will seek to increase their arousal to more optimal levels by engaging in stimulating activities (Hebb, 1955). This theory is supported by research showing that boredom, which is characterized by low arousal, may increase one's motivation to engage in stimulating activities, like gambling (Bench & Lench, 2013; Krueger, Schedlowski & Meyer, 2005). Thus, it is possible that if participants in the current study were under-aroused (i.e, bored), they may have engaged in more risk-taking in an attempt to increase their arousal.

Negative Social. In the negative social condition, participants did not differ in their levels of risk-taking when the peer was present (exposure) compared to when the peer was absent (non-exposure), when the exposure run was completed first. Thus, contrary to our predictions, participants did not engage in more risk-taking in the presence of a peer who rated them 3/5 than when they completed the task alone. This result is inconsistent with past research showing that socially induced physiological arousal was related to changes in risk-taking for both adolescents and adults, relative to when participants were not socially aroused (Jamieson & Mendes, 2016). Specifically, higher physiological arousal was linked to increased risk-taking in adolescents, and decreased risk-taking in adults. The findings by Jamieson and Mendes (2016) are also consistent with past research showing that being exposed to negative social contexts, reduces reward seeking behaviors in adults (Kumar, Berghosrt, Nickerson, Dutra, Goer, Greve & Pizzagalli, 2014).

Moreover, when the exposure run was completed second, no significant effect emerged. That is, participants did not differ in their levels of risk-taking when the peer was present (exposure) compared to when the peer was absent (non-exposure), when the non-exposure run was completed first. However, the pattern of results of the means suggests that we may have been underpowered to detect an interaction effect between exposure and run order in this context condition. For example, the difference in mean levels of risk-taking between the first and second run appears even more pronounced when the non-exposure run is followed by the exposure run compared to when the exposure run is followed by the non-exposure run (see Figure 3). This pattern suggests that it may be worth further exploring whether negative contexts promote risk-taking as this would challenge the dual systems model's proposition that peers encourage that peers encourage adolescent risk-taking because they are rewarding (Chein et al., 2011; Shulman et al., 2016; Steinberg, 2008). Given that the effect of exposure on risk-taking was not significant, it is possible that the negative social manipulation was not strong enough to elicit a significant effect. In addition to concerns about whether or not participants truly believed that they were interacting with a peer, it is possible that the rating provided by the peer was not negative enough to elicit changes in risk-taking. In the current study, participants in the negative social condition received a rating of 3/5 from their peer. The reason for choosing this rating, and not a lower rating (ex: 2/5,1/5, or 0/5), is due to ethical considerations. Although this rating appears to be neutral, research by Sommerville et al. (2013) found that even in neutral contexts, adolescents interpret peer observations as negative and report feeling more self-conscious and embarrassed than adults and children. Moreover, these increased negative subjective feelings converged with increases in skin conductance. However, this relationship may not be the case for young adults, who are less sensitive to neutral social information than adolescents (Sommerville et al., 2013). Therefore, it is possible that with a larger number of adolescents the peer effect may emerge more strongly in this negative context. As such, once data collection is complete, I plan to compare whether adolescents and young adults display different levels of risk-taking when exposed to a negative peer.

Another reason why the 3/5 rating may not have been strong enough to elicit a significant effect of exposure on risk-taking is because it may only be interpreted negatively if participants rated their peer higher than 3/5. For instance, if participants rated the peer poorly (0/5), they may not feel too badly getting a rating of 3/5 from their peer. In this case, it is possible that the participant interprets the rating of 3/5 as the peer liking them more than they liked the peer. In turn, the rating may appear more positive than intended. Conversely, if the participant rated the peer highly (5/5), they may feel worse getting a rating of 3/5. The participant may interpret the 3/5 as the peer not liking them as much as they liked the peer. In turn, the rating may appear more negative. As such, the success of the social manipulation may be influenced by participants' own ratings of their peer. With a larger sample, it may be possible to examine the difference between these types of participants (ex: those who rated the peer higher than 3/5 versus those who rated the peer lower than 3/5), but this study's sample was too small to do this.

Nonetheless, in an attempt to verify that the manipulation was successful, we examined the number of tokens participants left behind to their peer. Presumably, if participants received a negative rating from their peer, they may not have left as many tokens to their peer compared to participants who received a positive rating. However, there was no significant differences in the number of tokens left between the different context conditions. However, this does not necessarily mean that participants did not feel negatively in response to the rating. There are other possible reasons why participants may have given a similar number of tokens to their peers in each condition. For instance, because participants were led to believe that they would discuss with their peers at the end of the study, it is possible that participants who received a negative rating (3/5) gave their peer a good number of tokens in hopes of gaining their approval before meeting them. Given that it is unclear whether the manipulation had the intended effect, future research should aim to include a manipulation check where participants are asked to rate how the 3/5 rating from the peer made them feel.

When examining the relationship between skin conductance and risk-taking in the negative social condition we found a negative relationship, such that low levels of skin conductance predicted more risk-taking. This finding partly aligns with past research by Jamieson and Mendes (2016) who found a negative relationship between physiological arousal and risk-taking among adults. However, our sample also included adolescents, and Jamieson and Mendes (2016) found a positive relationship between arousal and risk-taking in adolescents. Given that we could not examine age differences in our sample, it is unclear how well our findings converge with those of Jamieson and Mendes (2016).

Positive Social. For participants in the positive social condition, there was no interaction between exposure and run on risk-taking. Participants engaged in similar levels or risk-taking in both in the presence of a peer (exposure) and in the absence of a peer (non-exposure), and this did not differ as a function of the order that these runs were completed. Given that our sample consists mostly of young adults, the current study's findings seem to partly align with those of Chein et al., 2011, who found that young adults and adults did not engage in more risk-taking when in the presence of a familiar peer (who presumably likes the participant) compared to when alone. Despite this, young adults are still sensitive to social stimuli, albeit less so than adolescents. Nevertheless, an effect between exposure to a positive peer and risk-taking was still expected. Thus, it is possible that the social manipulation was not strong enough to elicit a change in risk-taking among our current sample. For instance, participants' experience of a positive rating (5/5) from their peer may depend on the rating they assigned their peer. If participants rated their peer poorly (0/5), they may not feel as good getting a rating of (5/5), because they did not think highly of their peer. As such the high rating may have less value or be less influential than if participants had also rated their peer highly (5/5). This implies that the positive social manipulation may be influenced by participants' ratings of their peer. Once data collection is complete, it may be possible to examine the difference between these types of participants (ex: those who rated the peer 5/5 versus those who rated the peer lower than 5/5), but this study's sample was too small to do this. Furthermore, future research could include a manipulation check to help validate that the positive social manipulation had the intended effect, regardless of participants own ratings of the peer.

When examining the relationship between skin conductance and risk-taking in the positive social condition a negative relationship was found, such that low levels of skin conductance predicted more risk-taking. This result contradicts our hypothesis that increased physiological arousal would predict more risk-taking. It has been explained that experimental tasks completed may be impacted by boredom, tiredness, and or a lack of motivation (i.e, fatigue effect; Leary, 2012). In turn, these psychological states may limit the effect of experimental conditions. Given that the current study ranged from two to two and a half hours in length and that the virtual peer paradigm was the last portion of the study completed by participants, it is possible that participants were bored, tired, and or had a lack of motivation when it came time to complete this portion of the study. In an attempt to address potential boredom and to increase participants' motivation, we informed them that depending on their performance they could win additional tokens for a bonus prize. In future studies, the order in which tasks a presented could be counterbalanced, such that some participants complete the tasks earlier in the study session and others later in the study session to help address the potential impacts of boredom.

Finally, a post hoc analysis examining whether there were differences in skin conductance levels between the three salient context conditions revealed that the three groups did not differ in their levels of arousal when completing the exposure version on run 1. Additionally, the three groups did not differ in their levels of arousal when completing the exposure version on run 2. This suggests that regardless of the context in which participants were completing the risk-taking task, their levels of arousal were all similar. This suggests that our mainly young adult sample was not particularly influenced, at a physiological level, by any context more than the other. One possible explanation for this is that because young adults are better able to self-regulate their arousal in response to different types of stimuli (Porcelli and Delgado, 2017) there were no observable differences in arousal between the three contexts. Given that adolescents are said to have a less mature ability to self-regulate their arousal (Thayer and Brosschot, 2005; Porcelli and Delgado, 2017), it would be important for future studies to examine if this effect changes when the sample consists of adolescents.

Implications

This study's preliminary findings challenge the dual systems model in two ways. First, the dual systems model proposes that adolescents are particularly susceptible to risk-taking in the presence of peers because peers are rewarding (Steinberg, 2008). Our findings challenge this proposition by showing that in non-rewarding peer interactions, such as when a peer who rated the participant 3/5 observes them complete a risk task (on the second run), participants engage in more risk-taking then when alone. Given that this non-rewarding context encourages more risk-taking, it appears that peers may instead promote risk-taking by creating salient contexts, not simply rewarding contexts. Second, the dual systems model posits that adolescents are especially sensitive to increased risk-taking in rewarding contexts and that older individuals are less susceptible to these social contexts (Blakemore & Mills, 2014; Smith et al., 2015). Our findings indicated that at least in the non-social, but highly rewarding context and the negative social context our mainly young adult sample showed increased risk-taking when the exposure run was completed second. This result suggests that adolescents may not be the only ones who are sensitive to salient contexts, but young adults may be as well. However, because this effect was only found when the exposure run was second, this finding suggests that perhaps young adults are susceptible to peer contexts, but only when peers are also engaging in risk-taking.

Additionally, the finding that high physiological arousal is associated with reduced risk-taking in young adults suggests that perhaps they require a more salient manipulation of context (social or reward) in order for changes in levels of risk-taking to occur. Many laboratory studies find that young adults engage in less risk-taking than adolescents when in social or high reward contexts (Figner et al., 2009; Gardner & Steinberg, 2005; Chein et al., 2011). However, there are still many studies reporting young adults engaging in risk-taking (MacLean et al., 2014;

Kennison, Wood, Byrd-Craven & Downing, 2016). These findings suggest that perhaps certain contexts are salient enough to create reactions in young adults that foster risk-taking, whereas others are not.

Limitations and Future Research

There are certain limitations to this research that should be considered. First, social desirability bias may be a concern when asking participants whether they believed that the peer was real. Not knowing whether participants believed the social manipulation can influence the validity of the study. To circumvent this issue, future research should aim to emphasize the anonymity and confidentiality of the study to encourage honest reporting. Furthermore, future studies should aim to validate responses, regarding whether participants believed the peer was real or not, by collecting other data, as we did with the dictator game.

Another limitation was that the study's sample size was small and homogenous and was mainly comprised of White young adults in middle to upper class. This limitation may partly explain why we did not observe an effect of exposure on risk-taking and why we found an inverse relationship between skin conductance and risk-taking. A primary aim of the research was to examine age differences between adolescents and adults, but that was not possible given the incomplete data set. The findings obtained in the study are partly consistent with past research examining young adults. Thus, with a complete and more representative sample, it is possible that exposure and skin conductance may relate differently to risk-taking for different age groups and for individuals of different races and socio-economic statuses. Therefore, future studies should aim to use a sample that includes a more equal proportion of adolescents and young adults and a more diverse range of individuals to account for both developmental differences and individual differences in sensitivity to various contexts and their effect on risk taking.

Finally, the study's findings may only be generalizable to contexts in which adolescents and young adults are engaging with a single unfamiliar peer who is simply observing them. This limited generalizability is because the current study's findings differ from findings of studies using multiple unfamiliar peers who provide feedback on participants' performance (Gardner & Steinberg, 2005). Thus, it is possible that factors such as whether social contexts are virtual or non-virtual, made up of familiar versus unfamiliar peers, or made of one or more peers, have different effects on adolescent and young adult risk-taking. As such, future research should aim to examine age differences in risk-taking when individuals are in a range of contexts to better understand if certain contexts promote more or less risk-taking at different ages.

Conclusion

Altogether, this study's findings suggest that youth engage in more risk-taking in non-social, but highly rewarding context and that low arousal is associated with more risk-taking across all contexts. In the negative social context condition the pattern of results of the means suggests that we may have been underpowered to detect an interaction effect between exposure and run order. This pattern suggests that it may be worth further exploring whether negative contexts promote risk-taking as this would challenge the dual systems model's proposition that peers encourage adolescent risk-taking because they are rewarding (Chein et al., 2011; Shulman et al., 2016; Steinberg, 2008). Furthermore, these findings highlight that being under aroused may serve as a potential risk factor for young adult risk-taking.

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Appendices

Appendix A

The pictures used to create the peer profiles had been selected from the Chicago Face database (adult pictures; Ma et al., 2015) and the National Institute of Mental Health Child Emotional Faces Picture Set (youth pictures; Egger et al., 2011). Three unique profiles were created for each age group (12 to 14 years, 15 to 17 years, 18 to 22 years, and 23 to 30 years) and for each biological sex (man/boy or woman/girl), for a total of 24 profiles. Participants were matched to three peer profiles based on their self-reported age and gender. Each group of three peer profiles was designed to include one high status (i.e, more attractive) and two low status (i.e, less attractive) profiles. To gauge physical attractiveness of the peers, a preliminary study including 75 MTurk participants was conducted. MTurk participants were presented with 108 images selected from the face databases and rated each on attractiveness (on a scale from 0 = unattractive to 5 = very attractive) and estimated age (participants entered the estimated age in a textbox). Based on the results of this preliminary study, sets of three pictures were chosen for each age group X sex combination. The picture rated highest in attractiveness was used for the high-status peer profile and the two pictures rated lowest in attractiveness were used for the low-status peer profiles. However, the lowest rated pictures for girls in the 12-14 years old category were noticeably overweight, as such they were replaced with the next two lowest rated pictures to prevent this factor from influencing participants' peer ratings.

Appendix B

The instructions for the BART-Y that all participants were presented with are as follows: "Now you're going to see 30 balloons, one after another, on the screen. For each balloon, you can click the button that will pump up the balloon. Each time you click the pump button, the balloon pumps up a little more. BUT remember, balloons pop if you pump them up too much. It is up to you to decide how much to pump up each balloon. Some of these balloons might pop after just one pump. Others might not pop until they fill the whole screen. You will get 1 token (for both runs in the positive and negative social condition and for the standard run in the non-social condition) / 5 tokens (in the exposure run in the non-social condition) for each pump. The more you pump the more tokens you might win. BIT if a balloon pops, you lose all the tokens you earned on that balloon. To keep the tokens earned from a balloon and add them to your token bank, stop pumping the balloon before it pops and click the "Cash Out" button. The tokens from that balloon will be added to your token bank. After each time you cash out or pop a balloon, a new balloon will appear." Following this portion of instructions, an image depicting the task was presented (see Figure 4). After the image was presented, participants were informed to ask the experimenter if they had any questions, and if they did not have any, to press continue and start the task.

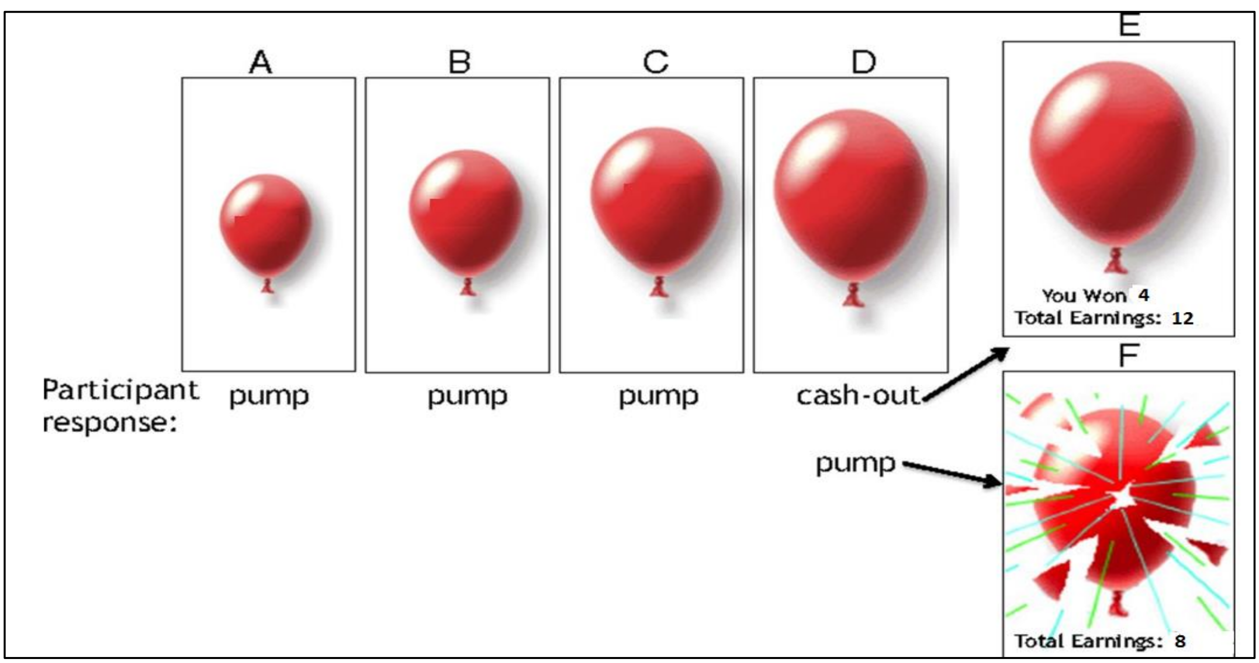

Figure 5. This image depicts an example of a trial on the BART-Y. Participants are presented with a balloon (A), as they pump air into the balloon it gets bigger (B, C, D), after any balloon they can choose to either cash-out or pump. If they cash-out (E) they will be shown their total

tokens accumulated for the given trial and their total tokens accumulated across all completed trials. If the pump and the balloon explodes (F) they do not earn tokens and are simply shown the total tokens accumulated across all completed trials.