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14. ABSTRACT

The purpose of our project is to compare decision-making of young males (ages 18-22), acting alone or within groups, under varying situational circumstances. In experiment 1 (completed), we established a test battery that reliably revealed the "peer effect" when individuals taking the test battery alone were compared with those taking the test battery while with their peers. During this reporting period, we have completed experiment 2, which showed that the presence of a slightly older adult significantly *attenuates* the peer effect, making young males in a peer context less impulsive and reward sensitive than they are when there is no adult present. We have also begun experiment 3, where we test fatigued young males in solo and peer contexts to investigate whether fatigue *exacerbates* the effect of peers on young adults' decision-making. In preparation for this experiment, we have trained additional research personnel (5 volunteer research assistants and one paid staff member), piloted the fatigue manipulation, and refined the experimental procedures. To date, we have tested 41 fatigued individuals in the "alone" condition and 23 fatigued in the "peer" group (foursome of 18-22 year olds), and continue to collect data.

15. SUBJECT TERMS					
Recruitment, enrollment, instruments, IRB, data collection, key personnel, experimental condition, tasks, piloting, active data collection					
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I. INTRODUCTION

The purpose of this research is to study the impact of peers and varying situational circumstances on risk-taking and decision-making among 18-22 year old males who are demographically similar to current warfighters. **AIM 1: Characterization of the Peer Effect in Groups of Four (COMPLETED)—** In the first experiment, we explored peer influences on a set of decision-making tasks that reliably and differentially emphasize key processes implicated in risky decision-making. Data from this experiment showed a robust peer effect in foursome of 18-22 year olds—that is, when young males are in a peer context (with three other team members), they engage in more risk-taking than when they are alone. These peer group data are our baseline comparison group against which we compare data from subsequent experiments, when either the age mix of the group members (experiment 2) or individual circumstances (i.e., level of fatigue; experiment 3) are manipulated. **AIM 2: Mitigating Impact of Adult Presence on the Peer Effect (COMPLETED)—** In experiment 2, we used the same tasks and procedures that reliably produced a robust peer effect in experiment 1 to show that the inclusion of a single, older team member in the team of 4 significantly attenuated young males' increased inclination toward risky decision-making. Results from this experiment are summarized on pages 10-13. **AIM 3: Exacerbation of the Peer Effect among Mentally Fatigued Individuals (IN PROGRESS)** — In experiment 3, which is currently underway, we are investigating whether increased levels of mental fatigue—a common element in combat situations—might exacerbate the peer effect. Progress on this experiment is documented on pages 14-15. **AIM 4: Mitigation of the Peer Effect by Cognitive-Regulation Training (*NOT YET INITIATED*).** In the final experiment, we will investigate whether it is possible to condition individuals to be more resistant to the peer effect by having them complete 4 weeks of cognitive training. Our ultimate interest is in comparing decision-making by young males acting within groups that are composed in different ways, under varying situational circumstances.

II. KEYWORDS

Young males, risky decision-making, peer context, recruitment, enrollment, IRB approval, key personnel, experimental conditions, battery of tasks, piloting, fatigue manipulation, active data collection.

III. KEY RESEARCH ACCOMPLISHMENTS

- **AIM 1: Characterization of the Peer Effect in Groups of Four—**to identify tasks and procedures that reliably produce a robust peer effect in foursomes of 18-22 year old males, and finalize a test battery based on the results of these experiments; to examine whether personality measures can identify individuals who are especially susceptible to the impact of peer influences on decision-making.
    - **AIM 1 COMPLETED (months 0-12):** We have successfully established a reliable experimental battery to demonstrate a robust peer effect in groups of four males between ages 18-22. To demonstrate this peer effect, we recruited and tested of 120 "solo" participants and 100 "peer group" participants. These peer group data are our baseline comparison group against which we compare data from subsequent experiments, when either the age mix of the group members (experiment 2) or individual circumstances (i.e., level of fatigue; experiment 3) are manipulated.
    - **PAPER PUBLICATION**: Silva, K., Shulman, E.P., Chein, J., Steinberg, L. (2015). Peers increase adolescents' exploratory behavior and sensitivity to positive and negative feedback. *Journal of Research on Adolescence*. DOI: 10.1111/jora.12219.
        - Refer to reportable outcomes section (on page 19) and see attached manuscript for details.
- **AIM 2: Mitigating Impact of Adult Presence on the Peer Effect—**to identify whether replacing one younger member of a foursome with one individual aged

25 or older attenuates the peer effect; to identify characteristics of individuals whose decision-making is relatively more likely to be affected by the presence of an older individual.

  - **AIM 2 COMPLETED (months 12-24):** In this experiment, one of the team members in the foursome of young males was replaced with a slightly older adult (between 25 and 30 years old). We recruited and tested of 100 young males in the presence of two young males and 1 older adult. We demonstrate that the presence of an older adult within the foursome attenuates the peer effect.
    - Refer to page 11 for a brief summary of the results.
  - **PAPER PUBLICATION**: Silva, K., Chein, J., & Steinberg, K. (in press). Adolescent Peer Groups Make More Prudent Decisions in the Presence of a Slightly Older Adult. *Psychological Science*.

- **AIM 3: Exacerbation of the Peer Effect among Mentally Fatigued Individuals**—to determine whether the peer effect is accentuated when individuals are mentally fatigued; to examine whether personality measures can identify individuals who are relatively more or relatively less susceptible to the peer effect, especially when fatigued.
  - **AIM 3 IN PROGRESS**: To date, we have hired new personnel, established a reliable fatigue manipulation, and currently actively collecting data for this experiment. We are about 32% through data collection. Refer to Table 1 on the next page for details.

TABLE 1. MAJOR GOALS OF THIS RESEARCH PROJECT AND PROGRESS TO DATE

	Central Aims	**TARGET SAMPLE**	**TESTED SAMPLE TO DATE**	**% COMPLETION**
Exp. 1	-Establish reliable and robust **peer effect**	**100 Solo** Participants **100 Group** Participants (tested in the presence of 3 young males)	▪ **120** solo participants ▪ **100** participants tested in a peer group	100% COMPLETE
Exp. 2	-Test mitigation of peer effect by **presence of older adult** group member	**100 Group** Participants (tested in the presence of 2 young males and 1 older adult)	▪ **100** group participants tested presence of an adult	100% COMPLETE
Exp. 3	-Demonstrate exacerbation of peer effect under **mental fatigue**	**100 fatigued Solo** Participants **100 fatigued Group** Participants (tested in the presence of 3 young males)	▪ **41** fatigued solos ▪ **23** fatigued groups	32% IN PROGRESS
Exp. 4	-Test mitigation of peer effect by C-R training	50 Group Participants ▪ **Placebo training** 50 Group Participants ▪ **C-R training**		0%

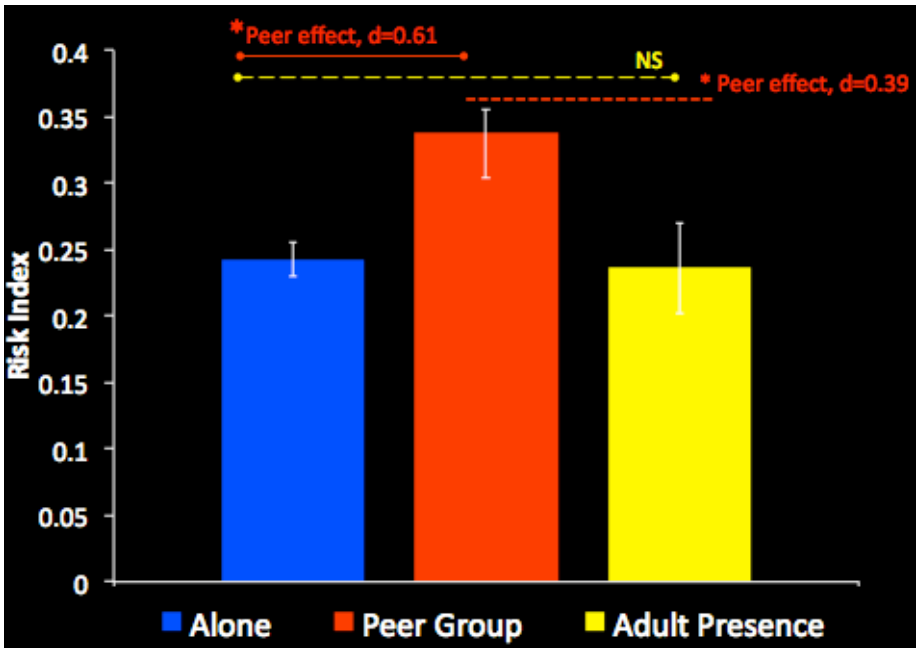
Note: C-R = Cognitive Regulation.

EXPERIMENT 2 AIM (COMPLETED): To determine whether the inclusion of one older adult (ages 25-30) within the foursome of males attenuates the effect of younger peers (ages 18-22) on young males' decision-making.

Data from experiment 2 showed that the presence of a slightly older individual in the peer group attenuates the peer effect. In comparison to the behavior of males in peer groups without the presence of an adult (data from experiment 1), young males in an adult-present context engage in less risk-taking, are less sensitive to immediate rewards, and learn faster from the negative and positive consequences of their choices. Data from experiment 2 is below. A detailed description of the experimental tasks on which these data are based is included in the appendix.

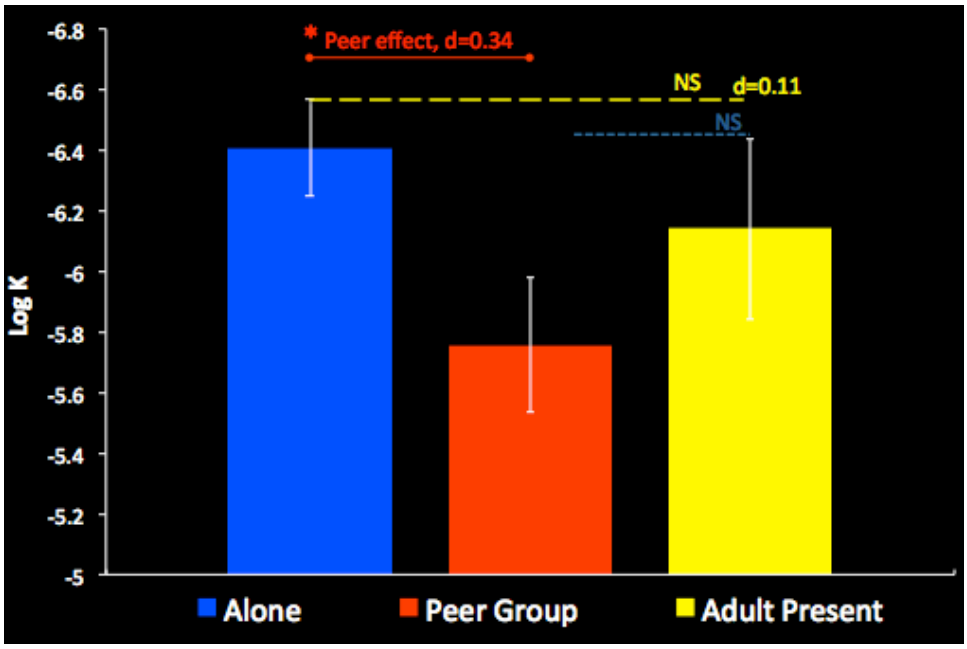
EXPERIMENT 2 RESULTS:

Figure 1. Risk-taking by Social Context.



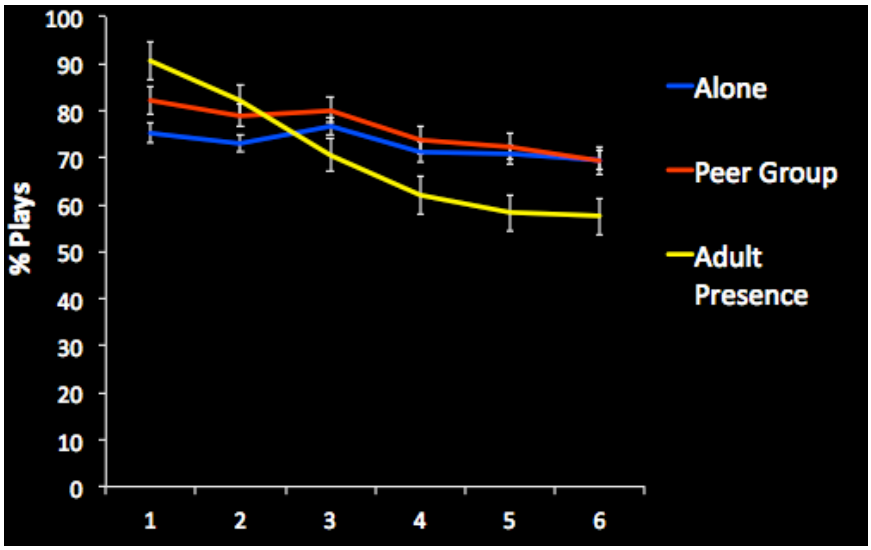
*Risk-taking data is based on behavior during the Stoplight Game. Risk index is the proportion of crashes and runs through a red traffic light.

Figure 2. Preference for Immediate Rewards by Social Context.



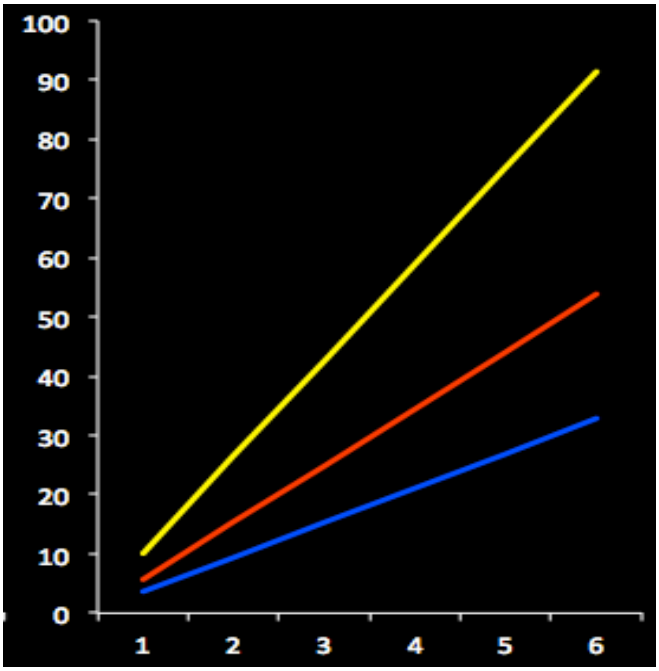
*Preference for immediate rewards is based on behavior during a temporal discounting task. LogK refers to the discounting rate, for which a higher value indicates stronger sensitivity toward immediate, relative to delayed rewards.

Figure 3. Overall Rate of Plays in the Iowa Gambling Task.



*Behavior in the Iowa Gambling Task is analyzed cross six blocks. Over rate of plays represents individuals' willing to play (rather than pass) on all decks, therefore we consider it an index of exploratory behavior. As illustrated, young males in the peer condition explore more in the initial blocks, relative to the alone condition. However, the rate of exploratory behavior is significantly higher among young adults in the adult-present condition, yet they decline their rate of plays sooner than individuals in the peer condition. This is indicative of faster learning from positive and negative feedback in the Iowa Gambling Task.

Figure 4. Net Score in the Iowa Gambling Task by Social Context, where yellow =adult-presence, red =Peer group, and Blue =Alone condition.



*Net score in the Iowa Gambling Task is an indication of the extent to which individuals integrate learning from positive and negative feedback to inform subsequent decision-making. As illustrated, young males in the adult-present condition (yellow line) integrate learning from feedback at a much faster rate than both peer (red) and alone (blue) conditions.

Some of the results from experiment 2 (namely data from the Stoplight and temporal discounting tasks) have been accepted for publication in *Psychological Science.* Refer to Reportable Outcomes on Page 19 for details. These data are also pending acceptance for presentation at two conferences in 2016.

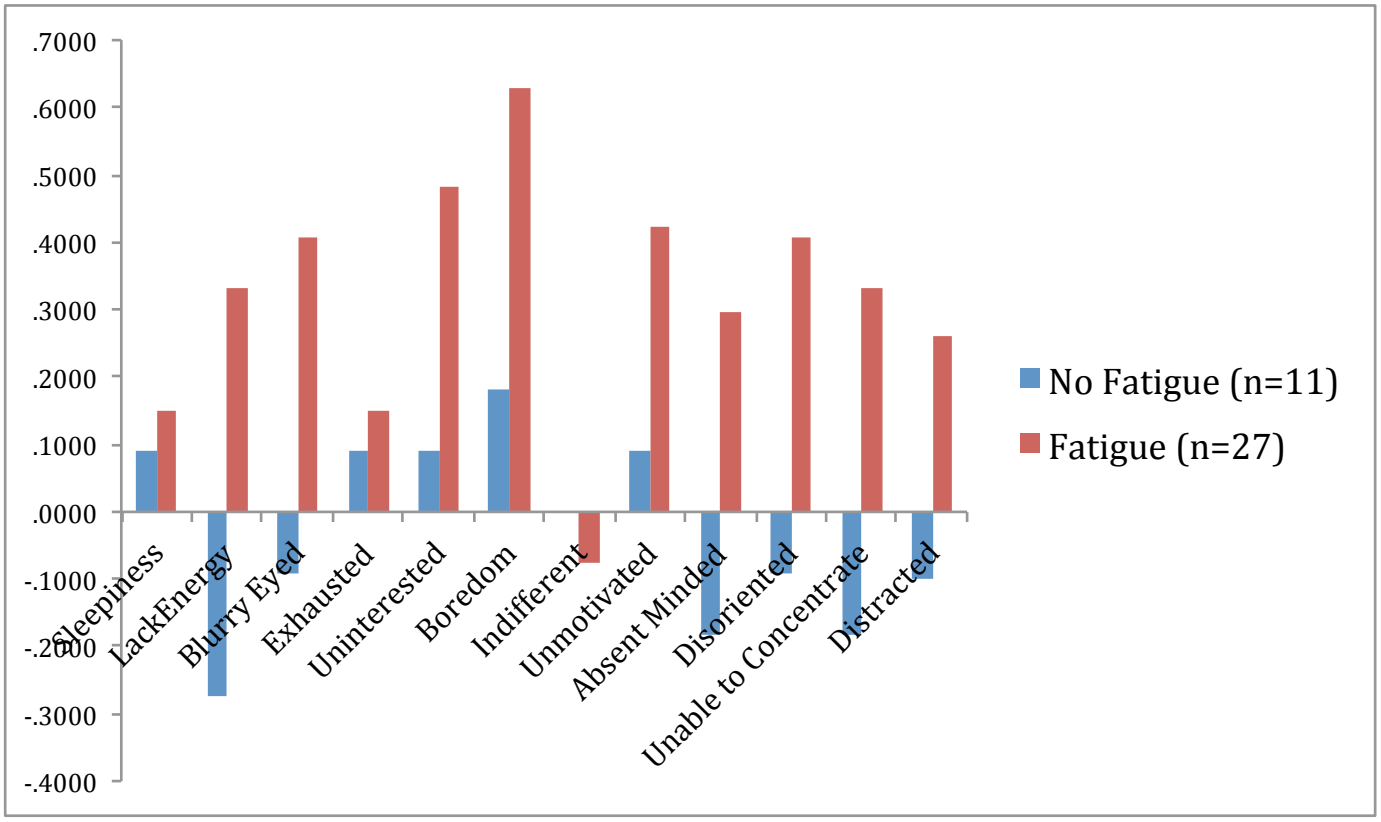
EXPERIMENT 3 (IN PROGRESS): to determine whether the peer effect is accentuated when individuals are mentally fatigued; to examine whether personality measures can identify individuals who are relatively more or relatively less susceptible to the peer effect, especially when fatigued.

Since the last reporting period, we have commenced data collection on experiment 3: successfully retained IRB approval of the present protocol, added a cognitive control measure to the battery of experimental (decision-making) tasks, hired/trained additional personnel to help with data collection, and completed piloting of the fatigue manipulation implemented in this experiment. Specifically, we piloted the use two continuous rounds of a cognitive control task (called "Go-No-Go," or GNG for short) to induce cognitive fatigue before subjects started the experimental battery. This fatigue manipulation lasts 20 minutes, and was tested against a placebo/control treatment, during which participants were asked to relax for 5 minutes before starting the experimental battery. In addition, participants in both the fatigue and control group completed a pre-and-post survey to help assess whether two continuous rounds of GNG was actually fatiguing subjects.

On the next page (15), we show pilot data from the fatigue manipulation used in Experiment 3. As shown, individuals who complete 20-minutes of "Go-No-Go" (GNG) report more cognitive fatigue than individuals in the control condition. Based on these preliminary, fatigue is measurable through items such as sleepiness, lack of energy, being blurry eyed, disoriented, unable to concentrate, etc.

At present, our efforts are focused on recruitment and testing of **fatigued** young males, tested in solo and peer group contexts. In the upcoming 6 months, we anticipate completion of experiment 3 (by February 2016) and beginning experiment 4 (by March 2016).

Table 2. Pilot Data Assessing the Effectiveness of our Fatigue Manipulation Tested against a Control/No Fatigue Condition.



IV. CONCLUSION

Our research findings up to this point indicate that the inclusion of a slightly older adult within a fireteam can significantly reduce young males' heightened propensity to endorse risky decisions in the presence of other same-age peers.

V. IMPACT

Nothing to Report.

VI. CHANGES/PROBLEMS

The original plan anticipated a September 2016 end date. However, in light of progress delays, we have submitted and been approved for a no-cost extension on this project.

VII. REPORTABLE OUTCOMES/PRODUCTS

1. **Experiment 1 (Iowa Gambling Task) data:**
    a. PUBLICATION: Silva, K., Shulman, E.P., Chein, J., & Steinberg, L. (2015). Peers increase adolescents' exploratory behavior and sensitivity to positive and negative feedback. *Journal of Research on Adolescence*. DOI: 10.1111/jora.12219 **PUBLICATION ATTACHED**
    b. CONFERENCE PRESENTATION: Silva, K., Shulman, E.P., Chein, J., & Steinberg, L. (May 22, 2015). Peers increase adolescents' exploratory behavior and sensitivity to positive and negative feedback. Annual Association of Psychological Science convention, New York, NY. **POSTER PRESENTATION ATTACHED**
2. **Experiment 2 data:**
    a. PUBLICATION (IN PRESS): Silva, K., Chein, J., & Steinberg, K. (in press). Adolescent Peer Groups Make More Prudent Decisions in the Presence of a Slightly Older Adult. *Psychological Science.*

VIII. REFERENCES

1. Silva, K., Shulman, E.P., Chein, J., Steinberg, L. (2015). Peers increase adolescents' exploratory behavior and sensitivity to positive and negative feedback. *Journal of Research on Adolescence*. DOI: 10.1111/jora.12219.
2. Silva, K., Chein, J., & Steinberg, K. (in press). Adolescent Peer Groups Make More Prudent Decisions in the Presence of a Slightly Older Adult. *Psychological Science.*

IX. APPENDIX

1. The Stoplight Game

The Stoplight Game is a simple driving task in which subjects control the progress of their vehicle along a straight track by deciding whether to brake as they approach a series of intersections, each with a traffic signal that has turned yellow. Participants are told that traveling through the intersection without incident will cost no time, that stopping and waiting for the signal to turn red and cycle back to green will cost some time, and that attempting to cross the intersection but crashing into a crossing car will cost a great deal of time. Importantly, both the timing of the traffic signals and the probability of a crash in the associated intersections are varied so as to be unpredictable by the participant. Risk-taking (i.e., not braking for the yellow light) is encouraged by offering monetary incentives for completing each course in a timely fashion. Successfully traveling through an intersection saves time, whereas braking and waiting for the signal to turn green wastes time. This task has been used in previous studies as a measure of sensation-seeking, and performance is made more risky by the presence of peers.

2. Temporal Discounting task

The Delay Discounting task assesses subjective preference for smaller, but more immediate, rewards relative to larger, delayed, rewards. In our adaptation of the task, the amount of the delayed reward was held constant at $1,000. We vary the time to delay in 6 blocks (1 day, 1 week, 1 month, 3 months, 6 months, and 1 year), presented in a random order. For each block, the starting value of the immediate reward is $200, $500, or $800, randomly determined for each participant. The respondent is asked to choose between an immediate reward of a given amount and a delayed reward of $1,000. If the immediate reward is preferred, the subsequent question

presents an immediate reward midway between the prior one and zero (i.e., a lower figure). If the delayed reward is preferred, the subsequent question presents an immediate reward midway between the prior one and $1,000 (i.e., a higher figure). Participants then work their way through a total of nine ascending and descending choices until their responses converge and their preference for the immediate and delayed reward are equal, at a value reflecting the discounted value of the delayed reward, known as the "indifference point." As is customary in studies using this task, two dependent variables are computed: the average "indifference point" and the discount rate (*k*), (with a lower indifference point and higher discount rate indicating stronger reward sensitivity). This task has been used in previous studies as a measure of preference for immediate reward, which we have shown is intensified in the presence of peers.

3. Iowa Gambling Task

The Iowa Gambling Task is a neurocognitive measure that has been extensively used in studied of individuals who persistently engage in risky behavior despite experiencing negative consequences, such as compulsive gamblers or substance abusers. In the original version of the task, participants are presented with four decks of cards, turned face-down, and told that two of the decks are winning decks and two are losing decks. They are then asked to draw cards from the decks so as to maximize their winnings. The task was modified for our purposes, such that participants make a play/pass decision with regard to one of 4 decks pre-selected on each trial, rather than deciding to choose to draw from any of 4 decks on any trial, as in the original task. This modification allows us to determine the independent effects of reward-seeking and cost-avoidance on card selection. For each trial, one of the four decks is highlighted with an arrow, and participants are given 4 seconds in which to decide to play or pass that card. If participants

choose to play, a monetary outcome is displayed on the card and the total amount of money earned is updated and appears on the screen. If participants pass on a given card, the image of the card on the screen displays the message "Pass," no outcome information is given, and the total amount of money earned does not change. As in the original task, two of the decks are advantageous and result in a monetary gain over repeated play. The other two decks are disadvantageous and produce a net loss over repeated play. In addition, within each type of deck (advantageous vs. disadvantageous), there is one deck in which the losses or rewards experienced are infrequent but relatively large, and one in which they are consistent and relatively small. The task is administered in 6 blocks of 20 trials each. Performance is operationalized in three ways: percentage advantageous deck choices (reward-seeking), percentage disadvantageous decks not chosen (cost avoidance), and net score (the difference between the percentage advantageous and disadvantageous decks chosen). Importantly, the percentage of advantageous decks chosen in a given block is *not* contingent upon the percentage of disadvantageous decks avoided, which permits the computation of independent reward-seeking and cost avoidance scores. This task has been used in previous studies as a measure of reward sensitivity, but has not been employed to date in studies of peer influence.

4. Go-No-Go Task

The Go-No-Go (GNG) task is a measure of response inhibition in which pre-specified stimuli (letters X's and K's) are presented in a continuous stream and participants are instructed to press a button (Go) as fast as they can when the letter X is presented on the screen, and withhold a response (No-Go) when the letter K is presented. Accuracy and reaction times are measured for each event. 'Go' events occur with higher frequency (75% of the time) than No-Go events, which makes it difficult to inhibit a pre-potent Go response.

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Peers Increase Late Adolescents' Exploratory Behavior and Sensitivity to Positive and Negative Feedback

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Adolescents take more risks with peers than when alone. It is not clear how peer presence affects adolescents' risky decision making, however. We used the Iowa Gambling Task (IGT)—a game used to assess decision making involving risk and reward—to examine how peers affect late adolescents' exploration of relevant environmental cues, ability to learn from the outcomes (positive and negative) of that exploration, and ability to integrate feedback to adjust behavior toward optimal long-term outcomes. One hundred and one 18- to 22-year old males (M = 19.8 years) were randomly assigned to play the IGT either alone or observed by peers. Late adolescents tested with observers engaged in more exploratory behavior, learned faster from both positive and negative outcomes, and evinced better task performance than those tested alone.

Most forms of risky behavior, including activities that jeopardize health and well-being, are more common during adolescence than before or after (Steinberg, 2008). Heightened risk taking during adolescence, typically in the pursuit of rewards, has been observed in several mammalian species, leading some writers to speculate that it is an evolutionarily adaptive behavior thought to encourage separation from family in order to facilitate independence, mating, and, ultimately, reproduction (Spear, 2000). Notably, human adolescents are more likely to take risks when they are with friends than when they are alone (Albert & Steinberg, 2011). This peer effect on risk taking may occur in part because peers heighten late adolescents' sensitivity to potential rewards (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011; Gardner & Steinberg, 2005; Smith, Steinberg, Strang, & Chein, 2015), especially immediate ones (O'Brien, Albert, Chein, & Steinberg, 2011; Weigard, Chein, Albert, Smith, & Steinberg, 2014).

Although adolescents are capable of understanding risk and the possibility of adverse outcomes associated with it (Reyna & Farley, 2006), the extent to which they utilize this information to guide decision making when they are with peers remains unclear. Although behavioral and neural data generally confirm that peers increase late adolescents' sensitivity to the anticipation and receipt of reward, less is known about the influence of peers on late adolescents' sensitivity to negative outcomes. In one relevant study, adolescents played a "Wheel of Fortune" gambling task, either alone or while believing that they were being observed by peers. Each trial involved gambling on a wheel that graphically displayed explicit information about the probabilities of winning and losing (Smith, Chein, & Steinberg, 2014). Adolescents gambled more when they thought they were being observed than when they were alone, and especially so when they were given information indicating that the probability of losing was greater than that of winning. Thus, peers may motivate adolescents to pursue opportunities for reward, even when the chances of positive outcomes are known to be slim.

Although informative, the findings from this gambling study are limited in at least two ways. First, the experimental paradigm always coupled information about the potential for loss with that about the potential for gain on any given trial—thus, it could not be determined whether the peer effect on risk taking arose because peers increased participants' sensitivity to potential rewards or because peers diminished their sensitivity to potential losses.

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Second, because every trial represented an independent probabilistic event, there was no reason for the participants to use feedback about the outcomes to inform subsequent decision behavior.

Exploring whether peer contexts influence late adolescents' ability to learn from the outcomes of their decisions is important. Because risk taking is relatively more likely to occur with peers, the rewards and consequences of risky choices are also more likely to be experienced in the presence of others. Peers may not only increase adolescents' reward seeking, but also may influence the extent to which positive and negative outcomes are incorporated into learned representations that inform subsequent decision making. To our knowledge, only one study has examined adolescents' sensitivity to negative feedback as a function of social context (Segalowitz et al., 2012), showing weaker engagement of the medial prefrontal cortex (mPFC) in response to loss when adolescents were in the presence of peers than when alone. In a related study, adolescents exhibited greater activation of the ventral striatum (a reward-processing region) when they were with peers than when they were alone (Smith et al., 2014).

Although one might conclude from these neuroimaging studies that peers increase adolescents' sensitivity to rewards and decrease sensitivity to costs, and that this contributes to increases in risk taking in the presence of peers, there were no behavioral differences across the alone versus peer contexts in either study. These findings indicate is that adolescents respond differently, at a *neural* level, to positive and negative feedback when they are in social contexts than when they are alone. We do not know whether subsequent decision making changes differentially as a result of the influence of peers on the way rewards and costs are processed.

In the current study, we extend these earlier studies by examining how peers affect late adolescents' decision making in a task in which optimal performance depends on exploring different options early on and learning from positive and negative feedback. We focus on late adolescents (ages 18–22) because there is considerable evidence that the prevalence of certain real-life, high-stakes risk behaviors (e.g., binge drinking, substance use, reckless driving, and unprotected sex) is highest among 18- to 22-year olds (Shulman & Cauffman, 2014; Willoughby, Good, Adachi, Hamza, & Tavernier, 2014). Moreover, previous studies confirm that decision making among 18- to 22-year olds is significantly influenced by social context (Albert & Steinberg, 2011; Gardner & Steinberg, 2005; Monahan, Steinberg, & Cauffman, 2009). Although individuals in this age range are adults by legal standards, developmental evidence suggests that they are psychologically less mature than adults aged 25 and older (e.g., Steinberg et al., 2008). At the same time, these late adolescents are subject to much less "adult" supervision than younger adolescents and often reside in situations in which they are in close contact with peers (in college, or in the military), which may contribute to their higher rates of many risky behaviors, despite their relatively greater maturity. The combination of these factors—psychological immaturity, peer-rich environments, and adult freedoms—makes late adolescents an important group in which to investigate risky decision making and the influence of peers. Importantly, the current study is part of a broader program of research, funded by the U.S. Army, designed to inform military decisions about how best to group soldiers into combat teams. Accordingly, the sample is limited to late adolescent males, who disproportionately comprise squads sent into battle.

We use a modified version of the Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994) to investigate how the presence of peers affects late adolescents' responses to both positive and negative feedback, as well as their ability to integrate experiences of loss and reward to optimize subsequent performance. The IGT is a widely used measure of affective decision making, which is thought to influence risk behaviors. In the version of the IGT used in this study, participants make play or pass decisions in response to one of four decks (A, B, C, or D) that is pseudorandomly preselected on each trial. As in the original IGT, two of the decks are good and generate long-term gain, while the other two are bad and generate long-term loss. The modified version of the task allowed us to separately quantify the rates at which participants learn to play more from the good decks—an indication of sensitivity to rewarding feedback—and learn to stop playing from the bad decks—an indication of sensitivity to punishing feedback (Cauffman et al., 2010). Moreover, the task allowed us to examine late adolescents' active exploration (via decisions to play rather than pass) of all decks throughout the task. In the study, we investigate whether peer presence affects late adolescent males' (1) tendency to explore relevant environmental cues, (2) ability to learn from the outcomes of that exploration, and (3) ability to integrate positive or negative feedback to adjust behavior toward optimal outcomes.

Although decision making during the IGT is not truly risky—participants are playing with pretend money—the affective and cognitive processes involved in the task are closely related to those involved in real-life risky decision making. The task was initially developed to characterize deficits in decision making in adults with lesions of the mPFC, a brain region implicated in decisions involving the pursuit of reward. People with mPFC lesions perform poorly on the IGT; they persist in pursuing a course that yields large immediate rewards despite suffering larger long-term losses (Bechara, Tranel, & Damasio, 2000). In addition to adults with mPFC damage, people who actually engage in a good deal of risky behavior in life, such as gamblers and substance users, also perform worse on the IGT than other adults (Bechara et al., 1994; Mazas, Finn, & Steinmetz, 2000; Monterosso, Ehrman, Napier, O'Brien, & Childress, 2001; Petry, 2001).

HYPOTHESES

We hypothesized that late adolescent males completing the IGT in a peer group would engage in more exploratory behavior and learn to play from the good decks at a faster rate than those completing the task alone. Because less is known about how peer presence affects late adolescents' sensitivity to punishment, we did not have a strong hypothesis about how peer presence would affect the rate at which participants learned to avoid choices that lead to loss. Regarding the extent to which individuals would integrate experience with reward and loss, we hypothesized that greater reward sensitivity among participants in the peer group would contribute to faster improvements in overall task performance (i.e., net score) compared to participants completing the task alone.

METHOD

Participants

Late adolescent males, ranging from 18- to 22-year-olds, were recruited from local colleges and the general community in a large northeastern U.S. city. Participants were also recruited through the subject pool of the home institution's introductory psychology course. In two prior studies of peer influences on late adolescents' decision making (Gardner & Steinberg, 2005; O'Brien et al., 2011), we compared groups of approximately 50 late adolescents tested alone with 50 tested while observed by peers and found significant group differences with effect sizes of $d = .47$ and $d = .40$, respectively. Although the two prior studies used tasks other than the IGT (a video driving game and a delay discounting task, respectively) and involved two peer observers (rather than three, as is the case in this study), we based our decision in this study to compare two groups of 50 participants each on this prior research. (With an expected effect size of .40, a total sample of 100 provides more than adequate power (.99) to detect a significant effect at $p < .05$.) Analysis for the current study is based on a sample of 101 subjects who completed the IGT either alone ($n = 50$) or in a peer group (i.e., with three late adolescent male peer observers; $n = 51$). Sample recruitment was halted once a predetermined minimum of 50 subjects per experimental group were tested.

Procedure

Manipulation of social context. Flyers advertising a study of decision making invited males between the ages of 18 and 22 to call our research office to learn more about participating in the research. Each caller was told that the study could accommodate up to five people at a time and was asked whether he had any friends (other males between 18 and 22) who might be interested in participating. If a participant referred a friend to the study, our research team communicated directly with that individual to confirm his eligibility. Five participants, some of whom were friends and some strangers, were independently scheduled to participate at a set time, but none was informed that he might participate as a member of a group.

When participants arrived in the laboratory, four of them were randomly assigned to the peer condition and one was randomly assigned to participate alone. Participants in each condition were escorted to separate rooms and instructed about the study. In the peer condition, one participant was randomly selected to take the test battery, which included several tasks, including the IGT, while the other three observed. (Only findings from the IGT are presented in this article.) Study compensation for the player and the observers was $35 per person (or 2.5 research credits for those in the subject pool). In addition to this baseline compensation, all participants were informed that they could win a $15 bonus contingent on the performance of the person completing the task. All participants in the alone condition received the same information regarding compensation. Similar to previous studies,

this strategy was used to increase motivation to perform well (Cauffman et al., 2010). In reality, all participants received both the baseline and bonus compensation.

After verbal consent and random selection of a target participant, all subjects in the peer condition were left in the room for approximately 10 min to permit the group to interact naturally. Within peer groups, 37% (n = 19) of the target participants did not know anyone else in the group, while the rest knew at least one person. IGT performance among peer group participants did not differ as a function of how many peers they knew prior to the study. All procedures were approved by the university's institutional review board as well as that of the U.S. Army (the funding agency).

Measures

Demographics. Participants reported their age, race/ethnicity, and education. Educational attainment was used as a proxy for socioeconomic status. Participants in each condition (alone, peer group) did not differ on any demographic variables (Table 1). Ninety-one percent of subjects were current college students. The mean age for the sample was 19.8 years (SD = 1.25). Sixty-seven percent of the sample was White, 12% Black/African American, 15% Asian/Pacific Islander, 4% Latino, and 2% other/mixed race.

Modified Iowa Gambling Task. As previously mentioned, we used a modified version of the task, in which participants make play or pass decisions on one of the four decks that are pseudorandomly preselected on each trial. As in the original IGT, two of the decks (C and D) are advantageous, generating modest immediate rewards and relatively small losses, and ultimately resulting in long-term monetary gains over repeated play. The other two decks (A and B) are disadvantageous, generating larger immediate rewards but large losses, and resulting in long-term loss over repeated play. In addition, within each type of deck (advantageous vs. disadvantageous), there is one deck in which the losses are infrequent but relatively large (e.g., −$1,150 and −$200 for the disadvantageous and advantageous decks, respectively), and one in which they are consistent and relatively small (e.g., −$250 and −$25 for the disadvantageous and advantageous decks, respectively); see Cauffman et al. (2010) for a complete description of the deck characteristics.

TABLE 1
Demographic Characteristics of the Study Sample by Social Condition

	Social Condition	
	Alone n = 50	*Peer* n = 51
Age, M (SD)	19.67 (1.29)	19.94 (1.20)
Race/Ethnicity, %		
White	64.7	70.0
African American	15.7	8.0
Asian	11.8	18.0
Hispanic	3.9	4.0
Other	3.9	0
Socioeconomic status, M (SD)[a]	12.94 (0.24)	12.94 (0.31)

[a]Educational attainment was used as a proxy for socioeconomic status, where 13 = *some college* (including current college students).

The payoff schedules for each deck reflected the net outcomes of the original IGT. In the original IGT, but not the version used in this study, every card in each of the decks bore an amount indicating a specific gain (e.g., $50 or $100, for good and bad decks, respectively), paired with a varying loss amount (e.g., −$250). In this study, we modified the outcome feedback, such that participants received information on the *net* gain or loss associated with each card, rather than information on both the gain and the loss separately (Bechara et al., 1994). For example, if in the original IGT the choice of Deck A produced a card indicating a simultaneous $100 gain and $250 loss, the outcome shown in our modified version of the task would be a $150 loss. This modification removes a heuristic for distinguishing between the good and bad decks, which makes the task more difficult and may encourage greater reliance on emotional cues (rather than explicit memory) to guide behavior. It also removes any advantage due to greater mathematical skill. Finally, this modification also prevents participants from unequally attending to the rewards or punishments, and instead encourages them to focus on the overall gain or loss for a given card.

Each subject starts the task with $2,000 (of pretend money) and is instructed that his goal is to win as much money as possible. Participants are told that there are good decks and bad decks in the task and that they will earn the most money by learning to play more from the good decks while avoiding the bad ones. On each trial, the computer selects a card from one of the four decks and participants are given 4 s to decide to either *play* the

card (revealing the monetary win or loss) or *pass* (in which case no feedback is provided). Subjects played a total of 120 trials, which were divided into six blocks of 20 trials each.

Iowa Gambling Task performance was operationalized in three ways: (1) percentage of good plays was calculated as the proportion of times a person decided to play (rather than pass) when presented with advantageous decks on a given block; (2) percentage of bad plays was calculated as the proportion of times a person decided to play when presented with disadvantageous decks on each task block; (3) net score was calculated as the difference between percentage of good and bad plays, with the latter being subtracted from the former.

Statistical Analysis

Latent linear growth models were fitted using the maximum likelihood estimation method in Mplus (version 7.0; Muthén & Muthén, 2012) to examine the rates at which participants (1) played, rather than passed, summed across all decks; (2) learned to play from the good decks; (3) learned to avoid the bad decks; and (4) integrated reward and loss experience to optimize net score, as well as (5) to determine whether the presence of peers affected these rates. Time (Blocks 1 through 6) was used as the repeated measure to determine the extent to which participants changed their behavior over the course of the task. Social context (alone, peer group) was specified as a between-subjects variable to explain variation in rates of change for percentage of plays (rather than passes), plays from advantageous decks, plays from disadvantageous decks, and net score.

We conceptualized playing, rather than passing, as an index of exploratory behavior, especially during the early blocks of the task, when participants have not yet learned which decks are good and which are bad. As in Cauffman et al. (2010), the rate of change across the task (i.e., slope) in percentage of good plays served as a measure of reward sensitivity, with more steeply positive slopes indicating increasing attraction to rewarding decks and quicker detection of which decks result in monetary gains over repeated play. The rate of change in percentage of bad plays across the task served as a measure of cost sensitivity, with more steeply negative slopes indicating greater sensitivity to losses produced by the disadvantageous decks. Net score was conceptualized as a measure of overall IGT performance that integrates sensitivity to gains and losses, with steeper positive slopes indicating faster improvements in task performance.

RESULTS

Exploratory Behavior

We first examined participants' overall tendency to play (rather than pass) during each task block, summing across deck types. A repeated measures analysis of variance was conducted with social context as a between-subjects variable and time as a within-subject variable. There was a main effect of time on overall decisions to play, F (5, 495) = 11.36, $p < .001$; as the task progressed, the percentage of decisions to play (rather than pass) decreased, with a linear trend, F (1, 99) = 20.71, $p < .001$. There was no main effect of social context, F (1, 99) = 2.68, $p > .05$. The interaction between social context and time was marginally significant, F (1, 99) = 3.84, $p = .053$. We conducted independent samples t-tests to assess the influence of social context on decisions to play at each block. Overall percentage of decisions to play (rather than pass) was significantly greater in the peer condition during Blocks 1 and 2, t (99) = −2.41, $p < .05$ and t (99) = −2.30, $p < .05$, respectively (Figure 1).

Learning From Experience

Because we were interested in individual differences in performance at the end rather than at the beginning of the task, time was centered on Block 6 in the initial latent linear growth model. As a consequence, the estimated intercepts in the models correspond to predicted level of performance (in terms of good plays, bad plays, and net score) during the last task block.

Reward sensitivity. With respect to plays from good decks, the model indicated that social context

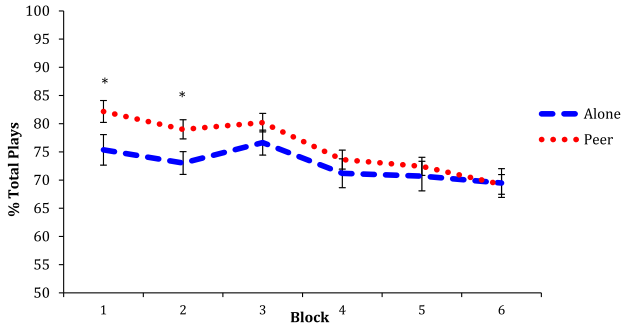

FIGURE 1 Total percentage of plays across time by social condition. *$p < .05$.

had a significant effect on the intercept (β = 9.97, *SE* = 3.32, $p < .01$); at Block 6, participants in the peer condition made a greater percentage of good plays compared to those in the alone condition. The average slope for both groups combined was positive and marginally significant (β = 1.14, *SE* = 0.59, $p = .05$), indicating that participants learned to increase their percentage of plays from good decks over time. The rate of learning to play from rewarding decks did not differ by social context, however (β = 0.64, *SE* = 0.83, $p = .437$).

Because, as noted above, individuals in the peer condition were playing at an especially high rate from the beginning of the task, we further sought to examine whether there was a potential ceiling effect with respect to sensitivity to rewarding decks for participants in the peer condition. Accordingly, we reran the model with the intercept set at Block 1 and found that participants in the peer group were indeed more likely than solo participants to play from advantageous decks in the first task block (β = 6.77, *SE* = 3.38, $p < .05$). Moreover, this model also revealed a negative and significant correlation between the initial percentage of good plays and rate of change. Thus, the heightened inclination to play from the advantageous cards during Block 1 may have created a ceiling effect for peer group participants, potentially limiting the rate of learning these participants could demonstrate by increasingly playing from rewarding decks as the task progressed.

To address this limitation, we reran the model to estimate the rate of change in advantageous plays from Block 2 through Block 6, controlling for the percentage of good plays on Block 1. Doing so improved overall model fit, and showed that, with initial play rate held constant, participants in the peer condition learned to shift behavior toward the advantageous decks at a faster rate than participants completing the task alone (β = 1.69, *SE* = 2.91, $p < .05$; Figure 2). The percentage of good plays during Block 1 had an independent effect on the reward-learning slope, indicating that making more good plays at the beginning of the task reduced the rate of learning from advantageous decks (β = −0.07, *SE* = 0.02, $p < .001$). There was no significant interaction between social context and good plays during Block 1 in the prediction of rate of learning.

Cost sensitivity. Next, we estimated the rates at which participants learned to avoid the bad decks. Being in a peer group was associated with a lower percentage of bad plays during Block 6 (β = −10.80, *SE* = 5.21, $p < .05$). Social context also had a significant effect on the slope, (β = −3.39, *SE* = 1.23, $p < .01$), with peer group participants quicker to respond to experiences of loss and reducing their percentage of plays from disadvantageous decks at a faster rate than solo participants (Figure 3).

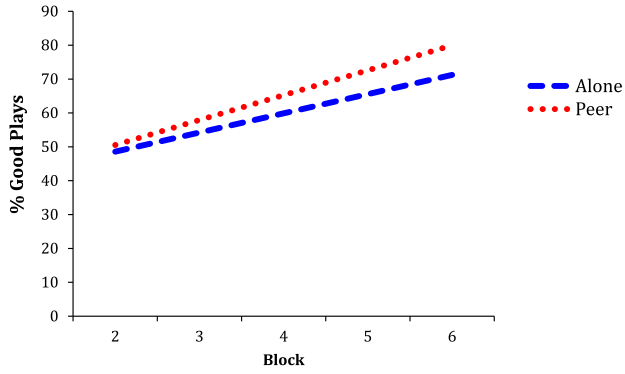

FIGURE 2 Percentage of plays from good decks across time by social condition.
Note. Results control for percentage of plays from good decks during Block 1.

To examine whether social context had a significant effect on the initial percentage of plays from the disadvantageous decks, we reran the model with the intercept set at Block 1, as we did in our analysis of plays from good decks. The model showed that during the initial task block participants in the peer groups also made a greater percentage of bad plays than participants who were alone (β = 6.26, *SE* = 2.67, $p < .05$), consistent with the higher overall level of exploratory behavior evinced by participants in the peer condition. However, the overall correlation between intercept and slope, across both social contexts, was nonsignificant, meaning that participants' initial level of attraction to the disadvantageous decks (at the start

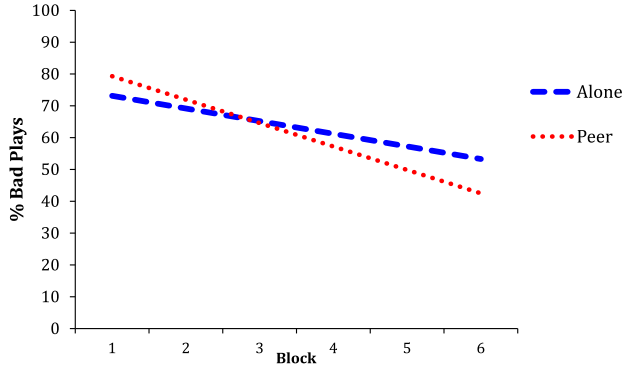

FIGURE 3 Percentage of plays from bad decks across time by social condition.

of the game) was unrelated to the rate at which they adjusted their choices in response to negative feedback over the course of the task.

Net score. Finally, overall IGT performance was examined in terms of participants' net score, which is a measure of performance that integrates sensitivity to gains and losses. For this measure, the intercept reflects the overall performance during Block 6, whereas the slope reflects the rate of improvement in overall performance over the course of the task. The model indicated a positive and significant rate of change in net score ($\beta = 5.96$, $SE = 1.00$, $p < .001$), indicating that all participants improved performance as the task progressed. However, social context had a significant effect on the rate of change ($\beta = 3.67$, $SE = 1.39$, $p < .01$), with participants in peer groups evincing faster rates of improvement in task performance over time (Figure 4). As a consequence, by the end of the task, participants in the peer condition had a higher net score than those in the alone condition ($\beta = 20.53$, $SE = 6.29$, $p < .001$).

Results of the relevant statistical analyses are summarized in Table 2.

DISCUSSION

If some level of risk taking in adolescence is inevitable, as has been argued (e.g., Steinberg, 2008), it is presumably through a process of exploration and learning, via trial and error, that late adolescents are able to eventually shift their behavior toward more prudent choices. The ability to learn from the consequences of past actions is particularly vital for young people, who, in search of novelty and opportunities for reward, often find themselves in new and unpredictable situations, often in group settings. The present study shows that the presence of peers increases the extent to which late adolescents learn from both positive and negative experience.

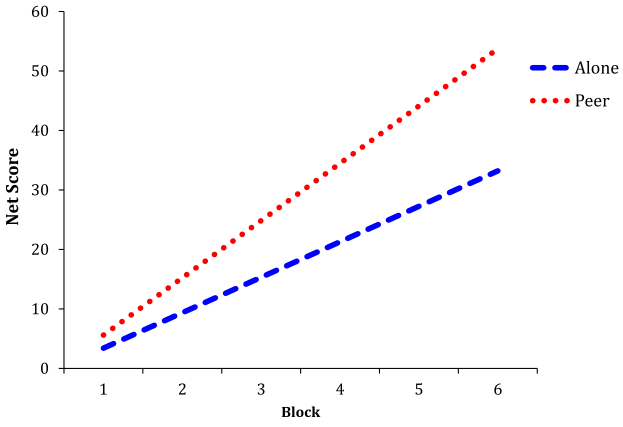

FIGURE 4 Net score across time by social condition.

Prior behavioral and neuroimaging studies have indicated that the presence of peers increases adolescents' sensitivity to the potential rewards of risky decisions (Chein et al., 2011; Gardner & Steinberg, 2005; Smith, Chein, & Steinberg, 2014; Smith, Steinberg, et al., 2015). The current study was designed to extend this previous research by examining whether the presence of peers specifically affects late adolescents' sensitivity to rewards or whether it enhances late adolescents' sensitivity to feedback more generally (both rewards and punishments). We also aimed to investigate whether social context affects the rate at which late adolescents learn to integrate experiences of reward and loss to guide decision making.

The modified version of the IGT employed in the present study afforded us the opportunity to examine exploratory behavior, by seeing how often participants sought to obtain information about the potential rewards and costs of alternative choices, by choosing to play rather than pass when given the opportunity to draw a card. Being in a peer group was associated with late adolescents' greater tendency to explore the environment, such that they made decisions to play much more frequently than solo participants during the initial blocks of the task, when they lacked information about each deck's payoff schedule. Participants in peer groups were not only more inclined than solo participants to explore the opportunities before them, but were also more responsive to feedback, even in the earliest stages of the task. It is important that the presence of peers increased both the rate at which participants shifted behavior toward making more plays from advantageous decks and the rate at which they came to avoid the disadvantageous ones. Thus, when in a peer group, late adolescents are quicker to learn which choices lead to rewards and which ones have costs. Notably, optimal decision making in the IGT requires individuals to rely on emotional cues (Bechara, Tranel, Damasio, & Damasio, 1996). Also, subjects have been found to display a preference for good decks over bad decks before they are consciously aware of which decks are good or bad (Bechara, Damasio, Tranel, & Damasio, 1997). The fact that, in our study, subjects in the peer condition performed better on the IGT therefore suggests that peer presence can affect decision making processes of which the subject is not even aware.

Our decision to make the peer observers' compensation contingent on the target adolescent's performance stemmed both from a desire to increase

TABLE 2
Unstandardized Coefficient Estimates for Models Predicting Change in Good Plays, Plays, and Net Score as a Function of Social Condition

	Good Plays		*Bad Plays*		*Net Score*	
	β	*SE*	*β*	*SE*	*β*	*SE*
Intercept (Block 6)	71.06***	6.37	53.28***	3.71	33.21***	4.49
Peer condition	8.72**	3.36	−10.80*	5.21	20.53***	6.29
Good plays on BL1	0.19*	0.08	—	—	—	—
Rate of change	5.74***	1.58	−3.97***	0.88	5.96***	1.00
Peer condition	1.69*	2.91	−3.39**	1.23	3.67**	1.39
Good plays on BL1	−0.07***	0.02	—	—	—	—
Variance components						
In intercept	234.49***	37.65	553.70***	97.09	841.37***	141.74
In rate of change	7.91**	2.75	25.74***	5.67	33.54***	7.12
Covariance	37.31***	8.56	110.86***	22.01	158.25***	29.91
Model fit statistics						
BIC	4004.50		5302.539		5540.58	
Chi-square (*df*)	41.51*** (16)		38.10** (20)		42.19** (20)	
RMSEA (90% CI)	0.13** (0.08, 0.17)		0.10 (0.05, 0.14)		0.11* (0.06, 0.15)	
CFI	0.93		0.88		0.88	
R^2 intercept	0.15		0.05		0.11	
R^2 rate of change	0.23		0.10		0.09	

Note. BL1 = Block 1; BIC = Bayesian information criterion; RMSEA = root mean square error of approximation; CI = confidence interval; CFI = comparative fit index. $N = 101$.
*$p < .05$; **$p < .01$; ***$p < .001$.

the salience of the peer context and to better mimic experiences in the real world, where adolescents' choices in groups often affect the welfare of their peers (e.g., when driving with passengers). We cannot rule out the possibility that the presence of peers increased late adolescents' rate of learning in the present study simply because their choices affected the amount of money that both they and their observers would earn—that is, adolescents' learning was faster in the group context because the stakes were in fact higher. (We note, however, that studies of adolescents in group settings using rodent models have found that peers have a greater influence on the behavior of juvenile than adult animals (Spear, 2009).) This may have motivated participants in peer groups to be more sensitive to both negative as well as positive cues in the IGT. Future studies using this paradigm might vary the extent to which participants' performance affects their observers' compensation in order to examine this issue further.

One limitation of the present study is that results are based on males and may not be generalizable to females, especially in light of evidence suggesting that males may be relatively more susceptible to peer influence (Gardner & Steinberg, 2005; Steinberg & Monahan, 2007; Sumter, Bokhorst, Steinberg, & Westenberg, 2009). Another limitation of our findings is that they are based on older adolescents, between 18 and 22 years old. It is possible that the presence of peers would evoke different patterns of outcome sensitivity, and overall IGT performance, at different ages, although previous studies have found an even stronger peer effect on risk taking in middle adolescence (e.g., Gardner & Steinberg, 2005). Lastly, relative to national race estimates in the United States, our study sample included a high percentage of Asian Americans and low percentage of Hispanics. This demographic profile is likely because the majority of our sample were college students, and U.S. college enrollment rates are highest for Asians and lowest for Hispanics. Thus, our findings may only be generalizable to college students (who comprise approximately two-thirds of all late adolescents in the United States).

Identifying the mechanisms through which peer presence heightens late adolescents' sensitivity to feedback is beyond the scope of this study, and a limitation that should be the subject of future work in this area. One possibility consistent with our results is that the presence of peers may enhance late adolescents' ability to learn from both rewarding and punishing events in a way that shifts behavior toward the most desirable long-term outcome. One way to interpret these findings is through an evolutionary lens; it would be adaptive for individuals to be as responsive to threatening events as they are to

rewarding ones in order to increase their chances of survival. An important implication of this study is that behavior in peer groups that we and others have interpreted as reflecting a peer effect on reward sensitivity may be more properly characterized as an effect on "outcome sensitivity." Although late adolescents may engage in relatively more risky behavior when they are with their peers, they also may learn more about the environment in group settings than when they are alone. In this regard, our findings suggest that spending time with peers during adolescence may be a double-edged sword, increasing the odds that adolescents will behave recklessly, but also that they will learn from the consequences of their actions.

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Background

- Adolescents are more likely to take risks when they are with friends than when they are alone
- This is evident even when adolescents know that the possibility of adverse outcomes is quite high
- We know that peers make adolescents more sensitive to potential rewards, but it is unclear how peers affect adolescents' sensitivity to potential costs
- If some level of risk-taking in adolescence is inevitable, it is presumably through a process of exploration and trial-and-error learning that youth are able to eventually shift their behavior toward more prudent choices

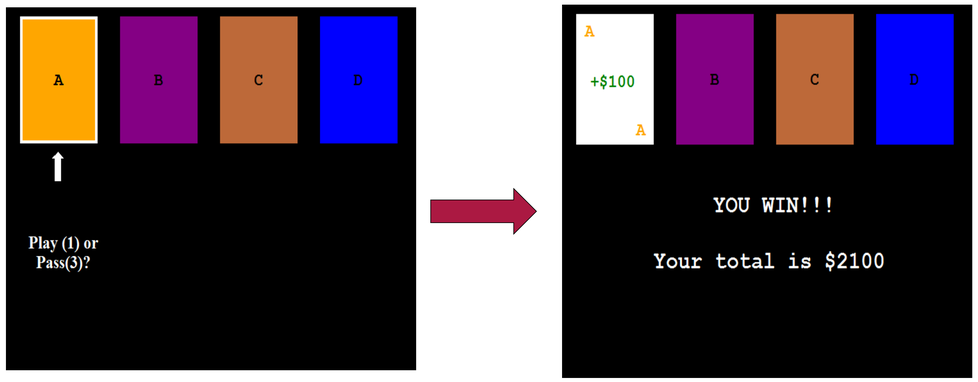
Present Experiment

- We use a modified version of the Iowa Gambling Task to investigate whether peer presence affects late adolescent males' (ages 18 to 22):
  - ✧ Tendency to explore opportunities for potential reward
  - ✧ Ability to learn from the outcomes of that exploration
  - ✧ Ability to integrate positive and negative feedback to adjust behavior toward optimal performance

Social Context Manipulation

- Participants were randomly assigned to one of two conditions:
  - ***1. Solo)***: 50 subjects were tested alone
  - ***2. Peer group***: 50 subjects were tested in the presence of 3 same-sex, similar-age peers

Modified Iowa Gambling Task



Four decks of cards:

- **Two were advantageous/good (lead to long-term gain)**
- **Two were disadvantageous/bad (lead to long-term loss)**

Participants played 120 trials, which were analyzed in blocks of 20 trials each.

Analysis

Latent linear growth models to examine the rates at which participants:

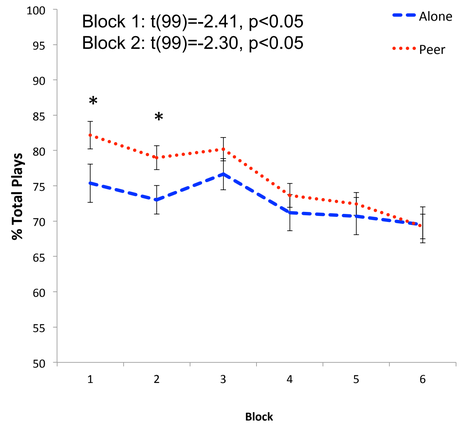
1. Played, rather than passed, summed across both good and bad decks
2. Responded to positive feedback and learned to play more from the good decks over time
3. Responded to negative feedback and learned to avoid the bad decks over time
4. Learned to integrate reward and loss experience, over time, to optimize *net score* (% good plays minus % bad plays)

Time (as Blocks 1 through 6) was used as the repeated measure to measure the extent to which participants changed their behavior over the course of the task.

Social context (alone vs. peer group) was used as the between-subjects factor to explain variation in rates of behavior change.

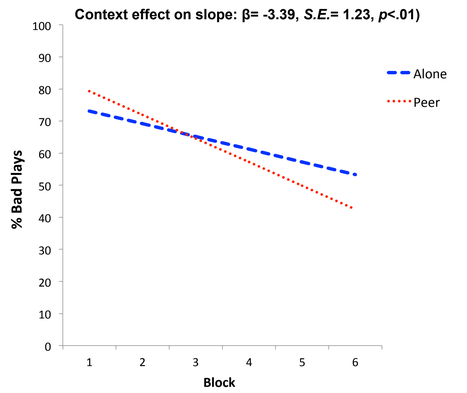
Exploratory Behavior

Total Percentage of Plays(across both good and bad decks) over Time by Social Context



Negative Feedback

Percentage of Plays from Bad Decks over Time by Social Context



Discussion

- Peer presence was associated
  greater tendency to explore o
- In a peer group, late adolesce
  learn from the consequences
  behavior to optimize perform
- Although young males may er
  behavior with peers, they ma
  environment in group setting
  alone.

Acknowledgements: This research was funded by U.S.

Group Influences on Young Adult Warfighters' Risk-Taking

MOMR Initiative on Warfighter Judgment and Decision Making

PI: Laurence Steinberg, Ph.D. **Org:** Temple University **Award Amount:** $529,147

Study Aims and Approach

• **Problem**: Need to identify factors that increase or decrease young adult warfighters' risky decision-making when in groups.

•**Hypothesis**: Young adults' tendency to make risky decisions when with their peers is exacerbated by fatigue and/or stress, but mitigated when an older adult is a member of the group or when individuals receive training designed to strengthen cognitive regulation abilities.

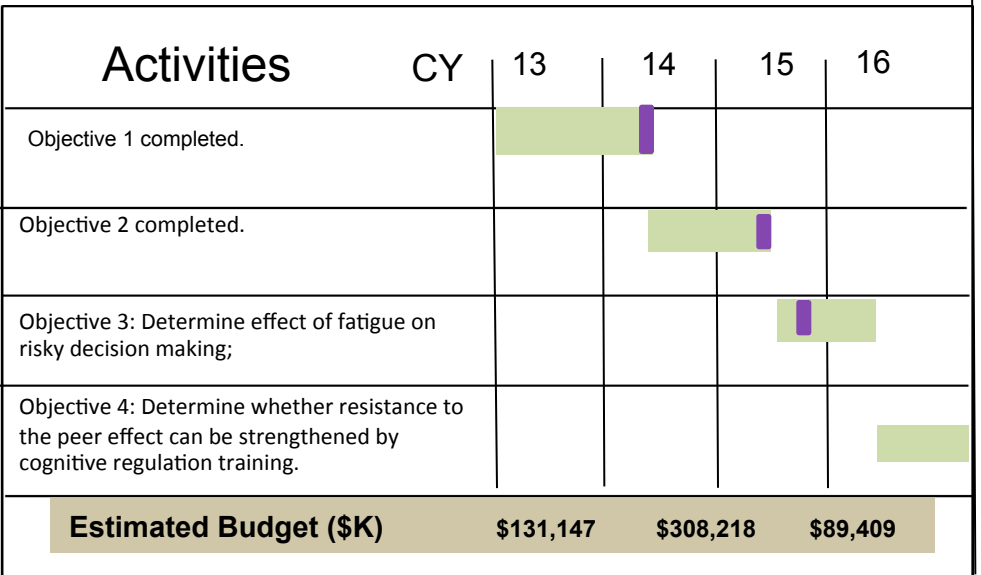
•**Objective 1**: To identify the parameters of decision-making situations that are most likely to lead fireteams composed of four young adults (18- to 22-year-olds) to make unnecessarily risky decisions in the presence of peers.

•**Objective 2:** To determine whether the inclusion of one relatively older individual (25-to-30 years old) within a 4-man fireteam mitigates the peer effect on risky decision-making.

•**Objective 3:** To determine whether cognitive fatigue exacerbates peer effect.

•**Objective 4:** To determine whether cognitive training, known to strengthen capacities that contribute to deliberative decision-making, can make young adults less susceptible to the peer effect on risky decision-making.

Timeline and Total Cost



Accomplishments: Objectives 1 & 2 have been completed. Two publications have emanated from this research.

Objectives and Progress:

- **Objective 3: Examine whether the effect of fatigue on risky decision making exacerbates the peer effect (in progress). Target sample is 200, and we have enrolled 64 participants, thus we are about 32% through this experiment.**
- **Objective 4: Determine impact of cognitive training (thought to enhance capacities associated with deliberative decision-making) on the relative susceptibility to the peer effect. Anticipated to start March 2016.**

Updated: November 25, 2015