

The Effects of Individual and Team Competitions on Performance, Emotions, and Effort

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It is well documented that competition can affect performance and emotion in sport. However, our understanding of the comparative effects of individual and team competitions on performance and emotion is limited. We also know little about emotion-based mechanisms underlying the effects of different types of competition on performance. To address these issues, 64 participants completed a handgrip endurance task during time-trial, one-on-one, two-on-two, and four-on-four competitions while self-report and possible corroborative physiological measures of enjoyment, anxiety, and effort were assessed. Results indicated that performance, enjoyment, anxiety, and effort increased from individual to team competitions. The observed increases in performance were mediated by increased enjoyment and effort. Our findings illustrate differential effects of individual and team competitions on performance and emotion. Moreover, they indicate that both enjoyment-based and anxiety-based mechanisms can explain changes in performance among different types of individual and team competition.

Keywords: intergroup competition, motor performance, isometric endurance, psychophysiology, enjoyment, anxiety

Competition influences motor performance (e.g., Stanne, Johnson & Johnson, 1999) and elicits emotions such as joy and anxiety (Jones, Lane, Bray, Uphill, & Catlin, 2005). In sport, competition can take place individually and as part of a team. For instance, golfers compete as individuals against the rest of the field on the regular US and European Tour events, but encounter one-on-one and team competitions in the Ryder and Solheim Cups. There are long and extensive lines of research demonstrating that motor performance is normally better (Stanne et al., 1999; Triplett, 1898) and emotions are generally more intense (Lazarus, 2000; Martens, 1975) during competitive than during noncompetitive conditions. However, there is a paucity of research examining the effects that different types of competition (i.e., individual, team) can have on emotions and performance. Moreover, we know little about the mechanisms that underlie the effects of different types of competition on performance. To address these gaps in the extant research literature, the first aim of the present experiment was to examine the comparative effects of individual and team competitions on performance and emotion during a motor task. The key purpose was to then evaluate enjoyment-

based and anxiety-based mechanisms to explain changes in performance among different types of individual and team competitions.

Effects of Individual and Team Competitions on Performance

Previous research has demonstrated that cognitive performance is often better during team (i.e., intergroup) competition than during individual (i.e., pure) competition. For instance, high-school students have been shown to learn more during mathematics classes (DeVries & Edwards, 1973), and perform better on a science test (Okebukola, 1986), when competing for rewards in a team of four than when competing as individuals. Team competition has also been shown to improve decision making (e.g., Bornstein & Erev, 1994), group productivity (e.g., Mulvey & Ribbens, 1999), and performance (e.g., Erev, Bornstein, & Galili, 1993) in the workplace. However, we are aware of just one study that has compared the effects of individual and team competition on performance in sport. Specifically, in a study of basketball shooting, Tauer and Harackiewicz (2004) found that participants made more successful free-throws during two-on-two competition than during one-on-one competition. Taken together, these findings indicate that team competitions may promote better performance than individual competitions in education, business, and sport.

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Effects of Individual and Team Competitions on Emotions

Research examining the effects of individual and team competitions on emotions in sport is sparse. However, Tauer and Harackiewicz (2004) found that enjoyment, which may be considered as the process of experiencing the positive emotion joy (e.g., Jackson, 2000), increased from individual to team competition during a basketball free-throw shooting task. These authors suggested that team competition should be more enjoyable than individual competition because it can foster a sense of relatedness through cooperation with teammates (cf., Deutsch, 1949; Ryan & Deci, 2000).

Anxiety, a negatively valenced emotion that is characterized by feelings of worry (Eysenck, Derakshan, Santos, & Calvo, 2007), could also differ between individual and team competitions. For instance, Martin and Hall (1997) found that anxiety decreased from individual to team competitions in female figure skaters. They suggested that individual competition should elicit greater anxiety than team competition because it increases identifiability (e.g., Simon & Martens, 1979; Gilovich & Savitsky, 1999). However, while identifiability is greater during individual competition, other anxiety-eliciting factors are greater during team competition. For instance, when compared with individual competitions, team competitions often include evaluation by and comparison with more opponents, while also burdening participants with feelings of responsibilities to teammates (Gray, 2004; Jones & Lavallee, 2010; Martens, 1975). Accordingly, Martin and Hall (1997) acknowledged that anxiety could also increase from individual to team competitions, and conceded that their results could have been confounded by a fixed condition order, where individual competition was always before team competition. The present experiment will thus be one of the first to adopt a counterbalanced within-subject design to assess whether anxiety increases or decreases from individual to team competitions.

Enjoyment-Based and Anxiety-Based Mechanisms to Explain Changes in Performance among Different Types of Competition

An enjoyment-based mechanism that could explain changes in performance among different types of competition can be derived from the arguments put forward by Tauer and Harackiewicz (2004). Specifically, they reasoned that increased enjoyment during team competition reflected increased intrinsic motivation (see also Tauer & Harackiewicz, 1999; Walker, 2010) due to a feeling of relatedness with teammates. They also noted that greater intrinsic motivation is positively associated with performance (e.g., Harackiewicz & Tauer, 2006), and is characterized by increased effort (e.g., Harackiewicz &

Sansone, 1991; Ryan & Deci, 2000). Accordingly, an enjoyment-based mechanism would predict that increased enjoyment should mediate increases in effort. Moreover, increases in both enjoyment and effort should mediate improvements in performance from individual to team competitions.

In accord with this enjoyment-based mechanism, Tauer and Harackiewicz (2004) demonstrated that increased enjoyment partially mediated improvements in basketball shooting accuracy from one-on-one to two-on-two competitions. Moreover, Cooke, Kavussanu, McIntyre, and Ring (2011) found that increases in both enjoyment and effort played a role in improving endurance performance from a noncompetitive condition to a team competition. Although these findings offer encouraging support for the aforementioned enjoyment-based mechanism, a complete test of the mechanism has yet to be conducted, as the predicted relationship between enjoyment and effort (i.e., increased enjoyment should mediate increased effort) has not been examined. This hypothesized pathway will be evaluated in the present experiment.

An alternative explanation of changes in performance among different types of competition is offered by popular anxiety-based mechanisms, such as processing efficiency theory (Eysenck & Calvo, 1992) and attentional control theory (Eysenck et al., 2007). Like the enjoyment-based mechanism, these anxiety-based theories would also attribute improvements in performance from individual to team competitions to increased effort. However, they would expect increased effort to be driven by increased anxiety, reasoning that increased effort reflects a compensatory strategy designed to mobilize auxiliary processing resources within our limited capacity working memory system, and thereby increase the attention devoted to a goal/task. Several studies have supported these anxiety-based mechanisms as explanations for the effects of competition on performance in sport (e.g., Williams, Vickers, & Rodrigues, 2002; Wilson, Smith, & Holmes, 2007; Wilson, Wood, & Vine, 2009). However, to our knowledge, no study has compared whether increased effort is mediated by increased anxiety (Eysenck & Calvo, 1992; Eysenck et al., 2007) or increased enjoyment (Tauer & Harackiewicz, 2004). Accordingly, this experiment will be the first to compare enjoyment-based and anxiety-based mechanisms to explain any changes in performance from individual to team competitions.

The Present Experiment

The first aim of this experiment was to examine the effects of different types of individual and team competitions on performance, enjoyment, anxiety, and effort. The key purpose was to then evaluate enjoyment-based and anxiety-based mechanisms to explain changes in performance among different types of individual and team competitions. To extend previous research we adopted the following key design features: First, we created two

levels of both individual (i.e., time-trial and one-on-one) and team (i.e., two-on-two, four-on-four) competition. This was done to provide a more comprehensive assessment of the effects of different types of competition on performance, enjoyment, anxiety, and effort than has been offered by previous research (e.g., Tauer & Harackiewicz, 2004). Second, our experiment used an isometric endurance task. We chose this task because previous research has demonstrated that performance on isometric and/or endurance-based tasks is influenced by variations in emotions and effort (e.g., Cooke et al., 2011; Perkins, Wilson, & Kerr, 2001).

Finally, we adopted a multimeasure approach by supplementing self-report measures of enjoyment and anxiety with measures of heart rate, heart rate variability (i.e., root mean square of successive differences in cardiac interbeat intervals—r-MSSD) and cardiac contractility (i.e., R-wave to pulse interval). These physiological variables could all be influenced by emotion, with both joy and anxiety being broadly associated with an increase in heart rate and, to a lesser extent, cardiac contractility (e.g., Sinha, Lovallo, & Parsons, 1992; Tugade & Fredrickson, 2004). Anxiety (worry) has also been associated with reduced r-MSSD (e.g., Pieper, Brosschot, van der Leeden, & Thayer, 2007; Mateo, Blasco-Lafarga, Martinez-Navarro, Guzman, & Zabala, 2012). Although these measures may not provide standalone indices of discrete emotions, they could be used to corroborate changes in self-reported enjoyment and anxiety across the competitions. The combined use of self-reports and physiological variables to study emotion is increasingly recommended (e.g., Mauss & Robinson, 2009). The present experiment will be one of the first to apply such a multimeasure approach to the study of competition and performance in sport.

Based on the research outlined above, we hypothesized that performance and enjoyment would increase (e.g., Tauer & Harackiewicz, 2004), and anxiety would increase or decrease (e.g., Martin & Hall, 1997; Gray, 2004), from individual to team competitions. We also expected that increases in performance from individual to team competitions would be mediated by increased enjoyment and effort (e.g., Eysenck & Calvo, 1992; Eysenck et al., 2007; Tauer & Harackiewicz, 2004). Finally, we expected that increased effort would be mediated by either increased enjoyment (e.g., Tauer & Harackiewicz, 2004) or increased anxiety (e.g., Eysenck & Calvo, 1992; Eysenck et al., 2007).

Method

Participants

Sixty-four (32 men, 32 women) students (age $M = 20.7$, $SD = 1.3$ years) enrolled in an undergraduate sports science course gave informed consent and participated in the experiment, which was approved by the local research ethics committee.

Task

Our isometric endurance task required participants to squeeze a handgrip dynamometer continuously, maintaining a grip force equivalent to at least 40% of their maximum voluntary contraction (MVC), for as long as possible. We chose this handgrip task and relative force requirement (i.e., 40% MVC) based on previous literature (e.g., Cooke et al., 2011) and to ensure that we controlled for individual differences in absolute strength. Participants were seated and used their dominant hand to hold the dynamometer, which was supported so that their arm was flexed at approximately 100°. A dual-color light-emitting diode panel was positioned opposite each participant to display grip force information. Green numbers indicated a force equal to or greater than 40% MVC. For example, green 0 represented a grip-force equivalent to 40% MVC, green 1 represented a grip-force equivalent to 41% MVC, and so on. Red numbers indicated a grip-force below 40% MVC (e.g., red 1 = 39% MVC, red 2 = 38% MVC). Participants were asked to maintain a grip force that ensured a low green number was displayed (i.e., to help ensure that the force maintained was close to the 40% MVC threshold) for as long as possible.

A computer program monitored grip force. The task was terminated if grip force fell below 20% MVC or if it was below the required force for more than 2 s. Both of these criteria were applied after 30 s of the task had elapsed to provide participants with time to stabilize how hard they should squeeze the dynamometer to produce 40% MVC. Force data were recorded through an analog-to-digital convertor (Power 1401, CED) and digitized at 2500 Hz with 16-bit resolution. Force and endurance time were recorded by a computer running Spike2 software.

Self-Report Measures

Enjoyment. To assess enjoyment, we used the seven-item enjoyment subscale of the Intrinsic Motivation Inventory (Ryan, 1982). Items, including “While doing it, I was thinking about how much I enjoyed it,” were rated on a 7-point Likert scale, with labels of 1 (*not at all true*), 4 (*somewhat true*), and 7 (*very true*). The item responses were averaged to provide one score for the subscale. McAuley, Duncan, and Tammen (1989) reported an internal consistency of .78 for this subscale. In this experiment, Cronbach’s alpha coefficients across the conditions were very good (.85–.89).

Anxiety. To assess anxiety, we used the cognitive anxiety item from the Mental Readiness Form–Likert (Krane, 1994). Participants rated their thoughts on an 11-point scale anchored with the terms *calm* and *worried*. Krane (1994) reported correlations between this scale and the Competitive State Anxiety Inventory-2 of .76 for cognitive anxiety, supporting its concurrent validity.

Effort. We measured effort using Zijlstra's (1993) effort rating scale. Participants were instructed to rate the level of effort that they expended in each competition using a vertical axis scale ranging from 0 to 150, with increments of 10 shown on the left edge of the scale and nine category anchors shown on the right edge of the scale. These included *no effort at all* (at 3 on the scale), *a fair amount of effort* (at 58 on the scale), and *extreme effort* (at 114 on the scale). The scale has acceptable test–retest reliability, with a correlation coefficient of .78 (Zijlstra, 1993).

Physiological Measures

To obtain physiological measures that could corroborate our self-report measures of emotion, we recorded an electrocardiogram, and used an infrared photoplethysmograph (1020 EC, UFI) to measure the pulse pressure wave at the right ear. We measured the electrocardiogram using three silver/silver chloride spot electrodes positioned on the right clavicle, the left clavicle, and a lower left rib. The electrocardiographic signal was amplified and filtered (0.1–300 Hz plus 50-Hz notch filter) by an AC amplifier (LP511, Grass), and the pulse signal was amplified by a custom-made amplifier with a gain of 100 and a bandwidth of 0.06–35 Hz. Based on the intervals between R-waves of the electrocardiogram, we computed heart rate and heart rate variability (r-MSSD). We also calculated the interval between the peak of the R-wave of the electrocardiogram and the foot of the upstroke of the ear pulse (R-wave to pulse interval). A decrease in R-wave to pulse interval indicates increased cardiac contractility (De Boer, Ring, Curlett, Ridley, & Carroll, 2007; Montoya, Brody, Beck, Veit, & Rau, 1997).

To interpret these cardiovascular measures as possible corroborative indices of emotion, it is important to control for any effects of muscle activity on the autonomic nervous system (Cooke et al., 2011; Obrist, 1968). Therefore, in addition to the aforementioned physiological variables, we also recorded electromyographic activity in the extensor carpi radialis muscle, which is used for gripping, in both the dominant and nondominant forearms. These sites were chosen to provide insight into the physical demands of the task (i.e., activity in the dominant arm) and any general muscular tension that was elicited by the conditions (i.e., activity in the nondominant arm). Differential surface electrodes and a reference electrode in a case containing a $\times 1000$ preamplifier were used to record electromyographic activity. Conductive cream was applied to the electrode contacts. The signal was amplified ($\times 2$) and filtered (10–1000 Hz) by a custom-made amplifier.

To improve the fidelity of all physiological signals, recording sites were exfoliated and degreased with alcohol wipes before electrodes were attached. This helped ensure that the signals were not contaminated by noise artifact during the task. Data were acquired through a Power1401 (CED) by a computer running Spike2 software. All signals were digitized at 2500 Hz with 16-bit resolution.

Procedure

Participants attended a 2-hr testing session in single-sex groups of eight individuals. Each participant was assigned to an experimenter at one of eight stations, arranged in an oval shape around the edge of the laboratory, where their MVC was recorded. Specifically, participants were seated and asked to squeeze the dynamometer as hard as they could. They completed a minimum of four maximal handgrip contractions, separated by 1 min of rest (Padilla et al., 2010). After four contractions, the computer program verified whether the second-largest contraction was within 5% of the largest contraction. If this criterion was not met, participants made additional contractions until this criterion was satisfied. This helped ensure that the MVC was accurate. The MVC was classified as the largest ($M = 458$, $SD = 128$ N) of the contractions. Participants were not aware that their MVC informed the force requirement in the subsequent endurance task.

After the MVC was obtained, 40% MVC was calculated and entered into the computer program, and the endurance task was explained. Then participants performed the task in a noncompetitive condition. We included this design feature to familiarize participants with the endurance task before the competition conditions, and to match them in terms of endurance performance, thereby ensuring that competitions were closely fought. We matched participants by reassigning them to a station, based on their noncompetitive endurance time. Specifically, the participant with the longest endurance time was assigned to Station 1, the participant with the second-longest endurance time was assigned to Station 2, and so on. The stations were positioned such that Stations 1, 4, 5, and 8 were on one side of the laboratory, and were directly opposite Stations 2, 3, 6, and 7, respectively (Figure 1). Participants were not told that their endurance time would dictate the station to which they would be assigned, and data from this noncompetitive familiarization condition were not included in our analyses.

Following this reassignment to stations, participants were reseated, and instrumentation for the recording of physiological signals took place. Once instrumented, participants stayed in their seat for the remainder of the experiment to prevent any effects of postural stress and to minimize any effects of movement on physiological responses (Obrist, 1968). Each participant completed the endurance task in time-trial, one-on-one, two-on-two, and four-on-four competitions in an order that was counterbalanced across testing sessions. Before each competition condition, participants sat quietly during a 5-min formal rest period. They were then given details of the upcoming competition and completed the task in this condition. Finally, following each competition, there was a 5-min recovery period to allow the physiological variables to return to resting levels. Physiological measures were recorded continuously, and self-report measures of enjoyment, anxiety, and effort experienced/invested *during* the competition were obtained in the first minute of the recovery period.

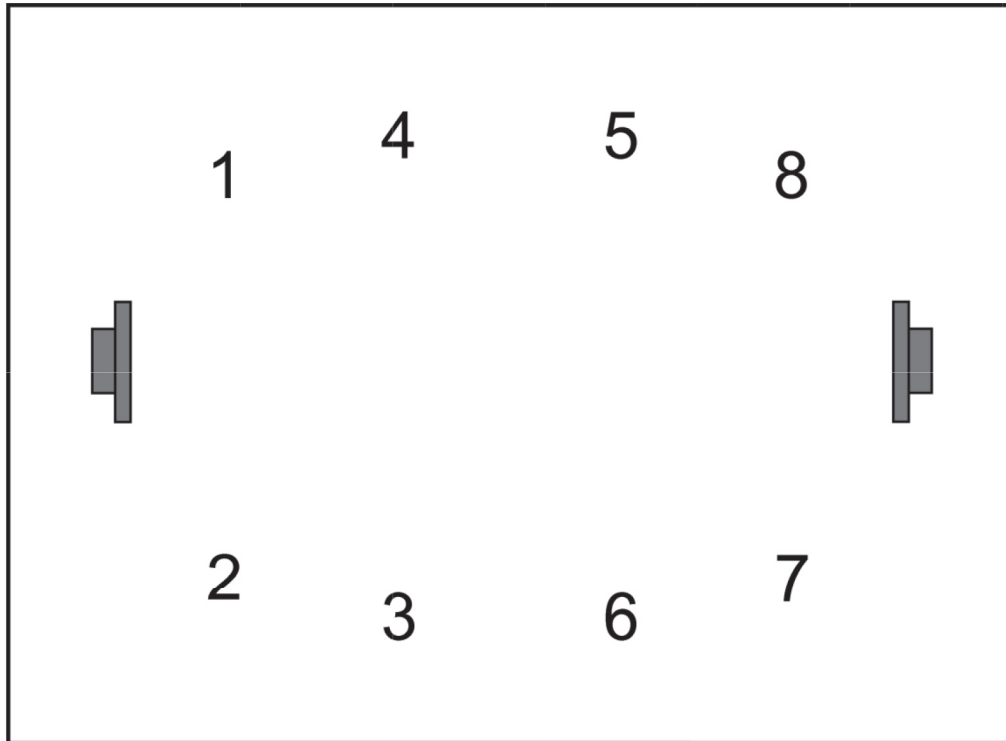


Figure 1 — Diagram of the laboratory depicting the position of stations and computer screens used to display points during the team competitions.

This sequence (i.e., rest, instruction, task, recovery) was repeated until all four competition conditions had been completed. At the end of the session, participants were thanked, debriefed, and asked not to disclose information about the experiment to others.

Competition Conditions

All participants took part in time-trial, one-on-one, two-on-two, and four-on-four competitions. Features that were common across all four competition conditions were as follows: First, participants were always instructed to maintain the handgrip contraction for as long as possible, even when their opponent(s) had been eliminated. Accordingly, while participants were also trying to beat opponent(s), maintaining the handgrip for as long as possible was the key objective. Second, each participant was always in view of the eight experimenters (i.e., one at each station) and seven coactors (i.e., the other participants) who were also in the laboratory. Thus, any effects on performance, emotion, and effort that were elicited by performing in view of others, rather than the competition process per se, were the same across all conditions (cf., Cooke et al., 2011). Finally, participants never received direct performance feedback (i.e., they were not told their endurance time) during the experiment. Consequently, they could not use their own endurance time from the first condition as a benchmark to compare themselves against

in the subsequent competitions. The specific details of each competition condition are described below.

Time-Trial Competition. In the time-trial competition, participants were informed that they were competing to be ranked as highly as possible on a leaderboard listing all of the participants in the experiment. They were also informed that the leaderboard would be circulated to all participants at the end of the study. Following these instructions, a “ready, steady, go” countdown was issued by the master experimenter. On the “go” command, all eight participants in a given session simultaneously initiated the time-trial competition.

One-on-One Competition. In the one-on-one competition, participants competed directly against an opponent, who simultaneously completed the endurance task, and was positioned directly opposite them. Specifically, the stations were positioned such that Stations 1, 4, 5, and 8 were directly opposite Stations 2, 3, 6, and 7, respectively (Figure 1). Thus, the one-on-one competitions involved Stations 1 versus 2, 3 versus 4, 5 versus 6, and 7 versus 8. Participants were told that they were in competition with their opponent to see who could maintain the handgrip for the longest. The four separate competitions that comprised this condition took place more or less simultaneously, with a small amount of latency jitter (less than 10 s) in the task onsets, due to the time needed for the master experimenter to initiate each of these four contests (i.e.,

walk to where the two participants were and say “ready, steady, go” four times).

Two-on-Two Competition. In the two-on-two competition, a team of two participants competed directly against an opposing team, who simultaneously completed the endurance task. The teams were created based on the stations that participants had been assigned, with opposing teams positioned directly opposite one another in the laboratory. Thus, the two-on-two competitions comprised Stations 1 and 4 versus Stations 2 and 3, and Stations 5 and 8 versus Stations 6 and 7. Participants were told that they were in competition with the opposing team to see which pair could earn the most points. Specifically, points were accumulated at a rate of one per second for each member of the team who was maintaining the required force. Points were displayed on a master computer monitor positioned in between the competing teams, which updated the combined score of each team in real time (Figure 1). The total number of points accrued by each team was briefly displayed on the screen at the end of the condition, but participants received no breakdown of their individual contributions. The two separate competitions that comprised this condition again took place more or less simultaneously, but for a few seconds of latency jitter as explained above.

Four-on-Four Competition. The four-on-four competition was the same as the two-on-two competition, except that participants were now in teams of four (i.e., Stations 1, 4, 5, and 8 versus Stations 2, 3, 6, and 7). As this condition comprised only one competition, all eight participants initiated the task simultaneously on the experimenter’s “go” command.

Data Reduction

We calculated values to represent the average physiological activity at rest (i.e., activity during the final minute of the rest period that preceded the first condition) and during each of the competition conditions (Cooke et al., 2011). Resting values were subtracted from the values obtained during each competition to illustrate physiological reactivity. This is a well-established method of presenting and analyzing psychophysiological data (Llabre, Spitzer, Saab, Ironson, & Schneiderman, 1991).

Statistical Analysis

Pulse data from three participants were unscorable; thus, the R-wave to pulse interval could only be calculated for 61 of the 64 participants. Data from all participants were included when analyzing the other variables.

Exploratory Analyses. Exploratory analyses of the effects of competition type on the performance, self-report, and physiological measures included sex and the order that participants completed the competition conditions as between-subject factors. A four competition condition (time trial, one on one, two on two, four on four) repeated-measures MANOVA, with sex and order

as between-subject factors, revealed a main effect for sex, $F(10, 44) = 3.23, p < .01, \eta_p^2 = .42$, but no effect for competition condition order $F(30, 138) = 1.32, p = .15, \eta_p^2 = .22$. Specifically, females had better endurance ($M = 95.94$ s) than males ($M = 80.24$ s) and demonstrated less nonspecific muscle activity ($M = +3.18$ μ V) than males ($M = +13.57$ μ V). Such effects can be attributed to sex differences in muscle firing patterns (e.g., Hunter & Enoka, 2001). No sex effects were revealed for any other variables, and there were no sex by condition interactions, indicating that the effects of the competition conditions were similar for both males and females. Given that sex and order did not moderate the effects of competition condition on performance, emotions, and effort, the main analyses reported below did not include sex or order as factors.

Main Analyses. Our analytic strategy was as follows: First, to examine the effects of competition type on performance, self-report and physiological measures, we conducted a four competition condition repeated-measures MANOVA, which revealed a significant multivariate effect for condition, $F(30, 31) = 6.95, p < .001, \eta_p^2 = .87$. Next, to probe this effect, we conducted separate four condition repeated-measures ANOVAs followed by planned comparisons for each performance, self-report, and physiological variable. We have reported the results of the multivariate solution for these analyses. Partial eta-squared is reported as a measure of effect size, with values of .02, .13, and .26 representing small, medium, and large effect sizes, respectively (Cohen, 1992). Finally, we used Judd, Kenny, and McClelland’s (2001) difference/sum regression procedure to test within-subjects mediation.

Supplementary Analyses. Supplementary analyses investigated whether any effects of competition on our physiological measures were influenced by condition differences in baroreflex-mediated cardiovascular control. Specifically, any increase in sympathetic activation that occurs outside of the first 60 s of isometric handgrip contractions could be elicited by the arterial baroreceptors (e.g., Ichinose, Saito, Kondo, & Nishiyasu, 2006; Seals, Chase, & Taylor, 1988). Accordingly, we ran four condition ANCOVAs to reexamine any effects of competition on our physiological measures while covarying for endurance time. We also conducted four condition ANOVAs on the physiological variables recorded inside the first 60 s of endurance time in each condition.

Results

Effects of Competition Type on Performance, Self-Report, and Physiological Measures

The results of the four condition ANOVAs employed to examine the effects of the different types of individual and team competitions on performance, self-report, and physiological measures are presented in Table 1.

Performance and self-reported enjoyment increased from the time-trial to the one-on-one to the two-on-two competitions, with no change thereafter. Self-reported anxiety increased from the time-trial to the one-on-one and two-on-two competitions, and again to the four-on-four competition. Self-reported effort increased from the time-trial to the one-on-one competition, with no further increase thereafter.

Analyses of the physiological measures indicated that heart rate increased from the time-trial to the two-on-two competition, but thereafter decreased in the four-on-four competition. R-wave to pulse interval fell from the time-trial to the two-on-two competition, but then rose in the four-on-four competition. r-MSSD fell from the time-trial to the remaining competitions. Finally, no effects of competition were revealed for muscle activity.

The mean resting levels of the physiological variables were as follows: heart rate = 73.97 bpm; R-wave to pulse interval = 162.17 ms; r-MSSD = 62.00 ms; dominant arm EMG = 13.27 μ V; nondominant arm EMG = 10.23 μ V. These resting values can be added to the reactivity (Δ) scores presented in Table 1 to calculate the absolute values for each physiological measure. Although these values refer to physiological activity during the rest period preceding the first competition condition, analyses of physiological activity in subsequent rests confirmed that all of the rest periods were similar. This indicates that the gap of approximately 12 min between competition tasks (i.e., a 5-min recovery period, 5 min of formal rest, 2 min of task instruction) was sufficient for physiological recovery to occur. Moreover, it confirms that physiological reactivity scores recorded during each condition were not contaminated by the responses that occurred during the preceding task.

Mediators of the Effects of Different Types of Competition on Performance

The ANOVAs reported above indicated that performance increased from the time-trial to the one-on-one competition and from the one-on-one to the two-on-two competition. We hypothesized that increased enjoyment and effort would mediate these effects. Accordingly, we used Judd et al.'s (2001) difference/sum regression procedure to evaluate self-reported enjoyment and effort as mediators of increased performance. Specifically, we regressed the difference in performance between the time-trial, one-on-one, and two-on-two competitions on the differences in self-reported enjoyment and effort. Mediation can be inferred if the difference in the potential mediators predicts the difference in performance (Judd et al., 2001). The residual difference, indicated by the unstandardized b , represents any variance over and above mediation.

These analyses revealed that the original 19.31 s of difference in endurance time between the time-trial and one-on-one competitions was significantly reduced to 3.44 and 7.99 s respectively when the condition dif-

ferences in self-reported enjoyment and effort were included in separate regression models. These residual differences of 3.44 and 7.99 s no longer represented a significantly greater endurance time during one-on-one competition ($ps > .23$). These findings suggest that enjoyment and effort fully mediated the improvement in performance from time-trial to one-on-one competition.

Similarly, the original 13.40 s of difference in endurance time between the one-on-one and two-on-two competitions was significantly reduced to 4.37 s by the condition difference in self-reported enjoyment. This residual difference of 4.37 s no longer represented a significantly greater endurance time during the two-on-two competition ($p = .51$). Therefore, self-reported enjoyment also fully mediated the improvement in performance from one-on-one to two-on-two competition.

Mediators of the Effects of Different Types of Competition on Effort

The ANOVAs reported above indicated that effort increased from the time-trial competition to the one-on-one competition. We hypothesized that increased enjoyment or increased anxiety would mediate this effect. A final set of mediation analyses, conducted in the same way as those described above, revealed that the original 14.05-unit difference in self-reported effort between time-trial and one-on-one competitions was significantly reduced to 7.91 and 10.20 respectively in the presence of self-reported enjoyment and anxiety. These residual differences in effort remained significant ($ps < .04$), indicating that increased enjoyment and anxiety were both partial mediators of increased effort.

Supplementary Analyses

As outlined previously, we performed two sets of supplementary analyses: First, four condition ANCOVAs which covaried for endurance times confirmed that the previously reported effects of competition condition on the physiological measures remained significant in the presence of the covariates: heart rate, $F(3, 58) = 30.58$, $p < .001$, $\eta_p^2 = .61$; r-MSSD, $F(3, 58) = 3.26$, $p < .05$, $\eta_p^2 = .14$; R-wave to pulse interval, $F(3, 55) = 29.11$, $p < .001$, $\eta_p^2 = .61$. Thus, the difference in physiological activity among the competitions was not an artifact of the different endurance times in these conditions.

Second, four condition ANOVAs on the physiological variables recorded during only the first half (i.e., up to the first 51 s) of endurance time in each condition confirmed that the previously described effects of competition on the physiological measures were already emerging at the early stages of each contraction: heart rate, $F(3, 61) = 45.81$, $p < .001$, $\eta_p^2 = .69$; r-MSSD, $F(3, 61) = 7.54$, $p < .001$, $\eta_p^2 = .27$; R-wave to pulse interval, $F(3, 58) = 29.77$, $p < .001$, $\eta_p^2 = .61$. These results indicate that the effects of competition on our physiological measures were not confounded by condition differences in baroreflex-mediated cardiovascular control.

Table 1 Effects of Competition Condition on Performance, Self-Report, and Physiological Measures

Measure	Competition Condition												F(3, 61) [#]	η _p ²	
	Time Trial		One on One		Two on Two		Four on Four		M	SD	M	SD			
	M	SD	M	SD	M	SD	M	SD							
Performance															
Endurance time (s)	68.80	37.75	88.11 ^a	42.10	101.51 ^{ab}	37.79	93.94 ^a	39.57	13.05 ^{***}						.39
Grip force (% MVC)	40.75	1.49	41.10	1.70	40.89	1.30	40.89	1.40	1.59						.07
Self-Report															
Enjoyment	3.26	1.05	3.85 ^a	0.98	4.15 ^{ab}	1.12	4.23 ^{ab}	1.14	13.22 ^{***}						.39
Anxiety	4.34	1.78	5.25 ^a	2.09	5.45 ^a	2.11	5.90 ^{ab,c}	1.97	14.27 ^{***}						.41
Effort	74.83	26.79	88.88 ^a	19.25	92.70 ^a	20.67	93.31 ^a	18.42	10.56 ^{***}						.34
Physiological															
Δ Heart rate (bpm)	+20.32	13.22	+30.32 ^a	13.71	+34.88 ^{ab}	12.50	+31.84 ^{ac}	14.03	59.14 ^{***}						.74
Δ r-MSSD (ms)	-37.73	36.09	-44.19 ^a	36.69	-46.60 ^a	35.55	-44.42 ^a	37.05	6.31 ^{***}						.24
Δ R-wave to pulse interval (ms)	-20.22	13.04	-30.47 ^a	13.77	-33.56 ^{ab}	15.08	-30.12 ^{ac}	16.03	51.69 ^{***}						.73
Δ Dominant arm EMG (μV)	+190.57	139.11	+205.79	149.07	+208.39	156.87	+207.81	157.03	2.65						.12
Δ Nondominant arm EMG (μV)	+6.63	17.92	+9.67	25.37	+9.46	17.09	+7.74	15.26	2.51						.11

Note. Superscripts a, b, and c indicate significant differences ($p < .05$) from the time-trial, one-on-one, and two-on-two competition conditions, respectively.

*** $p < .001$. #Indicates F(3, 58) for R-wave to pulse interval.

Discussion

Despite many types of individual and team competitions being prevalent in sport, little research has examined the effects of competition type on emotions and performance. We also know little about the mechanisms that could underlie changes in performance among different types of competition. To address these gaps in the literature, this experiment examined the effects of different types of individual and team competitions on performance, enjoyment, anxiety, and effort. It also evaluated enjoyment-based and anxiety-based mechanisms as explanations of changes in performance among different types of individual and team competitions. Our results are discussed in the sections that follow.

Effects of Competition Type on Performance

We found that performance (i.e., endurance time) increased from the time-trial to the one-on-one competition. This finding is consistent with one of the seminal social psychology studies, in which Triplett (1898) noted that cyclists rode more quickly when racing against opponents than when racing alone. Importantly, and in line with our hypothesis, we also found that performance increased from the one-on-one to the two-on-two competition. This replicates the finding of Tauer and Harackiewicz (2004), providing further evidence to indicate that team competition can promote better performance than individual competition in sport. Finally, we extended the design of Tauer and Harackiewicz (2004) by also considering performance during a four-on-four competition. Although performance in the four-on-four competition was similar to the two-on-two competition, it was no longer better than performance in the one-on-one competition. This could suggest that larger groups negate the proposed facilitative effects of team competition on performance. For instance, a potential negative effect of team competition is that individuals may engage in social loafing (e.g., Latane, Williams, & Harkins, 1979), with this being more likely to occur when the size of the team is large (e.g., Kerr & Bruun, 1983). In sum, our results emphasize that different types of individual and team competition can differentially influence performance.

Effects of Competition Type on Emotions

Different types of individual and team competitions also elicited different levels of enjoyment and anxiety. First, we found that self-reported enjoyment and anxiety increased from the time-trial to the one-on-one competition. Our finding of increased enjoyment agrees with Walker's (2010) observation that performing motor tasks with an opponent is more enjoyable than performing them alone. He suggested that social flow, a psychological state that occurs when operating alongside others, is more enjoyable than solitary flow, a psychological state that occurs when performing alone.

In contrast, our finding of increased anxiety seems to disagree with Martin and Hall's (1997) suggestion that differences in the level of identifiability are responsible for changes in anxiety among different types of competition. This is because participants were competing as individuals in both the time-trial and one-on-one competitions, and, thus, one would expect identifiability to have been the same (e.g., Martin & Hall, 1997; Gilovich & Savitsky, 1999; Simon & Martens, 1979). Moreover, the number of coactors and experimenters in view of participants (i.e., the audience) was the same across all competitions, thereby ruling out an audience-based interpretation of our result. However, it is possible that having an explicit opponent(s) increases the potential for comparing and evaluating performance regardless of the size of the audience (Martens, 1975). Therefore, increased anxiety from the time-trial competition to the one-on-one competition may be attributed to greater social comparison with, and evaluation by, an opponent in the one-on-one competition.

Interestingly, our physiological measures also varied between the individual competitions. Specifically, heart rate and cardiac contractility increased while r-MSSD decreased from the time-trial to the one-on-one competition. Moreover, force output, muscle activity, and the influence of the baroreceptors on cardiac activity were similar across all competition conditions. Accordingly, the observed changes in cardiovascular activity could have been driven by changes in emotion and, thus, provide corroborative evidence to support the self-report measures. Specifically, increased heart rate and cardiac contractility could reflect the observed increase in self-reported joy and/or anxiety, while decreased r-MSSD could be an additional marker of increased self-reported anxiety from time-trial to one-on-one competition (e.g., Mateo et al., 2012; Sinha et al., 1992; Tugade & Fredrickson, 2004).

Further differences in emotion were apparent among the one-on-one competition and the team competitions. Specifically, we found that self-reported enjoyment increased from the one-on-one competition to both of the team competitions. This hypothesized finding could have been driven by participants feeling related to and united with their teammates during the team competitions (Tauer & Harackiewicz, 2004; Ryan & Deci, 2000). Moreover, this finding appears to be partially corroborated by our physiological measures. Specifically, heart rate and cardiac contractility increased while r-MSSD was unchanged from the one-on-one to the two-on-two competition. Although this pattern of cardiovascular responding characterizes several emotions, it seems likely, in the context of the current study, to have been driven by the observed increase in self-reported joy (e.g., Sinha et al., 1992).

Finally, we found that self-reported anxiety was the same during the one-on-one and two-on-two competitions, but was elevated during the four-on-four competition. As participants faced four explicit opponents, the potential for comparing and evaluating performance

should have been greatest in the four-on-four competition (cf. Martens, 1975). Moreover, this team competition may have elicited feelings of responsibility toward teammates that were not present in the individual conditions (e.g., Gray, 2004; Jones & Lavallee, 2010). Therefore, greater anxiety during the four-on-four competition may be attributed to the additive effects of the multiple anxiety-inducing factors (e.g., social comparison and evaluation and responsibilities to others) that are present when competing in a team. However, our physiological measures provided no evidence to corroborate this finding. Specifically, *r*-MSSD was the same across one-on-one, two-on-two, and four-on-four competitions, whereas heart rate and cardiac contractility actually decreased from the two-on-two competition to the four-on-four competition. Accordingly, this effect of group size on anxiety may not be as strong as the previously described effects of competition on emotion.

Alternatively, it should be conceded that studies identifying increased heart rate and cardiac contractility coupled with decreased *r*-MSSD as physiological characteristics of increased anxiety generally investigated anticipatory anxiety, such as that experienced in the moments before a sporting competition or the delivery of a public speech (e.g., Mateo et al., 2012; Tugade & Fredrickson, 2004). Accordingly, even though our suggestion that these physiological responses might reflect anxiety and be used to corroborate self-reports of anxiety during task performance is appealing, much work remains before we can confidently present physiological response patterns as validated signatures of emotion.

Other potential reasons for disconnects between the self-report and physiological measures are as follows: First, our physiological measures could have been influenced by differences in ventilation across the different competitions (e.g., Mulder, 1992). We would not expect ventilation to have differed given that participants were seated and muscle activity was similar across all competitions. However, our lack of a ventilation measure means that this possibility cannot be ruled out. Future studies should concurrently measure ventilation so that its effects on autonomic activity can be taken into account (Mulder, 1992). Second, it is possible that self-report and physiological responses reflect different aspects of emotions. Indeed, Mauss and Robinson (2009) demonstrated that self-report and physiological measures of emotions are both relevant, but are not interchangeable, as they reflect unique sources of variance. Thus, our multimeasure approach seems justified. Efforts to validate physiological indices of emotions (e.g., Mateo et al., 2012) and further explore the best ways to assess emotion seem worthwhile avenues for future research.

Mechanisms Underlying Performance

To examine the key purpose of our study, we employed mediation analyses to evaluate enjoyment-based (Tauer & Harackiewicz, 2004) and anxiety-based (Eysenck &

Calvo, 1992; Eysenck et al., 2007) mechanisms as explanations for the observed changes in performance among different types of competition. Performance improved from time-trial to one-on-one to two-on-two competitions. In agreement with both enjoyment-based and anxiety-based mechanisms, we found that improvements in performance from the time-trial to the one-on-one competition were mediated by increases in effort. Moreover, in agreement with the enjoyment-based mechanism, we also found that improvements in performance from the time-trial to the one-on-one to the two-on-two competitions were mediated by increases in enjoyment. Finally, and crucially, mediation analyses revealed that both self-reported enjoyment and anxiety partially mediated the observed increases in self-reported effort. Thus, rather than being alternatives, this finding suggests that the enjoyment-based and anxiety-based mechanisms both play a role in explaining changes in performance among different types of individual and team competitions.

Limitations and Future Directions

There are some limitations of our experiment that need to be considered when interpreting our findings. First, our mediation analyses were conducted separately for each mediator. Future studies could gain a more detailed illustration of the causes of changes in performance by including all mediators in the same model. Structural equation modeling could be employed to conduct this analysis. Unfortunately, we were unable to apply this technique as our sample size was too small (MacKinnon, 2008). Second, it is conceded that anxiety can only be expected to increase effort when an individual is at least moderately confident of success (Hardy, Beattie, & Woodman, 2007). Accordingly, future research should assess self-confidence alongside anxiety and effort.

It would also be interesting for future research to examine whether personality traits interact with different types of competition. For example, Woodman, Roberts, Hardy, Callow, and Rodgers (2011) measured trait narcissism and found that highly narcissistic individuals performed better during conditions in which identifiability was high. This result could indicate that high narcissists will perform better in individual competition than in team competition. Future research could also obtain measures of attentional control, such as eye-gaze behavior (e.g., Wilson et al., 2009), which can provide a more detailed insight than we have provided into the attentional mechanisms that are implicated within anxiety-based theories of performance (e.g., Eysenck et al., 2007). Finally, future research could extend the current study by examining the effects of team competition on emotions and performance as a function of group size, with larger groups than employed here. This is because larger groups could increase incidences of social loafing (e.g., Kerr & Bruun, 1983), thereby reducing levels of effort (Woodman et al., 2011). Future research investigating performance in larger groups should shed light on this issue.

Conclusion

In conclusion, we have provided evidence to indicate that different types of individual and team competitions differentially influence performance, enjoyment, anxiety, and effort, with each of these variables tending to be greatest during team competitions. Moreover, we found that increased enjoyment and anxiety mediated increased effort. Furthermore, increases in enjoyment and effort led to improvements in performance. These findings support enjoyment-based (Tauer & Harackiewicz, 2004) and anxiety-based (Eysenck & Calvo, 1992; Eysenck et al., 2007) mechanisms to explain the effects of different types of competition on performance. Future research should continue to examine the roles of positive and negative emotions on performance, and add greater detail to our understanding of the powerful relationships among different types of individual and team competitions and emotions and performance in sport.

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