Collective Emotions in Doubles Table Tennis

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Abstract

Researchers have shown that the emotions that athletes experience during sporting competition can be transferred between team members to create collective team emotional states. Nevertheless, collective emotions have not yet been investigated for sporting dyads. In this study the emotional experiences of 68 doubles table tennis players (34 dyads) were examined at three time points, pre-competition, in-competition and post-competition. It was found that the intensity of each emotional state differed as a function of match situation (positive/negative). Moreover, in-competition anxiety, dejection and anger were shown to predict poorer subjective performance, and anxiety was shown to negatively impact future objective athlete performance. Most pertinently, within-dyad emotional aggregation was identified for athlete in-competition happiness and dejection, and for post-competition happiness, dejection and anger. These findings represent the first quantitative evidence of emotional convergence in sport dyads and provide support for the social-functional theory of emotion in sport.

Keywords: Emotion, temporal, performance, collective emotion, emotional contagion.
Collective emotions in doubles table tennis

Athlete emotions are defined as brief, discrete subjective experiences which can vary in response to the context specific sporting events which occur (see Wagstaff & Tamminen, 2021 for a recent review). For example, scoring or losing a point can alter an athlete’s emotional experience (Fritsch et al., 2020; Seve et al., 2007). Athletes’ emotions have also been found to develop as a result of the interpersonal emotional influence exhibited by their coaches, opposition and teammates. For instance, Van Kleef (2009) explained in the Emotions as Social Information (EASI) model that other individuals’ emotional displays can influence the affect, cognitions and behaviour of observers. As such, one can infer that athletes’ emotions do not occur in a vacuum as they are likely to impact, and be impacted by, social interactions (Tamminen & Bennett, 2017). For instance, observing a teammate’s positive emotional display may lead one to feel happier or a teammate witnessing you upset could result in them attempting to comfort you. A deeper understanding of the impact that these interpersonally developed emotions can have in an in-competition context will significantly advance both the literature and the applied field.

A primary focus of this study was the use of an in-competition emotion measurement method to assess the transient emotions that athletes experience throughout sport competition, as well as investigating the effect that these emotions may have on performance. In-competition, context-specific measurement of athlete emotion allows for a greater degree of measurement accuracy, specificity and the opportunity for multiple emotion assessments to occur (Campo et al., 2019; Campo et al., 2018; Freemantle et al., 2021). In the absence of in-competition measures, post-competition methods have been used to assess the prevalence, antecedents and consequences of athletes’ in-competition emotions (Martinent & Ferrand, 2009; Neil et al., 2011; Vast et al., 2010). Researchers have sought to identify athletes’ experienced emotions as well as focus on the effect that these emotions may have on athletes’
subjective and objective performance (see Janelle et al., 2020 for review). For instance, increased intensity of athlete positive emotion has been found to be associated with an improved subjective performance in softball (Vast et al., 2010), and an improved objective performance in basketball (Uphill et al., 2014). Uphill et al. using a questionnaire methodology, also highlighted, the significant detrimental impact that an increased intensity of negative emotions, such as anger, can have upon successful objective game involvements. Nevertheless, some researchers argue that the effect of anger can be both facilitative and debilitating for athletes depending on the sporting context (Robazza et al., 2006). Qualitative assessments in table tennis have indicated that simpler relationships may exist between the athletes’ experienced emotions and their performance. Using self-confrontational interviews, Martinent and Ferrand (2015) found that national level table tennis athletes associated positive emotion with successful performance and negative emotion with performance dissatisfaction. Qualitative assessments of table tennis athletes’ emotions have provided the field with useful insights. Yet, a quantitative assessment of athletes’ emotions, completed during competition, as in the current study, affords a rich examination of the emotional states that athletes experience and an objective understanding of how these transient emotional states may affect subsequent performance.

The above evidence and the majority of the ‘emotions in sport’ literature, focuses on the effect of individual athletes’ emotional states on an outcome measure relevant to the individual. Nonetheless, researchers are increasingly cognisant of social-functional approaches to emotion (Friesen et al., 2020; Van Kleef et al., 2019; Wagstaff & Tamminen, 2021). It is recognised that athletes’ emotions can occur, in part, as a result of the social environment in which the athlete is situated (see Tamminen & Bennett, 2017). In social contexts, emotions may help to communicate intentions and serve as deterrents, as well as strengthen group bonds and define social boundaries (Wagstaff & Tamminen, 2021).
Although an emotion is experienced individually, any emotional expression is likely to be public in its display, thus influencing those individuals in proximity. This influential emotional environment is a key facet of the EASI model (Van Kleef, 2009). Evidence that athletes experience interpersonal affective relationships has been presented in support of the EASI model and researchers have reasoned that the emotions felt during sport, especially team sports, should be considered social phenomena because they arise out of interactions rooted in social connections (Tamminen & Bennett, 2017).

Moreover, the social emotional influence that athletes experience when situated in teams has been shown to lead to the generation of collective team emotions through interpersonal emotional transfer (Tamminen et al., 2016; Wolf et al., 2018). Collective emotions are defined as the synchronous convergence of affect across individuals in response to a specific event (von Scheve & Ismer, 2013). Tamminen et al. (2016) found evidence for collective emotions in a qualitative assessment of student athletes’ emotional experiences and stated that collective emotions can be both positive and negative and can serve facilitative functions, such as a contribution to social bonds. Totterdell (2000) was the first to investigate the concept of social affect within a sports team. He found quantitative evidence for collective affective states within cricket players on the same team and showed that an athlete’s positive mood was significantly related to that of their teammates. Totterdell proposed that this emotional association occurred because of social phenomena, rather than simply the athletes individually experiencing the same emotion in relation to the same events.

Emotional contagion, the conscious and unconscious transfer of emotion between individuals in a group (Hatfield et al., 1994), was used by Totterdell to explain this interpersonal affective association. This bi-directional emotional transfer process is facilitated by tone of voice, physiological factors, facial expressions, and explicit verbal communication.
Further to the EASI model, other explanatory models have been proposed to explain shared action in teams which focus solely on conscious cognitive processes (see Reimer et al., 2006). For instance, Boss and Kleinert (2015) used Heider’s balance theory to explain performance lapses facilitated by social contagion in dyads. In Boss and Kleinert’s experimental work, the conscious appraisals relevant for emotional contagion were also cited as contributory factors for the interpersonal devaluation processes central to balance theory and the subsequent shared performance collapse. Nevertheless, emotional contagion, as explained by the EASI model, incorporates emotional transfer through both conscious (inferential processes) and unconscious (affective reactions) methods (Van Kleef, 2009). The EASI model emotionally relevant cognitive appraisals relate to individuals recognising others’ emotional displays and using that information to inform their own emotional state. In contrast to other more cognitive models, social functional emotional theories provide a useful encompassing explanation for the development of specifically collective emotions. This is due to the consideration of both conscious and unconscious processes, and evidence within sport for the underpinning emotional expression and identification behaviours. Additionally, evidence from outside of sport has shown the collaborative effect that automatic processes can provide more considered emotional appraisals in the facilitation of collective emotions when both processes are enacted collaboratively (Parkinson & Simons, 2009).

Although the contagious effect of emotion in sports teams is understudied, athletes are adept at identifying other athletes’ positive and negative non-verbal emotional expressions (Drewes et al., 2020), which arguably represent an essential cornerstone of emotional contagion. Furthermore, in support of the presence of emotional contagion in sport contexts, Rumbold et al. (2021) found evidence of collective emotions in soccer teams following a match. These collective emotions were partially facilitated by athlete’s verbalising their feelings and presenting emotional expression behaviours. Although not between teammates,
emotional contagion has also been found to be present in relationships between opposing soccer players (Moll et al., 2010) and in coach-athlete relationships (Cotterill et al., 2020) owing to similar demonstrated emotional indicators. Researchers of performance collapses have also established support for the presence of interpersonal emotional transfer in sport and the impact that these social emotional concepts can have on team performance and emotional states. For instance, in their qualitative explorations of performance collapses, Wergin et al. (2018) and Cope et al. (2010) demonstrated the existence of a contagious spreading of negative emotions when team performances became worse. It was also shown that one individual with a particularly detrimental and negative attitude was able to trigger an interpersonal spread (Cope et al., 2010). These studies offer further evidence that sport provides rich contextual and social characteristics for the study of inter-personal emotional aggregation through emotional contagion.

Emotional aggregation and emotional convergence are two terms used within the literature to outline and explain concepts related to the processes of emotional contagion. Emotional convergence describes the tendency for the emotions of two or more individuals to become more alike over a period of time (Zablah et al., 2017). Emotional aggregation has not been defined within the literature, and therefore, in the current study, we use the term to refer to a shared, group emotional state consisting of similar constituent individual group members’ emotions. As such, group emotional aggregation relates to a measurement taken at a single time point, while evidence of emotional convergence requires a group’s emotional similarity to increase over time. We argue that both emotional aggregation and emotional convergence necessitate the demonstration of emotional contagion.

Dyads are found across differing sporting contexts. For instance, dyadic relationships have been investigated in table tennis (Greenlees et al., 2005), tennis (Lausic et al., 2009) and volleyball (Wickwire et al., 2004). Sporting dyads consist of two individuals with ambitions
toward a shared competitive goal and who have shared experiences of the same events. Consequently, these pairs often engage in extensive communication while competing and a substantial amount of this intra-dyadic communication is emotional in nature (Lausic et al., 2009). Indeed, table tennis offers multiple opportunities for intra-pair communication throughout a match as a result of the teammates’ close proximity and the frequent pauses between points that often involve an explicit outward emotional reaction (Fritsch et al., 2020; Poizat et al., 2009). Relevant here is that observers have been shown to correctly categorise table tennis athletes’ post-point emotional reactions as either emotionally positive, neutral or negative, indicating that the nature of these outward emotional reactions can be largely accurately identified by a general healthy population (Fritsch et al., 2020). Instances of non-verbal emotional communication between table tennis players throughout matches, not solely between points, have also been shown to impact the in-competition cognitions and expectations of athletes (Greenlees et al., 2005). A qualitative investigation completed by Poizat et al. (2009) showed that a table tennis pair consistently communicated both verbal and non-verbal information while competing. Approximately 85% of this communicated information was relevant to the collaborative partnership and most of the information was symmetrically communicated (i.e., the pair were communicating similar information at similar times). These frequent instances of intra-team communication, which are often distinctly emotional, may provide the necessary opportunities for the development of collective emotions and emotional convergence in table tennis partnerships through both unconscious and conscious emotional contagion. Despite these observations, no studies have investigated how an athlete’s emotional state may affect that of their performance partner. Quantitative evidence for the presence of intra-team emotional aggregation has been presented for larger teams during matches (viz., cricket, Totterdell, 2000), yet evidence for the existence of the concept within sports dyads, has not been examined. The dyadic analysis
is important given their prevalence within sport, and in light of the widespread existence of informal dyad relationships in team sports (e.g., the scrum half and fly half in rugby, or the two sweepers in curling) and across stakeholder groups (e.g., between individual athletes and coaches). Evidence is required to better understand the within-dyad social emotional influence that sport partners can demonstrate, in order to examine the theory of EASI model processes within a wider range of applied contexts. Additionally, Totterdell’s (2000) work remains the only study in which researchers have included an assessment of intra-team emotional aggregation during a sport competition, and as such, there remains much to be explored in terms of in-competition collective emotional states in sport.

In the present study, our aim was to investigate the effect that athletes’ emotional states may have on their partners’ emotions while competing in table tennis matches as a dyad. Social-functional approaches to athlete emotions (Friesen et al., 2020; Van Kleef, 2009) were central to the development of the research aims. Owing to doubles athletes’ repeated exposure to each other’s emotional expressions (Fritsch et al., 2020; Poizat et al., 2009), as well as evidence of emotional aggregation in other sports (Rumbold et al., 2021; Totterdell, 2000), it was predicted that the dyad pairs would present an aggregated emotional state following periods of collaborative competition. We also expected the athletes’ emotional states to vary as a function of match (positive/negative) situation, and for individual emotional states to affect subjective and objective performance. In line with evidence from the literature, we hypothesised that positive emotions would predict better performance while negative emotions would predict weaker performances.

**Methods**

**Participants**

Sixty-eight male amateur table tennis players (34 dyads) competing in competitive doubles league matches were recruited. The average age of the sample was 31 years ($SD =$
13.3 years) and the pairs had, on average, competed together in 3 matches in the year prior to the study (range of 0 matches to 10 matches). In order to detect a medium to large effect size with 80% power for the comparison of the emotions experienced across the three match performance groups, G*Power suggested that a sample size of 66 participants was required. A sample size of approximately 29 dyads was needed to detect an intra-class correlation coefficient value of between .4 and .5 with 80% power and .05 alpha level (Bujang & Baharum, 2017). Actor-Partner Interdependence Models (APIM) are suited to smaller sample sizes and APIMs have been found to adequately detect differences in smaller sample sizes than those presented in this analysis (see Tambling et al., 2011).

Design

A three-time point (pre-competition, in-competition, and post-competition) longitudinal questionnaire design was used in this study to assess athletes’ emotions across a table tennis match. Analyses were run to examine the differences in emotion intensity across time and match performance. Additionally, the within-dyad emotional aggregation was assessed at each of the three time points. This design allowed for a deeper examination of the athletes’ emergent collective emotional experiences and considered the transience of sporting emotion (Campo et al., 2018).

Measures

Emotion

The athletes’ emotional states were measured using the Brief In-Competition Emotion (BICE) scale (Freemantle et al., 2021). The BICE scale has been developed for the assessment of athletes’ in-competition emotions and evidence has been presented to support the validity of this scale (Freemantle et al., 2021). The 10-item questionnaire measures emotion across the five principal factors of anxiety, happiness, dejection, excitement and anger and uses a 5-point Likert scale ranging from 0 (Not at All) to 4 (Extremely). All five of
the emotion factors presented a McDonald’s Omega reliability score of above .7 across the three data collection time points.

**Subjective Performance**

The participants were asked to rate how well they believed they were playing and how well they thought their pair were collectively playing using separate 70mm visual analogue scales ranging from Poor to Excellent. Similar measures of subjective performance have been utilised within the literature (e.g., Arnold et al., 2018). The athletes were also asked to provide an insight into how likely they thought it was that they would win the match. A 70mm visual analogue scale anchored at Very Unlikely and Very Likely was used for this measure. This is a similar methodology to that used in Totterdell (2000) which included a favourableness of match situation rating scale.

**Objective Performance**

The athletes’ objective performance was operationalised as the number of points the pairs’ opponents had scored subtracted from the number of points the participant pair had scored. A negative score indicated that the participants had lost more points than they had won. Point difference has been shown to be a useful indicator in predicting athlete performance and the likelihood of winning matches (Barreira et al., 2016).

**Susceptibility to Emotional Contagion**

The Contagion of Affective Phenomena Scale (Clarkson et al., 2021) was used to assess the participants’ susceptibility to experiencing emotional contagion. The scale includes 29 items using a 5-point Likert scale ranging from 1 (Never True) to 5 (Always True). An overall susceptibility score can be calculated, as well as a positive emotion susceptibility score (McDonald’s Omega = .836), a negative emotion susceptibility score (McDonald’s Omega = .883) and a general susceptibility score (McDonald’s Omega = .902). Positive emotion susceptibility is measured using items such as “when people around me are buzzing
with excitement, I get excited too”, while examples of an item assessing negative emotion susceptibility include “I feel tense when those around me are worrying about something”. General emotion susceptibility is assessed using items such as, “other people’s emotions impact my own emotions”.

**Procedure**

The participants provided informed consent before beginning their doubles table tennis match. All of the questionnaires were administered by the first author and were completed using pen and paper. The first data collection time point occurred approximately 10 minutes before the match commenced. At this pre-competition time point (Time 1), the participants completed the BICE scale and an assessment of the likelihood that they would win the match. The second data collection point (Time 2) was undertaken in the one-minute allotted break in play between the second and third games during the match. The participants completed the BICE scale, a subjective assessment of their own performance, their collaborative performance as a pair and the likelihood that they would win the match.

Following the completion of the match, the participants then immediately took part in the third data collection session (Time 3). Here the participants completed their final BICE scale assessment and a subjective assessment of their own performance and their collaborative pair performance since Time 2. Within approximately 30 minutes of the post-competition time point, the participants completed the Contagion of Affective Phenomena Scale (Clarkson et al., 2021). Institutional ethical approval was granted for this study (SFEC 2019-066).

**Data Analysis**

First, separate repeated measures ANOVAs were run to investigate how each of the five athlete emotional states changed over time (pre-, in- and post-competition). A single mixed ANOVA was also run to assess whether the BICE scale emotion factors were experienced at different intensities by participants who were winning, drawing or losing at
Time 2 and those who had won or lost at Time 3. In these ANOVA models, the within
subjects variable was emotion (anxiety, happiness, dejection, anger and excitement) and the
between subjects variable was the match performance (winning, drawing or losing and won
or lost). In addition, an ANCOVA model was completed which examined the relationship
between the five measured emotions at Time 1 and Time 2 with subsequent objective
performance (between-subjects), while controlling for the athletes’ objective performance at
the time of emotion measurement. Regression analyses were run to measure the extent to
which emotion could predict subjective personal performance. All statistical assumptions
were met for each of the analyses that were run.

The emotional aggregation exhibited by the dyad pairs was assessed using an Actor-
Partner Interdependence Model (Kenny et al., 2006). A partial intraclass correlation
coefficient (ICC) was calculated for the dyads’ five emotional states at Time 2 and Time 3
while controlling for the athletes’ objective (the pairs’ points difference at the time of
emotion measurement) and subjective (the self-assessment of the pair’s collaborative
performance) experiences of the match at the time. These two variables were chosen so as to
remove residual emotional similarity which may have occurred as a result of the partners’
shared match environment. Significant ICC values have previously been used to indicate
empirical support for aggregation (Bartel & Saavedra, 2000; Kenny & LaVoi, 1985) and ICC
values between .40 to .75 represent fair to good agreement (Fleiss, 1986). The
interdependence of the emotion scores was also assessed, such that any unexplained variance
in the similarity of the dyads’ emotion scores indicated the existence of an emotional
aggregation which did not occur as a result of the participants experiencing the same match
characteristics.

**Results**

**Performance Correlations**
The correlations between the objective and subjective performance measures for both Time 2 and Time 3 can be found in Table 1. The participants’ subjective assessments of their performance and their collaborative pair performance was highly correlated with their objective performance at both Time 2 and Time 3.

[Table 1 here]

**Emotional Experiences**

Table 2 presents the means, standard deviations and group differences of the five emotion factors at all three data collection time points. Post hoc Bonferroni pairwise comparisons showed that athlete Happiness at Time 1 was significantly higher than at Time 2. Athlete Anxiety was significantly higher at Time 1 and Time 2 than at Time 3. The athletes experienced significantly less Dejection at Time 1 compared to Time 2 and Time 3 and the same pattern was found when comparing Anger at Time 1, Time 2 and Time 3. The only significant difference between time points for Excitement was between Time 1 and Time 2.

A mixed factorial ANOVA assessing the effect of match situation and emotion factor on emotional intensity was completed for Time 2. Table 3 shows the means, standard deviations and confidence intervals while Table 4 shows the ANOVA results. Bonferroni corrected pairwise comparisons were also completed. Happiness scores were significantly lower for those athletes losing compared to those winning. The athletes felt significantly less dejected when winning and drawing compared to when losing. Additionally, the athletes were significantly less angry when winning compared to when losing. There were no significant differences in Excitement or Anxiety scores whether winning, drawing or losing.

A second mixed factorial ANOVA was conducted to examine whether the athletes’ post-match emotions differed at Time 3 dependent upon whether they had won or lost the match. A significant main effect was found for emotion, $F(1.80, 118.91) = 56.03, p < .001$, $\eta^2_p = .46$, and a significant main effect was found for match performance, $F(1, 66) = 5.48, p =$
.022, $\eta^2_p = .08$. The interaction effect was also significant, $F(1.80, 118.91) = 33.28, p < .001,$ $\eta^2_p = .36$. Bonferroni corrected pairwise comparisons were again run to assess this significant interaction effect and all five emotion factors were shown to present significantly different emotional intensities whether the athlete had won or lost the match (see Table 5).

[Table 2, 3, 4 and 5 here]

**Emotions and Performance**

**Subjective Performance**

Regression analyses were completed to investigate whether each of the emotion factor scores at Time 1 could predict subjective performance assessments made at Time 2. While controlling for the participants’ pre-match assessments of their likelihood of winning, only the participants’ levels of pre-competition Excitement had a significant additional predictive impact upon subjective personal performance levels at Time 2 (Beta = .262, $p = .011$, $R^2$ change = .080). These findings suggest that increased levels of pre-competition Excitement were related to higher subjective in-competition performance.

Similar regression models were then completed to assess the effect of the participants’ Time 2 emotion on their subsequent subjective personal performance while controlling for the Time 2 assessment of their likelihood of winning the match. The participants’ during match Anxiety (Beta = -.277, $p = .015$, $R^2$ change = .078), Dejection (Beta = -.309, $p = .005$, $R^2$ change = .100) and Anger (Beta = -.230, $p = .018$, $R^2$ change = .073) all contributed a significant additional effect to their subjective personal performance assessments. Time 2 Anxiety (Beta = -.221, $p = .037$, $R^2$ change = .048), Dejection (Beta = -.223, $p = .020$, $R^2$ change = .059) and Anger (Beta = -.191, $p = .021$, $R^2$ change = .058) also significantly predicted Time 3 subjective performance when Time 2 points difference was instead controlled for.

**Objective Performance**
An ANCOVA assessing the effect of Time 2 emotion on subsequent objective performance (won or lost) while controlling for the participants’ objective points difference at Time 2, $F(1, 65) = 1.72, p = .20, \eta^2_p = .03$ was then run. The main effect for both emotion factor, $F(1.76, 114.05) = 49.68, p < .001, \eta^2_p = .43$, and match performance, $F(1, 65) = .53, p = .01, \eta^2_p = .11$, were shown to be significant, and the interaction effect was non-significant, $F(1.75, 114.05) = 1.46, p = .24, \eta^2_p = .29$. Bonferroni corrected pairwise comparisons showed that only Time 2 Anxiety was significantly different for the participants who subsequently won or lost the match. The participants who lost ($M = 2.44, 95\% CI [1.76, 3.12]$) were found to have been experiencing more Anxiety at Time 2 than those who won ($M = 1.09, 95\% CI [.67, 1.50]$).

**Emotional Aggregation and Convergence**

At Time 2, both dyad Happiness (ICC = .488, $p < .001$) and Dejection (ICC = .395, $p = .008$) presented significant within-dyad partial ICC values. This was consistent with the prediction that the dyad pairs would experience emotional aggregation and present a collective team emotion. Of the within-dyad variance, 75.1% of the Happiness variance and 69.4% of the Dejection variance was not explained by the comparative subjective and objective match contexts that both dyad members were experiencing simultaneously. These results suggest that mechanisms other than the participants experiencing the same match characteristics contributed to the aggregated emotional states that the dyad pairs demonstrated. Owing to previous evidence from the literature which shows that sport provides the necessary social and contextual characteristics for interpersonal emotional transfer to occur, these influential emotional processes may have assisted in creating the within-dyad collective emotional states.

In additional support of the predictions, at Time 3, Happiness (ICC = .539, $p < .001$), Dejection (ICC = .491, $p = .001$) and Anger (ICC = .518, $p < .001$) scores all presented
significant within-dyad partial ICC scores when controlling for the athletes’ subjective and
objective experiences of the match at the time. Further, the within-dyad emotional variance
not explained by athletes’ subjective or objective performance was 62.1% for the Happiness
scores, 55.7% for Dejection scores and 61.2% for Anger. Consequently, large proportions of
the within-dyad emotional variance were caused by factors other than the shared match
timess and may therefore have been facilitated by interpersonal emotional transfer.

The partial ICC values were found to increase between Time 2 and Time 3 for all of
five measured emotions. These increases indicate that the athletes within the same dyads
presented a more similar emotional state as the match progressed, thus suggesting emotional
convergence. The ICC values can be found in Table 6.

[Table 6 here]

Emotion Aggregation and the Contagion of Affective Phenomena Scale

The participants recorded an average overall emotional contagion susceptibility value
of 2.88 ($SD = .50$), an average positive emotional contagion susceptibility score of 3.63 ($SD =
.56$) and an average negative emotional contagion susceptibility score of 2.52 ($SD = .56$). The
same APIM models from the aggregation analysis were run with the Contagion of Affective
Phenomena Scale (CAPS) scores also included as a predictor. Significant increases in the
variance explained by the models after the addition of the CAPS scores would suggest that
the participants’ subjective assessments of their susceptibility to experience emotional
contagion contributed to explaining their within-dyad emotion similarity. The addition of the
CAPS scores significantly increased the variance explained by the APIM model for the
within-dyad Happiness scores by 8.5% at Time 2 and by 18.9% at Time 3. The inclusion of
the subjective CAPS scores in the model for Dejection at Time 2 and Time 3, and for Anger
at Time 3 did not significantly affect the variance explained by the model.

Discussion
In this study, we examined the emotional experiences of doubles table tennis players using an in-competition emotion measurement technique. The emotions that the athletes’ experienced throughout their matches were highlighted, as well as the impact that these emotions had upon the athletes’ subjective and objective performance. In addition, and in line with the study hypotheses, we present data that provide evidence of within-dyad emotional aggregation at both the in-competition and post-competition time points.

In general, the results of the present study act to support the hypothesis and the current literature which suggests that athletes experience more negative emotions when losing or following a loss and they experience more positive emotions when winning or following a win (see Jones & Sheffield, 2007; Polman et al., 2007). These quantitative results can be interpreted to also support the qualitative findings presented by Seve et al. (2007) and Martinent and Ferrand (2015), who showed that table tennis players experience more pleasant and fewer unpleasant emotions when winning games and vice versa when losing games. The participants who were drawing at Time 2 demonstrated an emotional response which was consistently emotionally situated between the winning and losing athletes’ emotional experiences. For example, the drawing athletes were not as happy as the winning athletes but happier than the losing athletes. Table tennis matches cannot be drawn, therefore both a match win or loss were still possible for these athletes and it is thus not surprising that their emotional profiles were somewhat indicative of the possibility of either eventual match outcome. The novel in-competition methodology used in this research provides further evidence of the transient emotions which Campo et al. (2018) suggest are experienced by athletes in-competition, but which have not previously been quantitatively assessed. To extend this work, researchers might continue to adhere to the methodological recommendations outlined by Wagstaff and Tamminen (2021) regarding the necessity for in-competition assessment when measuring in-competition athlete emotion.
Another objective of the present study was to assess the effect of the five measured emotions on the athletes’ subjective and objective performance. It was found that pre-competition excitement positively impacted future subjective performance while in-competition anxiety, dejection and anger each negatively affected future subjective performance. The present findings therefore suggest that negative emotions are debilitating when experienced during table tennis matches. The athletes’ decrease in subjective performance assessments may have occurred because of maladaptive cognitive appraisals impacting on the athletes’ attitude towards their own performance through internally exaggerating the athletes’ mistakes and ignoring their successful actions (Nicholls et al., 2012). Subjective performance was also highly correlated with objective performance, further highlighting the importance of seeking to improve athletes’ emotional states.

Interestingly, only in-competition anxiety was associated with a reduction in the athletes’ subsequent objective performance. The effect of state anxiety on objective sporting performance has been widely examined, with the vast majority of studies indicating, similarly to the results of the present study, that more intense experiences of anxiety lead to poorer performance (see Woodman & Hardy, 2003). Nevertheless, the objective performance measure that was used here (a win or a loss) was as much a measure of the participants’ pair performance as the participants’ own performance. Therefore, that individual level subjective anxiety was shown to relate to a pair level objective performance measure, indicates the full extent of the impact that experiences of state anxiety can have on athletes’ performance.

The key aim of the current study was to investigate the effect of an athlete’s emotion on their partner’s emotional state and identify any instances of collective emotions. Collective emotions were identified as synchronous emotional states exhibited across individuals in response to a stimulus (von Scheve & Ismer, 2013). In the present study, we have interpreted the data as showing that at Time 2 (between game 2 and 3 of the match) the
athletes’ within-dyad experiences of happiness and dejection were significantly related, and at Time 3 (immediately following the match) within-dyad happiness, dejection and anger were significantly associated. In line with this interpretation, we argue that these results support our hypothesis that happy, dejected and angry emotional states were collectively experienced by the collaborative dyads. This represents the first evidence of this phenomenon in dyadic sport. The significant association between the paired athletes’ happiness scores directly supports Totterdell’s (2000) study which found that cricket players’ happiness was related to the happiness of their teammates regardless of the match situation and any personal hassles. Yet, in the present study, within-dyad collective emotion was also found for participants’ in-competition experiences of dejection and anger, indicating that negative emotions may also aggregate in sports teams and lead to collective emotional states.

In our analysis, within-dyad happiness, dejection and anger emotional aggregation was present after controlling for the pairs’ objective and subjective experiences of their match performance. As a result, and in line with Totterdell’s (2000) conclusions, it can be assumed that some portion of the demonstrated collective emotional states were not established simply as a result of the pair experiencing the same events simultaneously. Owing to previous research indicating that interpersonal emotional transfer may be present in sport (Cotterill et al., 2020; Rumbold et al., 2021; Totterdell, 2000), and evidence that small-sided collaborative teams can experience emotional contagion when undertaking collaborative tasks (Ilies et al., 2007), it was hypothesised that the emotional aggregation highlighted in this study occurred, in part, as a result of emotional contagion (Hatfield et al., 1994). Emotional contagion is the interpersonal transfer of affect, facilitated by facial expressions, tone of voice, gestures and other behaviours (Barsade et al., 2018). In support of this theory, the socially intense environments that sport fosters have been shown to lead to both explicit emotional expressions and subtle, nuanced emotional indicators (Fritsch et al., 2020; Lausic et al., 2015;
Poizat et al., 2009; Tamminen et al., 2016). Indeed, happiness and dejection are two emotions that are easily expressed and identified (Keltner et al., 2019), which may suggest why these two emotions showed a significant within-dyad association at the in-competition time point and the post-competition time point. It is suggested that expressions of excitement and anxiety, when compared to happiness and dejection, may not be so easily demonstrated and identified by individuals, which explains why these emotions did not elicit a significant partial ICC score. Nevertheless, expressions of anger are often frequently explicitly exhibited in sport (Gonzalez-Garcia et al., 2019), hence it is not a surprise that at Time 3, anger was shown to also significantly aggregate within the pair. Hatfield et al. (2014) previously stated that emotional experiences must be of suitable intensity for emotional contagion to occur and therefore it seems that the emotional intensity threshold for anger was met at Time 3 following an increase in the average anger intensity from Time 2.

The within-dyad emotional aggregation observed here was also found to increase for all of the five emotions as the match progressed. Further, the statistically significant aggregation of Happiness and Dejection at Time 2 and then Happiness, Dejection and Anger at Time 3 can be interpreted as support for the pairs experiencing emotional convergence and their emotional states becoming more similar over time. This is the first explicit evidence of longitudinal emotional convergence during sporting competition and these observations significantly extend previous studies which have either not addressed the changes in within-team emotional similarity over time (e.g., Totterdell, 2000) or have only measured within-team emotion aggregation at a single time point (e.g., Rumbold et al., 2021).

The Contagion of Affective Phenomena Scale (Clarkson et al., 2021) was also found to significantly increase the explained variance in the athletes’ within-dyad happiness aggregation. This finding supports the theory that part of the emotional aggregation identified during these table tennis matches can be explained through emotional contagion.
Additionally, the findings suggest that the CAPS may also provide a useful indication as to individuals’ tendencies to experience interpersonally aggregated emotions and may act as a predictor for the likelihood of social emotional transfer in athletes. Further research is encouraged to assess the role that the CAPS may play in predicting emotional contagion.

Regarding limitations, the naturalistic approach that was implemented in this study may have acted as a limitation in presenting supportive evidence for the emotional contagion hypothesis as it was not possible to manipulate the participants’ emotions and the events that they experienced (see arguments proposed by Totterdell, 2000). Instead, as a result of this design, we utilised an analysis technique which provided evidence of within-dyad emotional aggregation and cases of unexplained emotional similarity. As such, this analysis demonstrated evidence of collective emotional states (von Scheve & Ismer, 2013), although the exact causes of these collective emotions are not explicitly clear. Nevertheless, the athletes’ objective and subjective experiences of the match were controlled for in the calculation of emotional aggregation, which would suggest that the collective emotions did not occur solely because of the pairs’ simultaneous experiences of match events. In addition, owing to the frequent emotional communication that sporting dyads have been shown to demonstrate (Lausic et al., 2009), as well as the largely symmetrical information sharing in table tennis doubles pairs (Poizat et al., 2009), it is probable that the required characteristics (e.g. emotional intensity and clear emotional expression) were present for within-dyad collective emotions to occur through interpersonal emotional transfer. Future researchers may wish to conduct experiments which manipulate the emotions of sporting teams before competition to provide further evidence of emotional transfer. Nevertheless, an emotional manipulation would be difficult to achieve in sporting competition and would include an ecological validity cost.
In sum, within-dyad associations in athlete emotion were found for the emotions of happiness and dejection, in-competition, and happiness, dejection and anger post-competition. Previous researchers have found evidence for the presence of emotional aggregation in a range of relationships within sport (e.g., coach-athlete Cotterill et al., 2019; opponent-opponent Moll et al., 2011; large group teammates Totterdell, 2000) and the wider literature has shown that the emotions experienced within sport are socially relevant and interpersonally influential (Tamminen & Bennett, 2017; Van Kleef et al., 2019). Hence, the evidence presented in this study provides support for social-functional theories of emotion within sport and further indicates the effect that teammates’ emotional displays can have upon other’s cognitive and affective states (Van Kleef, 2009). Moreover, this work can be interpreted to indicate that athletes should be wary of negative emotions being transferred within teams, as well as hopeful for the transfer of positive emotion. As such, researchers could extend the present work by investigating the association between athletes’ individual performance measures whilst competing in teams and their transient in-competition emotional profiles. For instance, if an athlete makes a mistake at ‘match point’ this may trigger a more intense intra-personal reaction and thus stronger interpersonal emotional influence than if a mistake is made at the beginning of the competition.

Our examination of table tennis dyad members’ in-competition emotional states has highlighted the salient emotions that athletes experience throughout matches and the collective nature of these emotions. We argue that the presented collective emotions occur, in part, because of emotional contagion. These findings support previous research investigating interpersonal emotional phenomena and provide further evidence that individuals’ emotions are interpersonally relevant in social situations.


Tables

Table 1. Bivariate Spearman’s Rho Correlations between subjective and objective performance measurements taken at Time 2 and Time 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Time 2 Objective Performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Time 2 Subjective Personal Performance</td>
<td>.594**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Time 2 Subjective Collaborative Performance</td>
<td>.625**</td>
<td>.651**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Time 3 Objective Performance</td>
<td>.691**</td>
<td>.419**</td>
<td>.550**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Time 3 Subjective Personal Performance</td>
<td>.510**</td>
<td>.579**</td>
<td>.609**</td>
<td>.587**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Time 3 Subjective Collaborative Performance</td>
<td>.416**</td>
<td>.343**</td>
<td>.590**</td>
<td>.694**</td>
<td>.803**</td>
<td></td>
</tr>
</tbody>
</table>

Note. N = 68
**p<.01
Table 2. Descriptive Statistics and group differences for each of the Five BICE Scale Emotions at Time 1, Time 2 and Time 3

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Time 1 Mean</th>
<th>Time 1 SD</th>
<th>Time 2 Mean</th>
<th>Time 2 SD</th>
<th>Time 3 Mean</th>
<th>Time 3 SD</th>
<th>Differences across Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happiness</td>
<td>5.38</td>
<td>1.76</td>
<td>4.60</td>
<td>2.30</td>
<td>4.90</td>
<td>2.41</td>
<td>$F = 4.27, \ p = .02$</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1.63</td>
<td>1.62</td>
<td>1.76</td>
<td>1.75</td>
<td>0.93</td>
<td>1.67</td>
<td>$F = 8.80, \ p &lt; .001$</td>
</tr>
<tr>
<td>Dejection</td>
<td>0.91</td>
<td>1.59</td>
<td>1.96</td>
<td>2.09</td>
<td>2.59</td>
<td>2.79</td>
<td>$F = 15.15, \ p &lt; .001$</td>
</tr>
<tr>
<td>Excitement</td>
<td>4.38</td>
<td>1.69</td>
<td>5.51</td>
<td>1.87</td>
<td>5.07</td>
<td>2.15</td>
<td>$F = 8.74, \ p = .001$</td>
</tr>
<tr>
<td>Anger</td>
<td>0.94</td>
<td>1.54</td>
<td>2.19</td>
<td>2.29</td>
<td>2.35</td>
<td>2.59</td>
<td>$F = 13.05, \ p &lt; .001$</td>
</tr>
</tbody>
</table>

Note. $N = 68$
Table 3. Descriptive Statistics for each of the Five BICE Scale Emotions whether winning, drawing or losing at Time 2

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Winning</th>
<th></th>
<th>Drawing</th>
<th></th>
<th>Losing</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Confidence Intervals</td>
<td>Mean</td>
<td>SD</td>
<td>Confidence Intervals</td>
</tr>
<tr>
<td>Happiness</td>
<td>5.55</td>
<td>2.40</td>
<td>[4.60, 6.50]</td>
<td>4.54</td>
<td>2.02</td>
<td>[3.67, 5.41]</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1.00</td>
<td>1.23</td>
<td>[.28, 1.72]</td>
<td>2.04</td>
<td>1.51</td>
<td>[1.38, 6.70]</td>
</tr>
<tr>
<td>Dejection</td>
<td>0.96</td>
<td>2.40</td>
<td>[.15, 1.76]</td>
<td>1.77</td>
<td>1.48</td>
<td>[1.03, 2.51]</td>
</tr>
<tr>
<td>Excitement</td>
<td>5.66</td>
<td>1.90</td>
<td>[4.99, 6.56]</td>
<td>5.81</td>
<td>1.77</td>
<td>[5.08, 6.53]</td>
</tr>
<tr>
<td>Anger</td>
<td>1.23</td>
<td>2.49</td>
<td>[.29, 2.16]</td>
<td>2.27</td>
<td>1.93</td>
<td>[1.41, 3.13]</td>
</tr>
</tbody>
</table>

*Note. N = 68*
**Table 4.** ANOVA results table for the differences in emotion intensity across different emotion factors and match situation

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotion Factor (A)</td>
<td>1.79</td>
<td>116.15</td>
<td>50.63</td>
<td>&lt;.001</td>
<td>.44</td>
</tr>
<tr>
<td>Match Situation (B)</td>
<td>2</td>
<td>65</td>
<td>1.94</td>
<td>.152</td>
<td>.06</td>
</tr>
<tr>
<td>A × B</td>
<td>3.57</td>
<td>116.15</td>
<td>4.94</td>
<td>.002</td>
<td>.13</td>
</tr>
</tbody>
</table>

**Table 5.** Descriptive Statistics for each of the Five BICE Scale Emotions at Time 3 whether the athlete had Won or Lost the match

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Won</th>
<th>Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Happiness</td>
<td>6.24</td>
<td>2.06</td>
</tr>
<tr>
<td>Anxiety</td>
<td>0.50</td>
<td>1.05</td>
</tr>
<tr>
<td>Dejection</td>
<td>0.82</td>
<td>2.04</td>
</tr>
<tr>
<td>Excitement</td>
<td>5.97</td>
<td>1.78</td>
</tr>
<tr>
<td>Anger</td>
<td>0.94</td>
<td>2.09</td>
</tr>
</tbody>
</table>

**Table 6.** The Partial ICC values for all Five Emotions at Time 2 and Time 3.

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Time 2 partial ICC Value</th>
<th>Time 3 partial ICC Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happiness</td>
<td>.488*</td>
<td>.539*</td>
</tr>
<tr>
<td>Anxiety</td>
<td>.227</td>
<td>.266</td>
</tr>
<tr>
<td>Dejection</td>
<td>.395*</td>
<td>.492*</td>
</tr>
<tr>
<td>Excitement</td>
<td>.004</td>
<td>.189</td>
</tr>
<tr>
<td>Anger</td>
<td>.288</td>
<td>.519*</td>
</tr>
</tbody>
</table>

*p<.05