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Digital Peer Interactions Affect Risk Taking in Young Adults

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Digital interactions are an increasingly common communication method among young adults, but little is known about whether such remote exchanges influence riskiness. The current study examined whether observing and interacting with, versus simply observing, a digital peer affect risk taking in young adults aged 18–25. Participants who remotely viewed risky behavior by a peer or computer increased risk taking; however, compared to a control condition, only exposure to risk-encouraging messages from a digital peer resulted in sustained risk-taking behavior. These findings suggest that short text-based messages from a risk-encouraging digital peer can influence risk-taking behavior in young adults. Given the rapid proliferation of digital communication among this age group, these results highlight a potentially important source of peer influence on risky behavior.

Risk taking has been defined as engaging in behaviors associated with a subjectively desirable potential outcome (i.e., associated with high sensation or reward), but that expose the individual to potential harm or loss (Geier & Luna, 2009). Much of the research on risk taking has focused on the strong preference for immediate rewards exhibited by individuals during early and mid-adolescence (Steinberg, 2004). However, young adults (age 18–25) also engage in high rates of risk taking (Park, Mulye, Adams, Brindis, & Irwin, 2006). Salient examples of risk-taking behaviors among young adults include driving at excessive speeds, binge drinking, and engaging in unprotected sex (Arnett, 1991; Mulye et al., 2009; Park et al., 2006). As significant negative health ramifications often follow from these risky behaviors, understanding the various factors contributing to risk taking during young adulthood represents an important public health priority.

Theories of risk taking, shaped by developmental cognitive neuroscience research, suggest that the asynchronous development of socio-emotional and reward and cognitive control networks largely underlies risky behavior (Casey, Jones, & Hare, 2008; Steinberg, 2008). Accumulating evidence suggests that socio-emotional and reward networks, which include orbitofrontal cortex, ventral striatum, amygdala, and medial prefrontal cortex, among other regions (e.g., Ernst et al., 2005), tend to show enhanced activation beginning in early adolescence, around the onset of puberty (Galvan, 2010). For example, several studies have demonstrated that adolescents and young adults show heightened reactivity in response to peer interactions and otherwise emotionally arousing or rewarding stimuli compared to younger or older age groups (Casey et al., 2008; Ernst et al., 2005; Galvan, Hare, Voss, Glover, & Casey, 2007; Steinberg, 2008). With notable exceptions (e.g., Bjork et al., 2004), there is considerable empirical evidence supporting the view that maturational changes beginning in early adolescence and extending into young adulthood are characterized by a relative hypersensitivity to rewarding stimuli (Galvan, 2010).

Concomitant with increased reward responsiveness during adolescence and young adulthood are limitations in cognitive control, particularly inhibitory control. Cognitive control networks, which include frontal, parietal, and anterior cingulate cortices, among others, are known to exhibit protracted maturation that extends into the early to mid-twenties (Gogtay et al., 2004; Luna, Velanova, & Geier, 2008). One implication of this late maturation of prefrontal regions is that adolescents and young adults may be limited in their ability to exert sufficient regulation over behavior, particularly under conditions of heightened social and emotional arousal, resulting in an increased likelihood of risky behavior (Casey et al., 2008; Steinberg, 2008).

Risk taking during adolescence and young adulthood, compared to adulthood, is likely to occur in a peer context, an environment associated with increased arousal and potential for social reward (Gardner & Steinberg, 2005; Steinberg, 2004). For example, adolescents and young adults

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performing a simulated driving experiment were far more likely than older adults (aged 24 and above) to run a yellow light (a risky choice) versus safely stop when performing the task with peers compared to alone (Gardner & Steinberg, 2005). Subsequent neuroimaging work used a similar driving task in the presence of peers, including brief communication during the task, in adolescents, young adults, and older adults (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011). Results demonstrated increased activation of ventral striatum and orbitofrontal cortex in the peer condition that was inversely correlated with age. Greater regional activation in the prefrontal regions of older adults compared to adolescents was also observed, with young adults demonstrating an intermediate level of prefrontal engagement (Chein et al., 2011). These results suggest that the neural systems underlying aspects of decision-making risk in young adults have not yet reached fully mature levels of function.

Despite these recent advances, understanding of the complexities of social influences on risk taking in young adulthood remains limited. One important gap in our understanding, for example, relates to whether young adults' choice behavior will be similarly affected following passive observation of a peer engaging in risk taking (e.g., modeling or imitation) compared to a situation in which the peer actively encourages the adolescent to take more risks (e.g., pressure). The strength of peer modeling on risky behavior is perhaps most evident in studies investigating substance use in adolescents and young adults. Studies have suggested that the presence of peers is associated with increased alcohol consumption (Quigley & Collins, 1999) and increased smoking in young adults (Harakeh & Vollebergh, 2013). Harakeh and Vollebergh (2012a) compared the impact of active (modeling smoking behavior) and passive (the offering of a cigarette) peer influence on smoking behavior in young adults. The results demonstrated that participants exposed to a smoking peer were more likely to smoke a cigarette, but active pressure to smoke in the absence of modeling did not significantly influence smoking in participants (Harakeh & Vollebergh, 2012a). These findings demonstrate the strength of peer influence; however, the methods by which peers exert influence over risk taking in young adults are likely complex and may involve a combination of passive modeling and other more active mechanisms (e.g., Rolison & Scherman, 2003).

An understudied, but increasingly common, method of active and passive peer influence in young adults (as well as adolescents) is via digital communication. Internet social networking sites and mobile technology (e.g., smartphones), which are particularly popular among college-aged individuals, often utilize text-based communication that is readily accessible and frequently includes risk-related information. For instance, two recent studies found text references to alcohol on 73% of college-aged male Facebook (Egan & Moreno, 2011) and 56.3% of MySpace profiles, with peer pressure as the most common displayed alcohol use motivation (Moreno et al., 2010). Therefore, digital communication represents a potentially important source of peer influence on risky behavior.

Although relatively few studies have investigated the effect of digital communication on risk-taking in young adults, changes in risk behavior have previously been shown to occur after only brief online interactions (Harakeh & Vollebergh, 2012b; Moreno et al., 2009). For example, young adults exposed to a heavy-smoking peer in a video chat room were significantly more likely to smoke cigarettes (Harakeh & Vollebergh, 2012b). Such findings provide empirical support for the influence of digital peers on risk-taking behavior related to substance use in young adults. Conversely, a brief email intervention from a physician resulted in a significant reduction in sexual references in online social profiles of at-risk young adults aged 18–20 (Moreno et al., 2009). A more precise understanding of digital social influence on general risk-taking will help better tailor prevention efforts aimed at curtailing risky and reckless behavior in a population that frequently communicates using digital media.

In this study, we investigated the effects of peer influence on choice behavior in young adults (aged 18–25) using the Balloon Analogue Risk Task (BART) as a model of risk taking (Lejuez et al., 2002). The age range in the current sample overlaps with the developmental period described as *emerging adulthood* (Arnett, 2000). The BART is a well-validated laboratory-based choice task in which participants decide how much to inflate a simulated balloon presented on a computer screen before it bursts. Importantly, elevated risk taking on the BART has been associated with increased alcohol consumption (Fernie, Cole, Goudie, & Field, 2010), substance use (Pleskac, Wallsten, Wang, & Lejuez, 2008), aggression (Crowley, Raymond, Mikulich-Gilbertson, Thompson, & Lejuez, 2006), and self-reported measures of sensation-seeking and impulsivity (Lejuez, Aklin, Zvolensky, & Pedulla, 2003). Here, we used a modified version of the

BART in which participants entered a specific number of pumps (risks) they wanted to make at the onset of each trial and then observed the sequence of events automatically unfold (Pleskac et al., 2008). The automatic BART has been shown to yield unbiased statistics related to risk taking because the number of pumps the participant intended to enact can be recorded, even if the balloon bursts.

Our primary objective was to assess whether young adult participants would exhibit increased riskiness on the BART after remotely interacting with a peer. To our knowledge, only a few studies have used a modified BART to measure the influence of peers on risk taking. Most relevant to the current research, Cavalca et al. (2013) recruited smoking and nonsmoking adolescents to complete a modified peer BART that included a computer-simulated digital peer component. The results demonstrated that peer feedback significantly increased the number of balloon explosions in adolescent smokers, but not nonsmokers. The authors reported that there were no significant effects with regard to the number of target pumps between BART types or smoking status (Cavalca et al., 2013). Here, we extend prior studies by examining risky decision making under different sources of risk information (peer or computer) and different methods of influence (*modeling* or *pressure*). We hypothesized that exposure to risky information provided by either a peer or computer would be associated with significant increases in risk taking in young adults, relative to a control condition in which no risk information was presented. In addition, consistent with previous research highlighting the importance of peers, we hypothesized that risk information attributed to a peer would be associated with greater increases in risky behavior than risk information attributed to a computer. Finally, of primary interest, we hypothesized that the source and method of influence would interact, such that active encouragement to take greater risks from a digital peer would be associated with the largest increases in risk taking among young adults.

METHOD

Participants

Participants were 96 young adults with an average age of 19.01 years ($SD = 1.37$; 53% female) recruited for a study investigating choice behavior from introductory psychology courses in Fall 2010. In addition to receiving course credit, all participants were entered into a $100 raffle at the conclusion of the semester. They were informed they could earn additional entries (thus increasing their chance of winning) based on their BART performance. Previous research using the BART has employed this raffle reward approach to increase the ecological validity of decision making, as participants must weigh the potential gain of accruing more points (thus increasing the chance to win money) against the potential risk of losing points for that balloon (Maner, Gailliot, Butz, & Peruche, 2007). The university IRB approved all study procedures. Five participants were excluded: two due to technical errors (one due to a computer error that resulted in a different risk presentation and one for whom the program failed during the experiment) and three that were over the age of 25, resulting in a final sample of 91. Among these participants, 81% were Caucasian, 12% were Asian, 3% were Hispanic, 1% were African American, and 2% identified as "other."

Procedure

Upon arrival, participants entered a lobby where a gender-matched undergraduate research assistant, who served as a confederate for the study, was already waiting. In all experimental conditions, the experiment began immediately after the participant arrived, minimizing any opportunity for the participant to communicate with the confederate. All participants received the same initial instructions irrespective of experimental condition. Specifically, participants were told they would be performing a task on separate computers and that they may or may not have the opportunity to interact with each other. The confederate and the participant were then placed in adjacent testing rooms containing only a desk, chair, and computer.

After providing consent, participants completed a working memory task that is not a focus of this study (data not presented), followed by a baseline administration of the automatic BART. For the baseline administration, participants completed 10 practice balloon trials to become familiar with the task, after which they completed an additional 30 balloon trials (i.e., 40 balloons total). At the beginning of each trial, the participant was prompted to enter a number. The number corresponded to the number of "pumps" that would inflate the balloon; however, the participant was informed the balloons might unpredictably "burst." In all versions of the automatic BART (baseline and experimental), the maximum number of pumps possible was set to

128 for each balloon with an explosion a priori equally likely to occur on a given pump subject to the constraint that, within each sequence of 10 balloons, the average explosion point was on pump 64. The number of pumps on successful (i.e., unpopped) balloons was added to the participant's point total; any points that had accumulated for a burst balloon were lost. For both the baseline and experimental BART administrations, participants saw the point total on each trial but were not provided with a cumulative point total during the task. At the end of each BART administration, participants were presented with the total amount of points earned from unpopped balloons.

After completing the baseline BART administration, participants were randomly assigned to one of four conditions: control ($n = 22$), computer ($n = 22$), peer-observe ($n = 23$), or peer-observe+interact ($n = 24$). The experimental BART administration occurred within a few minutes of completing the baseline administration. In the control condition, participants remained in the testing room and repeated the baseline BART exactly as described above. This group served as a control for any changes in risk taking associated with performing the task a second time.

Participants in the other three conditions (computer, peer-observe, and peer-observe+interact) completed a modified version of the automated BART that included 40 "other" balloon trials that alternated with the participant's trials in a fixed pattern across groups. In all conditions, the participant did not know the outcome (i.e., popped or unpopped) of the "other" balloon trials; instead, they only saw the target number ostensibly entered by the peer or computer for each trial. Unbeknownst to participants, "other" balloon trials were always exactly 40% riskier than participants' own target responses during the baseline BART administration.

For the three experimental groups, we manipulated the attribution of the "other" balloons. In the computer condition, participants completed the BART with alternating trials that were "randomly entered" by the computer program (i.e., not attributed to the peer in the adjacent room). In the peer-observe and peer-observe+interact groups, the participant and the confederate were brought back out to the main room for additional instructions. The researcher briefly explained they would be performing another version of the balloon task in which they would periodically alternate inflating balloons. They were told that they would earn the points only on their own balloon trials. The confederate and the participant then returned to their individual testing rooms, and the researcher entered the participant and confederate names into the BART program and ostensibly "synced" the computers. The alternating "other" target values for the peer-observe and peer-observe+interact were identical to the computer group (i.e., 40% riskier than the participant's baseline), except the confederate's name appeared before each "other" trial. In addition to observing target values entered by the "peer," participants in the peer-observe+interact group were told they would have two opportunities to send a message to the other participant during the task. After completing balloon trials 10 and 25, the participant had the opportunity to send a message to the "peer" in the adjacent room by typing in a text box that was displayed for 60 s. After the participant typed a message to the "peer," the words "transferring feedback" were displayed on the screen for 2 s, followed by a message that was "sent" from the "peer" that appeared on the participant's screen for 7 s. All participants in the peer-observe+interact group received the same risk-encouraging message after the first and second feedback opportunity: "Hi. I can't see your points, but the numbers you picked look low. I think you can go higher" and "Your numbers still seem really low… If I were you I'd go a lot higher," respectively.

At the conclusion of the experimental BART, points earned from unpopped balloons on the baseline and experimental administrations of the BART were summed to calculate the participant's final total. The number of entries that participants earned for the raffle was based upon this point total. Specifically, at the conclusion of data collection, the point totals across participants were divided into quartiles to determine number of entries. The winning participant was drawn at random and mailed a check for $100.

Analytic Strategy

Our primary goal was to examine the effects of the four experimental conditions (control, computer, peer-observe, and peer-observe+interact) on change in risk-taking behavior during the automatic BART. Groups did not differ on any demographic variables (i.e., age, gender, years in college, ethnicity; all $ps > .73$). Prior to analysis, we calculated individual-level risk scores for each participant using an approach that has been used previously to operationalize within-individual changes in performance on the BART (White, Lejuez, & de Wit, 2007) and other paradigms assessing risky behavior

(Prinstein, Brechwald, & Cohen, 2011). First, the average target value from the baseline administration of the BART was calculated for each participant. This average characterizes individual risky choice behavior in the absence of any influencing factors. Then, target scores from the experimental BART administration were divided into three bins (1, 2, and 3 corresponding to balloon trials 1–10, 11–25, and 26–40, respectively) based upon the points at which the participants in the peer-observe+interact group interacted with a digital peer. Separating balloon trials in this manner allowed us to assess potential changes in risky behavior immediately following these digital interactions. To quantify within-person change in risk behavior across time, individual risk scores were calculated as the difference between the mean number of "target pumps" entered by participants during the baseline BART administration from the mean number of target pumps entered during each bin of the experimental administration of the BART.

RESULTS

We conducted a 4 (group: control, computer, peer-observe, peer-interact+observe) × 3 (time: Bins 1–3 of experimental trials) repeated measures ANOVA with risk scores as the dependent measure. The sphericity assumption was not met, so the Huynh–Feldt correction was applied. Results demonstrated a significant main effect of time [$F(1.72, 149.17) = 14.93$, $p = .000$, $d = .37$], such that mean risk scores increased across bins collapsing across groups [M (SD) = 7.7 (20.1), 14.3 (16.9), and 16.0 (21.0) for Bin 1, Bin 2, and Bin 3, respectively]. There was also a significant main effect of group [$F(3, 87) = 3.12$, $p = .03$, $d = .57$], indicating that risk scores significantly differed between the four experimental groups collapsing across bins. Of primary interest, results also indicated a significant group*time interaction [$F(5.14, 149.17) = 2.90$, $p = .015$, $d = .29$]. As the main objective of the study was to detect such differential responses, and because the presence of this interaction may have implications for interpreting main effects, subsequent analysis focused on characterizing the nature of this result.

We conducted separate follow-up univariate ANOVAs examining the effect of group on risk scores for each bin. The effect of group was significant for the second [$F(3, 91) = 6.70$, $p = .000$, $d = .94$] and third [$F(3, 91) = 3.14$, $p = .03$, $d = .64$] bins, but not the first bin [$F(3, 91) = 0.86$, $p = .46$]. During Bin 1 (balloons 1–10), participants in the control group received no additional risk information, but participants in the computer-observe, peer-observe, and peer-observe+interact were exposed to trials presenting "other" target scores that were 40% riskier than the participant's own baseline. Importantly, participants in the peer-observe+interact group had not yet received risk-encouraging messages from the "peer." To characterize the aforementioned group effects, Bonferroni-corrected post hoc tests were performed for Bins 2 and 3. For Bin 2 (balloons 11–25), significant differences were revealed between the control group and each of the remaining conditions: computer ($p = .02$), peer-observe ($p = .05$), and peer-observe+interact ($p < .001$). As depicted in Figure 1, each of the experimental groups exhibited larger risk scores than the control group during the second bin. For Bin 3 (balloons 26–40), only the peer-observe+interact condition significant differed from the control condition ($p = .03$); all other comparisons were nonsignificant (all $ps > .26$). Thus, compared to the control group, only the peer-observe+interact condition was associated with significantly increased risk scores during the final portion of the task.

DISCUSSION

Prior research suggests that peer influence is an important contributor to risky behavior in adolescents and young adults (Ham & Hope, 2003; Varela & Pritchard, 2011). The current analysis suggests that risk taking increases in young adults when presented with risk information by an "other" (i.e., peer or computer). Importantly, results also suggest that a brief risk-encouraging digital message from a peer has a sustained influence on risk taking relative to a control condition, whereas just observing risk information from a peer or a computer has a less persistent effect. Interpreted in the context of online social networking sites and wireless communication that frequently utilize short text-based messages, these findings suggest that receiving risk-encouraging messages from a digital peer has an impact on the behavior of young adults.

The current study utilized a modified version of the automatic BART to evaluate the influence of a brief digital peer interaction on behavioral risk choice in young adults. Previous research studying the impact of peers on risk taking in young adults has frequently utilized self-report measures to assess associations between the presence of peers and risky behavior (e.g., Pinchevsky et al., 2012). In these studies, modeling (passive) and peer pressure (active) are often assumed to be a primary influ-

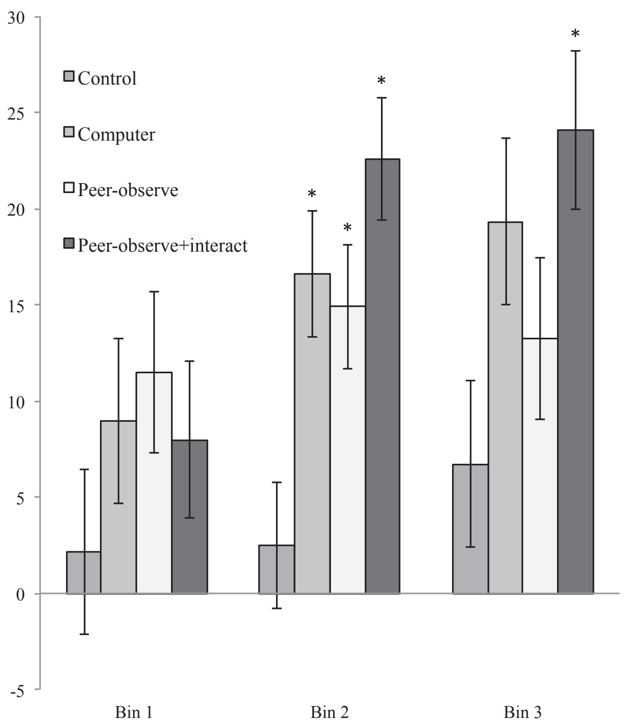

FIGURE 1 Risk scores were calculated as the difference between the mean number of "target pumps" entered by participants during the baseline BART administration from the mean number of target pumps entered during Bins 1, 2, and 3 (experimental balloon trials 1–10, 11–25, and 26–40, respectively). *$p < .05$ (Bonferroni corrected) compared to control group.

ence on the decision to engage in risky behavior. Notably, researchers have argued that many studies on adolescent and young adult risk taking employ hypothetical risky situations that bear little resemblance to actual risk-taking behavior (Steinberg, 2004). By using a behavioral estimate of risky decision making that has been previously correlated with actual risk taking behavior (Lejuez et al., 2003; Pleskac et al., 2008), we were able to investigate changes in risk taking that are likely to have real world implications.

The current results suggest that risk taking increases under both passive and active conditions. Unexpectedly, the peer-observe and computer-observe conditions were associated with similar changes in risk-taking behavior. Consistent with our primary hypothesis, however, active risk encouragement appears to produce the most sustained increases in risk taking. Participants who ostensibly received messages directly from a perceived peer (peer-observe+interact group) in the current study may have perceived this information as unambiguous and accurate, increasing the influence that it had on their decision making. In contrast, the information gleaned by only observing a peer or computer may have been perceived as a potentially unreliable source of information. That is, in the absence of explicit verification provided by the peer or computer, individuals in the peer-observe and computer-observe groups may have judged the observed behavior as more ambiguous (i.e., the extent to which the behavior was successful was unclear), reducing the impact that it had on their own choices. Taken together, the current findings suggest that young adults are susceptible to influence by peers, and although observation (i.e., modeling) increases risk taking, active pressure may further increase risk taking (or perhaps lead to increases in risk that are more long-lasting). Additional research further characterizing the nature of these effects would be valuable.

Results from a recent study provide additional support for the notion that digital peer interactions affect risk taking, although the pattern of effects was not entirely consistent with the current results. Specifically, Cavalca et al. (2013) found that risk-encouraging prompts ostensibly delivered by an online peer increased risk taking during the BART in adolescent smokers, but the prompts did not have a significant effect on the behavior of adolescent nonsmokers. The lack of effects in nonsmokers contrasts with the observation that conceptually similar peer messages increased risk taking in the present sample, which was comprised of a nonclinical sample of young adults with very low rates of substance use (including smoking). This discrepancy may relate to several methodological differences between the current study and the study by Cavalca et al. (e.g., studying young adults vs. adolescents, using the automatic vs. original "manual" version of the BART). Perhaps most notably, the studies differed with respect to the presentation of risk information. For the current study, all participants initially completed a baseline BART to assess for risk taking in the absence of additional risk information. After the baseline BART, participants (except the control group) completed one of three different BART administrations with additional risk information that was based on the participant's own baseline values. Once exposed to the risk information, participants in all three "other" experimental groups demonstrated increased risk taking characterized by higher target values compared to baseline. Finally, the feedback in the peer-observe+interact group was always a risk-encouraging digital message, irrespective of participant target values. In contrast, Cavalca et al. (2013) employed a within-subject approach that counterbalanced standard and peer BART administrations and varied peer feedback on target pumps (i.e., "higher" or "just right"). It is possible that participants who received the peer BART first continued to enter higher values on the subsequent standard BART that was based on the previously provided "peer" feedback. Future research is needed to explore these possibilities. More generally, continued investigation of risk taking in adolescent and young adult populations that may be more susceptible to peer influence is an important research avenue that has direct implications for interventions intended to reduce risky behavior. For example, interventions designed to reduce risky behavior in young adults (e.g., information related to safe sex practices) could be administered via social networking sites (e.g., see Moreno et al., 2009).

The above results highlight a novel method to assess the immediate influence of peers on risky behavior in young adults, but several limitations should be noted. First and foremost, the study population consisted of predominantly Caucasian (81%) young adults enrolled at a large university. Previous research has suggested a potential moderating role for ethnicity in predicting risky behavior (e.g., substance use) during college (e.g., Borsari, Murphy, & Barnett, 2007). Similarly, previous research has also suggested significant gender differences in risk behavior in the presence of peers (Varela & Pritchard, 2011). Therefore, additional research is necessary to help clarify the impact of ethnicity and gender on risky decision making and susceptibility to digital peer influence. Second, the modified automatic BART used in the study may have certain limitations that would be useful to address in future research. It is possible that a more active version of the BART, in which participants manually inflate balloons, could result in increased task engagement and potentially stronger associations between risk choice and peer influence. Within the current study design, the "peer" was an unaffiliated gender-matched confederate. Future research would benefit from including an observation and interaction group with a known peer (e.g., a friend) or expanding research to include risk taking in a group setting. Incorporating digital interactions with a known peer or within a group setting may provide greater insight into the effects associated with common methods of communication among young adults. The current study utilized only simple text presentation as a method of influence. This is analogous to many digital communication methods employed by young adults, but other methods of digital peer influence (e.g., video or picture communication) may also potentially influence risky decision making. We also chose not to include a computer-observe+interact group given our focus on the effects of active and passive peer influence. Considering the literature highlighting the potential impact of interactions with a computer in a socially-based laboratory task (e.g., Zardo, Williams, & Richardson, 2004), the direct effect of a computer interaction would be important for future investigations. Lastly, emotional arousal likely has a significant influence on decision making in adolescents and young adults (Steinberg, 2004); future research would benefit by examining the effects of induced or naturalistic emotional states on responses to digital peer interactions to provide greater insight into the impact of emotional arousal on peer influenced risk taking.

Currently, adolescents and young adults are bombarded with mobile phone texts, status updates, and chat messages via multiple social networking sites and wireless communication methods. The portability and accessibility of digital peers means that risk-related information is continuously accessible to young adults and adolescents. Recent studies have evaluated the influence of digital communication on perceptions and beliefs; however, to our knowledge, the present study is one of the first to directly investigate the immediate impact of remote risk encouragement from different sources on actual risk-taking behavior. The present study provides evidence that a short, text-based digital communication from a peer can influence risky decision making in young adults. The influence of digital peer interaction may help inform new methods of targeted interventions aimed at reducing risky behavior in young adults.

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