Motivation Science
2016, Vol. 2, No. 3, 157–170

2333-8113/16/$12.00 http://dx.doi.org/10.1037/mot0000038

The Opposing Processes Model of Competition: Elucidating the Effects of Competition on Risk-Taking

Emily J. Hangen, Andrew J. Elliot, and Jeremy P. Jamieson
University of Rochester

This research examined opposing motivational processes produced by competition in vivo. Participants ($N = 115$) were randomly assigned to competition or no competition conditions, and completed a risk behavior measure (the Columbia Card Task). Cardiovascular responses were monitored during performance to assess challenge (approach-motivated) and threat (avoidance-motivated) states. Competition participants exhibited more sympathetic arousal than controls, but no main effects of competition emerged for the motivationally tuned cardiovascular measures or risk outcomes. Instead, consistent with the opposing processes model, within the competition condition some participants were approach-oriented (as indicated by challenge-type physiological responses), whereas others were avoidance-oriented (as indicated by threat-type physiological responses). Moreover, participants who exhibited a challenge pattern of physiology reactivity were more risk-seeking than participants who exhibited a threat pattern of reactivity. Findings are discussed in the context of existing work on competition and risk, and the opposing processes model of competition.

Keywords: competition, psychophysiology, motivation, risk, opposing processes

Supplemental materials: http://dx.doi.org/10.1037/mot0000038.supp

Competition is ubiquitous. We regularly compete with one another in academics, sports, and the workplace; additionally, normative standards pervade social, economic, and political systems. Given the ubiquity of competition, a critical question becomes, "What influence does competition have on behavior?" In the present study, we seek to elucidate how competition may lead people to increase or decrease risk behavior. Specifically, we utilize the *opposing processes model of competition* (Murayama & Elliot, 2012) to elucidate how approach and avoidance motivation are integral to explaining links between competition and risk.

Emily J. Hangen, Andrew J. Elliot, and Jeremy P. Jamieson, Clinical and Social Sciences in Psychology, University of Rochester.

This research was supported by a National Science Foundation (NSF) graduate research fellowship (NSF GRFP DGE 1419118) awarded to Emily J. Hangen and an NSF research grant Award to Jeremy P. Jamieson (HRD 1420063).

Correspondence concerning this article should be addressed to Emily J. Hangen, Clinical and Social Sciences in Psychology, University of Rochester, 403 Meliora Hall, Rochester, NY 14627. E-mail: emily.hangen@rochester.edu

Competition and Risk-Taking

Risk-taking can be defined as choosing an option with a range of possible gain-loss outcomes (Figner & Weber, 2011). That is, "riskier" decisions include the potential for substantial gain and substantial loss, whereas more "cautious" decisions include a smaller range of possible outcomes. In the present research we focus on how interpersonal competition shapes risk decisions.

Despite the importance of risk in competitive contexts, the empirical literature on competition and risk-taking is underdeveloped. A direct positive relation between competition and risk is found in a few instances (e.g., Ku, Malhotra, & Murnighan, 2005; Mowen, 2004;), but overall, research has yielded mixed results (e.g., Fischer, Kubitzki, Guter, & Frey, 2007; Kühberger & Perner, 2003; Stankovic, Fairchild, Aitken, & Clark, 2014; Veliz, Boyd, & McCabe, 2015). In fact, most research assumes a null direct relation, opting to focus instead on factors within competitive situations that increase/decrease risk-taking (Kräkel & Sliwka, 2004; Mishra, Barclay, & Lalumière, 2014; Nieken & Sliwka, 2010; Seel & Strack, 2013).

Mixed findings regarding competition and risk are akin to those observed for competition and performance: Some researchers posit positive effects of competition on performance (Locke, 1968; McClelland, 1961; Parker, 1998; Shields & Bredemeier, 2009; Smith, 1776/1937), and others posit negative effects (Deci & Ryan, 1985; Hobbes, 1651/1994; Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Kohn, 1986; Maehr & Midgley, 1991). Recently, Murayama and Elliot (2012) posited the *opposing processes (OP) model of competition and performance*, which shows that both perspectives have merit. This model states that competition facilitates performance if it evokes approach goals ("trying to do better than others"), but impairs performance if it evokes avoidance goals ("trying to avoid doing worse than others"; Elliot & Church, 1997; Hulleman, Schrager, Bodmann, & Harackiewicz, 2010; Van Yperen, Blaga, & Postmes, 2014). If the effects of the opposing approach and avoidance processes are examined together, rather than separately, this would manifest as an overall null effect in comparisons of competition versus no competition. Thus, a clear analysis of the influence of competition on outcomes requires examining approach and avoidance processes separately.

Using Murayama and Elliot's (2012) OP model, we posit that within the same competitive situation some individuals will be approach motivated, while others will be avoidance motivated, leading to different effects on risk behavior. Rather than relying on prospective or retrospective reports of approach/avoidance, which are subject to biases (Stone et al., 2000) and cannot assess motivational processes *during* competition, we monitored competitors' physiological responses in vivo as specified by the *biopsychosocial (BPS) model of challenge and threat* to gain insights into approach/avoidance motivation.

Competition and the BPS Model of Challenge and Threat

Competition is inherently stressful: Individuals must actively address task demands by marshaling resources, which activates biological stress systems (for a review see Gutnick, Walter, Nijstad, & De Dreu, 2012). The specific acute stress responses, however, depend largely on cognitive appraisal processes (e.g., Jamieson, Mendes, & Nock, 2013).

Challenge and threat responses have been tied to approach and avoidance motivated affective states, respectively (e.g., Beltzer, Nock, Peters, & Jamieson, 2014; Jamieson & Mendes, 2016; Jamieson, Nock, & Mendes, 2013; Jamieson, Valdesolo, & Peters, 2014). Individuals experience approach-motivated challenge states when appraisals of coping resources exceed perceived situational demands. Alternatively, avoidance-motivated threat states manifest when perceived demands exceed resources. Physiologically, both challenge and threat states are accompanied by increases in sympathetic arousal. Challenge states activate the sympathetic–adrenal–medullary (SAM) axis, and downstream lead to increased cardiac efficiency and dilation of the vasculature. On the other hand, threat is associated with relatively greater activation of the hypothalamus–pituitary–adrenal (HPA) axis—the end product of which is cortisol— and is associated with decreased cardiac efficiency, and increased vascular resistance downstream (see Seery, 2011, for a review).

The extant competition research that included physiological measures has focused on the influence of competition on nonspecific measures of arousal (e.g., heart rate, blood pressure, preejection period [PEP]). These studies demonstrate that competitive situations, indeed, increase arousal (Cooke, Kavussanu, McIntyre, Boardley, & Ring, 2011; Matsumura, Yamakoshi, Yamakoshi, & Rolfe, 2011; Wittchen, Krimmel, Kohler, & Hertel, 2013). Assessing opposing approach and avoidance processes online, however, requires measuring motivationally tuned physiological responses. Only a few studies, however, have manipulated competition and measured challenge (approach) and threat (avoidance) physiological indicators (Harrison et al., 2001; Veldhuijzen van Zanten et al., 2002). These studies suggested that competition elicits responses consistent with challenge *and* threat (a central premise of the OP model). However, extant research relied on small sample sizes (total Ns ≤ 36) and assessed performance on physical/motor tasks. Other research has manipulated variants of competition and measured physiological responding (Moore, Wilson, Vine, Coussens, & Freeman, 2013) or measured physiological responding in competition contexts (Turner, Jones, Sheffield, & Cross, 2012; Turner et al., 2013). These studies likewise indicated that competition elicits responses consistent with challenge *and* threat.

Current Research

Little research has examined even basic associations between challenge/threat responses and risk-taking outside competitive contexts (for exceptions see Frings, Rycroft, Allen, & Fenn, 2014; Jamieson, Koslov, Nock, & Mendes, 2013; Jamieson & Mendes, 2016). In those contexts, approach-motivated challenge responses increased risk taking relative to threat in adults. Building on the extant literature, we hypothesized that physiological responses indicative of challenge would increase risk in an interpersonal competition context relative to threat. This is the first study to investigate the influence of challenge and threat states during competition on risk-taking.

The current research focused on interpersonal competitive situations because this type of competition has received the vast majority of theoretical and empirical attention (Murayama & Elliot, 2012). Interpersonal competition is defined as situations where two or more people vie for a mutually exclusive outcome (Johnson & Johnson, 1989).

First, we anticipated no overall, direct relation between competition and risk-taking. The opposing processes (i.e., challenge/threat states) exhibited across participants were presumed to cancel each other out when combined in main effect analyses, producing an overall null direct relation. That is, we predicted that competition would elicit opposing *types* of challenge/threat responses *across individuals*. Thus, a greater number of competition participants, relative to controls, were hypothesized to meet physiological classifications for challenge (i.e., approach) *and* threat (i.e., avoidance). Moreover, we predicted that individuals exhibiting approach-oriented challenge responses would exhibit increased risk relative to threatened participants (see also Jamieson, Koslov, et al., 2013; Jamieson & Mendes, 2016).

Method

Participants

One hundred and 15 undergraduate students (59% female; 50 White/Caucasian, 21 Asian, 15 Black/African American, 29 other/not reported) were recruited to participate and compensated with two credit hours. We determined a priori that data collection would run for two consecutive academic semesters.

Procedure

Upon arrival, participants met another same-sex student (a confederate) waiting to complete the same study. An experimenter greeted both and brought each to separate testing rooms. After completing intake questionnaires, autonomic sensors were affixed. Participants then sat alone for a 5-min baseline recording.

After baseline, participants and confederates were brought together for a “get-to-know-you” exercise. The pair completed an abbreviated (5-min) *Fast Friends* task (Page-Gould, Mendoza-Denton, & Tropp, 2008). Confederates provided scripted answers during this interaction. The interaction served two purposes: 1) it enhanced the cover story that two participants were completing the study, and 2) it reduced the possibility that potential competition effects would stem from the confederate’s idiosyncrasies.

Participants were then separated and randomly assigned to one of two conditions. *Competition* participants were told they would be competing on a card game against the person they just met and *no-competition* control participants were asked to try their best on a game we were pilot testing, implying the task was unrelated to the prior social interaction (see supplementary materials for full manipulation materials).

Participants completed a brief pretask questionnaire (see supplementary materials), were refreshed on task instructions, and given 15-min to complete 50 trials of the card game. They were instructed that they could not “finish early” and would need to remain in the room for the full 15-min (to discourage them from rushing through the task). After completing the task, participants’ sensors were removed and they were debriefed.

Physiological Measures

The following signals were collected at baseline and during the competition: Electrocardiography (ECG), impedance cardiography (ICG) with band sensors, and blood pressure (BP).

ECG and ICG signals were collected at 1000 Hz, and integrated with a MP150 system (Biopac Systems Inc., Goleta, CA). BP readings were obtained from the brachial artery on the nondominant arm using a Colin7000 ambulatory medical system (Colin Medical Instruments, San Antonio, TX). Recordings were taken at 2-min intervals during each epoch (baseline, task) and initiated by an experimenter in a "control room" separate from testing rooms.

ECG and ICG signals were visually examined for artifacts, and the ensemble averages were analyzed using Mindware software (IMP v3.0.21; Mindware Technologies, Gahanna, OH). One-minute segment times were analyzed. Trained coders visually examined all B, Q, and R points and corrected erroneous placements (<5% of points).

Analyses focused on PEP—a measure of sympathetic arousal—and cardiac output (CO) and total peripheral resistance (TPR). Together, this set of responses distinguishes approach-motivated challenge and avoidance-motivated threat states (e.g., Jamieson, Mendes, & Nock, 2013). PEP indexes the contractile force of the heart by measuring the time from the initiation of left ventricle contraction to aortic valve opening. Greater sympathetic activation is indicated by shorter PEP intervals. CO is the amount of blood ejected from the heart during one minute. An increase in CO indicates improved cardiac efficiency and is typically observed in challenge states, whereas a decrease (or little change) in CO is suggestive of threat. TPR is a measure of overall vascular resistance. When threatened, vascular resistance increases, limiting blood flow to the periphery and producing high TPR scores. On the other hand, vasodilation (i.e., reduced TPR) accompanies challenge states so as to facilitate delivery of oxygenated blood to the brain and periphery. TPR was calculated with the following validated formula: TPR = (mean arterial pressure/CO) * 80 (Sherwood et al., 1990).

Risk Behavior

Participants completed the "hot" version of the Columbia Card Task (CCT), which is sensitive to affective-motivational processes (Figner, Mackinlay, Wilkening, & Weber, 2009; Jamieson, Koslov, et al., 2013). For each trial, participants were shown 32 cards "face down" (see Figure 1). Participants' goal was to earn the highest number of points possible by selecting "win" cards. Selected cards were "turned over" and indicated whether a card was a "win" or a "loss." Participants were free to choose as many cards as they liked, but if they chose a loss card, the "loss amount" was subtracted from their score on that trial and the trial ended. To retain points earned, participants could voluntarily terminate trials at any time before a loss card was selected. The point value of win cards (10 or 30), number of loss cards present (1 or 3), and negative point value of loss cards (−250 or −750) were displayed onscreen and independently randomized from trial-to-trial. Participants completed 50 CCT trials.

Points earned *and* the likelihood of losing increase with each card chosen. Thus, selecting more cards leads to greater outcome variability and is therefore a riskier strategy than turning over fewer cards. Because loss cards represent an artificial ceiling on performance—one cannot turn over any more cards after a loss card is selected—risk behavior was operationalized as cards turned over on voluntarily terminated trials (see Figner et al., 2009; Jamieson, Koslov, et al., 2013; Jamieson & Mendes, 2016). To discourage "chasing" – increasing risk after losses—participants were instructed to maximize scores on *each* trial and told that final scores would be based on an average of three random trials.

Results

All data exclusions, manipulations, and measures analyzed for this study are reported (see supplementary materials for ancillary analyses). Six participants were excluded a priori from analyses: Two (1 competition, 1 control) were not sufficiently proficient in English to understand instructions, three (1 competition, 2 controls) reported suspicion regarding the confederate, and one control participant believed, contrary to instructions, that he was competing with the confederate. Data from two participants (both competition condition) could not be analyzed because no baseline recording was taken due to experimenter error. Ten participants did not provide usable risk data (e.g., Jamieson, Koslov, et al., 2013; Jamieson & Mendes, 2016): Seven (3 competition, 4 con-

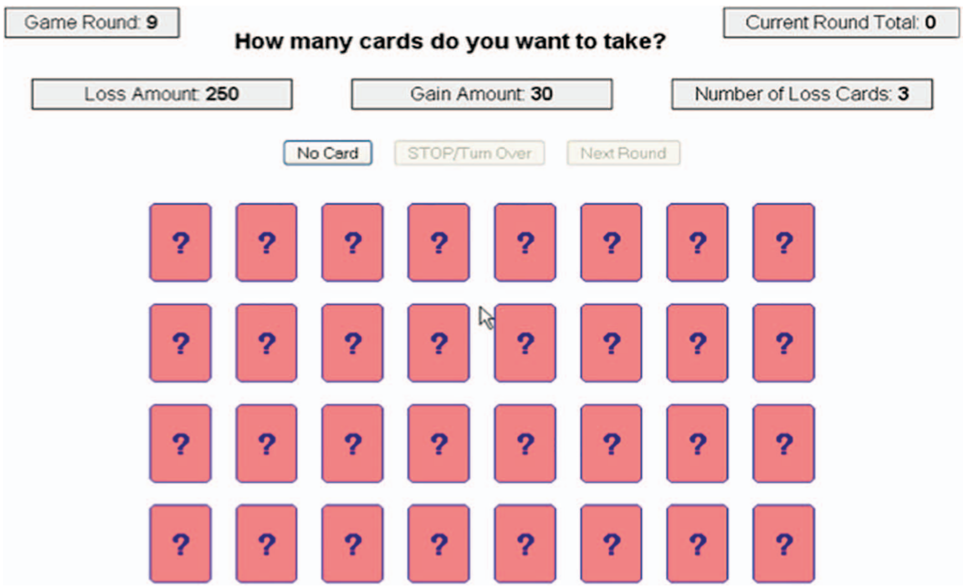

Figure 1. Sample Columbia Card Task trial. Loss amount, gain amount, and number of loss cards were independently randomized trial-to-trial. Game round indicates trial number (50 trials total). Current round total displays points earn per trial. See the online article for the color version of this figure.

trol) misunderstood instructions and lost on >90% of trials, one competition participant selected "no card" on every trial so as to finish as quickly as possible (contrary to instructions), and two participants (both controls) experienced a software error.[1] The final sample analyzed contained 97 participants ($N = 97$).

Outlier analyses were conducted using Tukey's (1977) approach. Results in the text are reported with outliers removed, but all raw analyses with outliers retained are provided in footnotes accompanying analyses.

Group-Level Physiological Effects

Prior to computing physiological reactivity scores, we tested for differences in raw baseline measures (PEP, CO, and TPR); none emerged as a function of competition condition: *t*s < .51, *p*s > .60 (see Table 1 for descriptive statistics). We then computed reactivity by subtracting scores taken during baseline from those collected during the target task (see Llabre, Spitzer, Saab, Ironson, & Schneiderman, 1991, on the use of change scores; see also Jamieson, Koslov, et al., 2013; Jamieson & Mendes, 2016; Jamieson, Nock, & Mendes, 2012; Mendes, Major, McCoy, & Blascovich, 2008, for similar approaches).

Participants assigned to compete exhibited greater SNS arousal during task performance as indexed by reduced PEP interval from baseline, ($M = -5.71$ ms; $SD = 6.29$) compared to no competition controls ($M = -0.52$ ms, $SD = 4.86$), $t(95) = 4.54$, $p < .001$, $d = 0.93$. Moreover, the reduction in PEP observed in the competition condition was significantly different from 0 (i.e., no change from baseline), $t(48) = -6.36$, $p < .001$, $d = 1.84$.

We then tested for main effects of competition on the "motivationally-tuned" CO and TPR reactivity measures. Recall, challenge states are characterized by increased CO and decreased TPR, whereas threat states are characterized by decreased (or little change in) CO and increased TPR (e.g., Blascovich, Mendes, Hunter, & Salomon, 1999; Jamieson et al., 2012; Mendes, Reis, Seery, & Blascovich, 2003). We expected no overall effect of competition on CO or TPR because in the OP model some competition

[1] Including these 10 participants in analyses of physiological measures had no impact on the results.

Table 1
Raw Means and Standard Deviations for All Physiological Measures for Baseline and During Task Performance

Cardiovascular measure	Baseline		Task performance	
	M	*SD*	*M*	*SD*
Preejection period (in ms)				
Competition	102.76	10.71	97.04	11.85
Control	102.60	12.84	102.08	12.54
Cardiac output (in liters per min)				
Competition	6.85	1.93	6.56	2.11
Control	6.86	1.97	6.35	1.71
Total peripheral resistance (in dyne-sec × cm^{-5})				
Competition	1,086.72	381.19	1,145.47	416.67
Control	1,108.79	368.13	1,132.42	333.58

participants should be challenged (approach motivated) whereas others should be threatened (avoidance motivated). Indeed, competition had no significant overall effect on CO, $t(95) = -1.47$, $p = .15$, nor TPR, $t(94) = -0.45$, $p = .65$ (see Table 1).

Taken together, group-level analyses suggested participants assigned to compete exhibited greater SNS arousal relative to controls (Cooke, Kavussanu, McIntyre, & Ring, 2011; Wittchen et al., 2013), but groups did not differ in measures diagnostic of approach- nor avoidance-motivated responding.

Analyses of Opposing Processes During Competition

Opposing approach/avoidance processes during competition were tested using two approaches. First, we created absolute challenge and threat profiles with classification procedures used previously in the BPS literature (Mendes et al., 2003). Second, we computed a relative (to the sample) threat-challenge continuous index following procedures used previously (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004; Seery, Blascovich, Weisbuch, & Vick, 2004; Seery, Weisbuch, & Blascovich, 2009; Shimizu, Seery, Weisbuch, & Lupien, 2011).

Absolute challenge and threat classification. We first used the absolute classification procedure to test whether competition elicited challenge *and* threat states compared to no competition controls. Challenge states are characterized by sympathetic arousal (shorter PEP interval from baseline), improved cardiac efficiency (elevated CO from baseline), and vasodilation (reduced TPR from baseline). Thus, participants were classified as *challenged* if they exhibited the following pattern of reactivity: PEP <0, CO >0, TPR <0. Alternatively, participants were classified as *threatened* if PEP <0, CO <0, TPR >0. As in previous research (Mendes et al., 2003) participants not meeting criteria for challenge/threat classifications were labeled *indeterminate.* See Figure 2 for profile frequencies.

A 2 (competition vs. control) × 2 (challenge/threat vs. indeterminate) between-subjects Chi-Square test examined the frequency of challenged and threatened relative to indeterminate participants between conditions. Supporting predictions, the proportion of participants exhibiting challenge/threat or indeterminate responses significantly differed by condition, χ^2 1, $N = 97) = 14.11$, $p < .001$. As shown in Figure 2, there were a greater number of challenged *and* threatened participants, $n = 26$ (relative to indeterminate participants, $n = 23$) in the competition condition than in the control condition (challenged and threatened participants, $n = 8$; indeterminate participants, $n = 40$), consistent with the opposing processes model.

The above standard challenge/threat classification method (Mendes et al., 2003) could be construed as conservative because threat can elicit "little or no change" in CO as well as decreases (e.g., Jamieson et al., 2012). Thus, we repeated the analysis with a less conservative CO criterion for threat classification. Specifically, threat participants were reclassified using the following reactivity criteria: PEP <0, CO < .5 *SD* change, TPR >0. This more fully cap-

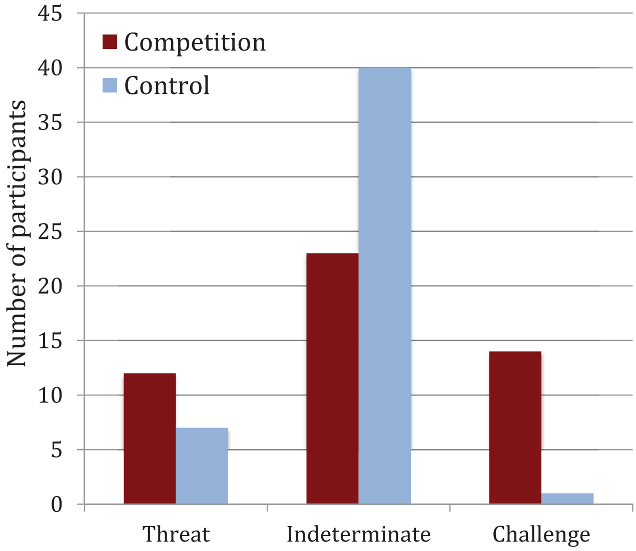

Figure 2. Distribution of participants meeting the standard classification criteria for the three stress profiles (Mendes et al., 2003) as a function of competition condition. See the online article for the color version of this figure.

tures "little or no change" *and* decreased CO effects of threat. This less conservative approach produced the same pattern of results as above: Competition produced a greater number of challenged ($n = 16$) *and* threatened ($n = 15$) participants relative to no competition (challenge $n = 3$; threat $n = 8$), $\chi^2(1, N = 97) = 16.08$, $p < .001$.

Additionally, as was done previously (Mendes et al., 2003), we conducted a *more* conservative test than the initial approach by repeating the physiological classification analysis with the threshold for *each* reactivity measure set at .5 SDs of change from 0: *challenge* = PEP $< -.5$, CO $> .5$, TPR $< -.5$; *threat* = PEP $< -.5$, CO $< -.5$, TPR $> .5$. Again, the effect was the same using the more conservative criteria: Competition produced a greater number of challenged ($n = 8$) and threatened ($n = 4$) participants than no competition (challenge $n = 0$; threat $n = 2$, $\chi^2(1, N = 97) = 8.11$, $p = .004$.

We then examined the proportion of challenged and threatened participants within the competition condition. For the OP model to produce null direct effects of competition on outcomes, competition should elicit similar numbers of challenged and threatened participants. Three one-way chi-square analyses—one for the standard physiological classification and one for each of the alternative classifications—indicated that the proportion of competition participants experiencing challenge was not significantly different than the proportion of competition participants experiencing threat using any of the profiling methods, χ^2s < 1, ps $> .44$.

Continuous threat–challenge index. To further explore the impact of competition on motivated responding, we computed a continuous threat–challenge index and tested for differences in variability between competition and control conditions. The continuous index was created by following standard procedures (Blascovich et al., 2004; Seery et al., 2004, 2009; Shimizu et al., 2011). First, we confirmed that participants were sufficiently engaged by testing whether PEP decreased from baseline to task performance, which, indeed, it did, $t(96) = 5.01$, $p < .001$. Then, we standardized CO and TPR reactivity scores and subtracted TPR from CO. Higher scores indexed more challenge-like states (see Seery et al., 2009, for identical procedures).

To explore the impact of competition on the continuous physiological response index, two Levene's tests were used to test for homogeneity of variance between competition and control conditions. First, we compared homogeneity of variance on a baseline threat–challenge index between conditions to establish that variances at baseline were not significantly different. To do so, we computed a baseline threat–challenge index using the same procedure as described earlier, but with raw baseline CO and TPR scores instead of reactivity CO and TPR scores. Consistent with predictions, the competition and control conditions did not exhibit different variances at baseline for the threat–challenge index: Levene's test, $F(1, 95) = 0.04$, $p = .84$. Then, we compared homogeneity of variance on the threat–challenge *reactivity* index between conditions. Consistent with the results of the classification analyses, the Levene's test was significant, $F(1, 94) = 4.01$, $p = .048$, $d = 0.41$. Variability in physiological reactivity was significantly greater in the competition condition ($s^2_{competition} = 3.93$) compared to the control condition ($s^2_{control} = 2.50$).

Risk-Taking Behavior

The next analyses examined the relation between competition and risk-taking, and between motivated physiological responses and risk-taking. Three outliers (two competition, one control) were removed from risk-taking analyses because their values exceeded the upper third quartile plus 1.5 times the interquartile range (Tukey, 1977).

First, as predicted, we observed no significant main effect of competition on risk-taking ($M_{control} = 10.53$, $SD = 3.83$; $M_{competition} = 10.77$, $SD = 3.95$), $t(92) = -0.31$, $p = .76$. Next, we examined how approach (challenge) and avoidance (threat) states predicted risk-taking using the absolute classification and continuous score approaches.

Absolute challenge and threat classification. The number of cards participants chose was regressed on a contrast model of absolute physiological response classifications with the following weights: +1 = Challenge, 0 = Indeterminate, −1 = Threat. The overall model was significant, $R^2 = 0.05$, $\beta = 0.21$, $p = .040$ (See Figure 3).[2] Consistent with predictions, challenged participants made riskier decisions (i.e., chose more cards; $M = 12.25$, $SD = 4.34$) than threatened participants ($M = 9.45$, $SD = 4.32$), $F(1, 92) = 4.36$, $p = .040$, $d = 0.44$ (indeterminate participants $M = 10.61$, $SD = 3.53$).

Continuous threat–challenge index. We also regressed the number of cards participants chose on the relative threat–challenge continuous index and PEP reactivity. PEP reactivity was included in the model to conceptually replicate the absolute challenge and threat classification analysis (which includes PEP reactivity in classifications), and to examine differences in the predictive power of general arousal and motivated responses. That is, the OP model posits a null relation between arousal and risk taking, but a significant association between motivated responding and risk. The overall model was significant, $R^2 = 0.08$, $F(2, 90) = 3.85$, $p = .025$.[3] As expected, sympathetic arousal did not significantly predict risk-taking, $\beta = 0.14$, $p = .20$, whereas the threat–challenge index was a significant predictor of risk, $\beta = 0.30$, $p = .007$ (see Table 2). The more challenged (i.e., approach motivated) participants were, riskier the decisions they made (i.e., chose more cards).

Discussion

This research was the first to examine motivationally tuned cardiovascular responses in the context of the competition-risk behavior relation. Relative to no-competition controls, participants assigned to compete exhibited increased SNS arousal, replicating the basic effect of competition on arousal (Cooke et al., 2011; Wittchen et al., 2013). It is noteworthy that our manipulation of simply informing participants that they would be competing on the task (competition condition) versus instructing participants to "perform their best" on the task (control condition), was sufficient to produce SNS activation. More important, and supporting the OP model, the competition condition included more challenged (approach) *and* threatened (avoidance) participants compared to the control condition. Also, participants who responded with approach-motivated challenge responses exhibited increased risk-taking relative to those who responded with avoidance-motivated threat. Together, these findings suggest that competition

[2] When outliers were included the results were not significant, but trended in the expected direction, $\beta = 0.14$, $F(1, 95) = 1.81$, $p = .18$, $d = 0.28$.

[3] When outliers were included the overall model was not significant, $F(2, 93) = 1.55$, $p = .22$, $d = 0.26$; as a predictor of cards chosen, the threat–challenge index trended in the expected direction, $\beta = 0.19$, $p = .085$.

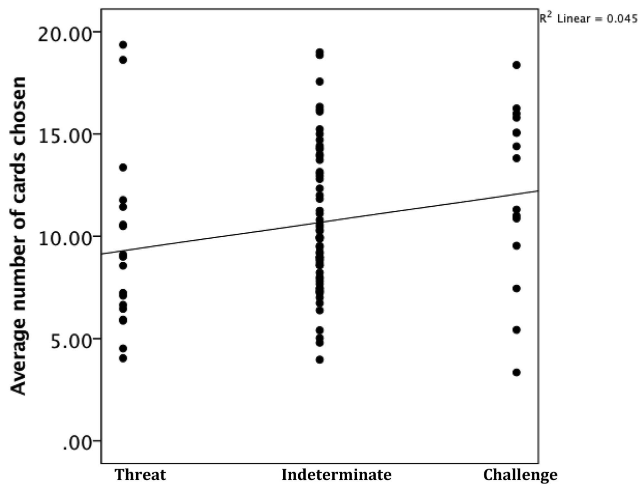

Figure 3. Risk behavior (number of cards selected on nonloss trials) as a function of physiological profiles.

has an important indirect (rather than direct) influence on risk-taking.

We should add that our research not only contributes to the competition literature by focusing on risk-taking, but it also contributes to the risk-taking literature by focusing on competition. As noted by Linde and Sonnemans (2012), "Theories (and experiments) on decision making under risk typically ignore (and exclude) a social context" (p. 45), and competitive situations are clearly an important social context in which to begin to rectify this oversight.

Despite the urging of methodologists to examine indirect effects in the absence of direct effects (MacKinnon, 2008; Preacher & Hayes, 2008; Zhao, Lynch, & Chen, 2010), researchers commonly stop probing a relation of interest if a direct link is not present. The present research, and the OP model of competition more generally, illustrates the importance of such persistence, as separate analysis of approach and avoidance processes provides more clarity on the nature of the competition-risk behavior relation.

The present research measured effects of competition on approach- and avoidance-motivated *responses*, as indexed by physiological reactions (challenge = approach; threat = avoidance), and tested how motivated responses predicted risk outcomes. Challenge/threat are conceptualized as *responses* and this conceptualization stands in contrast to gain/loss cognitive frames (see Tversky & Kahneman, 1981), which *manipulate* the salience of potential outcomes. Gain/loss frames make salient positive or negative possibilities, depending on the situation described (Highhouse & Yüce, 1996; Lopes, 1987). Challenge/threat responses are not determined by the salience of potential outcomes per se, but rather by a combination of demand and resource appraisals (Jamieson, in press). So, gain/loss framing can influence challenge/threat responses by impacting appraisal processes (Seery et al., 2009), but stress appraisals and responses are not thought to impact

Table 2
Summary of Multiple Regression Analysis for Cards Chosen

Variable	B	95% CI	β	*p*
Arousal (PEP reactivity)	.088	[−0.05, 0.22]	.141	.197
Threat–challenge reactivity index	.647	[0.18, 1.11]	.299	.007

Note. R^2 = .079. PEP = preejection period; CI = confidence interval.

effects of message framing on risky choice (O'Connor, Ferguson, & O'Connor, 2005). Thus, the pattern of data observed in our research does not contradict research on the effects of gain/loss framing on risk-taking (for details, see Highhouse & Yüce, 1996; Xie & Wang, 2003).

Limitations and Future Directions

Although the data from the present research provide support for the OP model of competition, limitations must be considered. It is important to note that this study provided correlational, not causal evidence for the risk-taking findings. Thus, we caution against interpreting the association between the continuous threat-challenge index and risk behavior too strongly. First, it is possible that third variables impacted risk effects because opposing motivational processes were measured, not manipulated. Second, the regression analysis reported here assumes a direct linear relation between the predictor (threat-challenge index) and the outcome (risk taking), but this assumption is tenuous. For instance, trends using physiological predictors may be nonlinear (e.g., curvilinear) and/or physiological responses may be released in pulsatile patterns, obscuring linear relations (for similar arguments, see Mendes & Jamieson, 2011; Yeager, Lee, & Jamieson, 2016). Thus, future research may seek to constrain physiological responses (e.g., a dexamethasone suppression test (DST) pharmacologically decreases cortisol; for a social stress review, see Allen, Kennedy, Cryan, Dinan, & Clarke, 2014) or manipulate the psychological experience of challenge/threat (e.g., Jamieson, Mendes, & Nock, 2013).

Similarly, this research cannot explain why competition evoked challenge in some individuals and threat in others. Questions regarding mechanisms could be addressed in subsequent research by manipulating appraisals (Jamieson, Mendes, & Nock, 2013), as noted above, and/or measuring individual differences, such as approach/avoidance temperament (Elliot & Thrash, 2010) or regulatory focus (Higgins, 2001). Future research along these lines has the potential to provide additional clarity and precision regarding the nature of the competition-approach/avoidance relation.

The competition manipulation used in this research was minimal, producing relatively weak (compared to the social evaluative threat literature, Dickerson & Kemeny, 2004) physiological responses. Participants were instructed that he or she would be competing with the person they met, but he or she completed the task alone in a room (presumably the competitor was in the adjacent room). Future research should seek to examine these relations and extend this research in a more powerful competition situation. Moreover, this research cannot speak to the impact of different *types* of competition on motivated responding and risk behavior. Here, we examined responses in an interpersonal competition context. However, competition can also be intrapersonal (i.e., competing with oneself), such as trying to beat a personal best score. Or, competition may occur between groups (intergroup competition) rather than individuals, such as different social groups competing for the same societal resources. Future research would do well to test whether different types of competition elicit opposing motivational responses. Likewise, additional work is needed to broaden the focus to different types of risk contexts (e.g., physical, financial, relational).

Evidence for opposing approach and avoidance processes was based on self-reported goals in the original OP model of competition and performance (Murayama & Elliot, 2012). In this study, however, we used physiological measures to index opposing processes. The benefit of using physiological measures is that they provided a direct, in vivo assessment of motivated states (Mendes, Blascovich, Major, & Seery, 2001), but individuals cannot be profiled as experiencing challenge and threat *simultaneously* and the achievement goal literature suggests a positive relation between self-reported performance-approach and performance-avoidance goals (e.g., Elliot & Murayama, 2008; Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey, 2010; Senko & Harackiewicz, 2005). This discrepancy suggests future research into how approach and avoidance motivational processes manifest and feed-forward to direct risk behavior.

Conclusions

Interpersonal competition is an acutely stressful situation that has received some attention in risk research, but less than might be warranted given the importance and ubiquity of competition in daily life (from economic and political structures to vocational and avocational pursuits to minute-by-minute social comparisons with friends and acquaintances). Most work on competition and risk-taking behavior, and on competition and psychological functioning more generally, seems driven by the premise that competitive situations are either good or bad, enhancing or detrimental. As the competition literature develops and matures, we believe it will become more and more clear that this either/or premise is overly simplistic, and that a more nuanced perspective, such as that posited by the OP model of competition, is necessary.

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Received May 21, 2016
Revision received November 7, 2016
Accepted November 14, 2016 ■