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The influence of mental toughness on responses to feedback in snooker: A real-time examination

James C. Welsh [a,b,*], Stephen A. Dewhurst [b], John L. Perry [c]

[a] Liverpool John Moores University, Byrom Street, Liverpool, L3 3AF, UK
[b] University of Hull, Cottingham Road, Hull, HU6 7RX, UK
[c] University of Limerick, V94 T9PX, Ireland

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ABSTRACT

Two experiments investigated whether mental toughness (MT) is associated with the ability to respond to and/or overcome unwanted information during real-time sport performance. Participants were male snooker players ranging from club to professional level, and MT was measured using the MTQ48 (Clough et al., 2002). In experiment 1, players performed five break-off shots and received deceptive feedback (either positive or negative) from the researcher about their performance relative to other players. Then they performed another five break-offs. Results showed a significant decline in performance following feedback, but no interaction with the nature of feedback or MT variables. In experiment 2, feedback was delivered by a coach and yielded a significant effect on performance. Specifically, negative feedback improved performance while positive feedback impaired performance. The Life Control subscale of the MTQ48 was a significant covariate. The results suggest that negative feedback, delivered constructively by a respected figure, may act as a catalyst for performance enhancement in snooker and that this is moderated by MT.

1. Introduction

Dealing with contextual stressors such as negative feedback is purportedly an underpinning attribute of mentally tough individuals in sport (e.g., Gucciardi et al., 2009a; Gucciardi et al., 2017; Jones et al., 2002, 2007; Madrigal et al., 2017; Meggs & Chen, 2018). Yet, despite a consensus across the extant mental toughness (MT) literature supporting this view, little experimental attention has been devoted to examining MT during sporting activity. Although recent experimental efforts have made some theoretical inroads into the relationship between forgetting and MT (e.g., Dewhurst et al., 2012, 2019), the relevance of these findings to sport remains undetermined. In order to address this, we conducted two experiments to investigate how MT influences sporting individuals' responses to perceived failure during real-time performance (s) in situ; specifically, within the sport of snooker.

Evidence suggests that MT is both a personality trait (e.g., Clough et al., 2002; Horsburgh et al., 2009) and a state-like resource "that is purposeful, flexible, and efficient in the nature for the enactment and maintenance of goal-directed pursuits" (Gucciardi, 2017, p. 18). Hence, MT can be viewed as a relatively enduring aspect of people's personality. On the basis that snooker requires players to cope with prolonged periods of concentration amidst in-game contextual stressors (see Welsh et al., 2018), MT would appear to represent a useful construct to examine within the context of snooker.

While different conceptualisations of MT exist in terms of whether it is a unidimensional or a multidimensional concept (see Gucciardi et al., 2015), most are multidimensional in nature. At the same time, qualitative studies have yielded additional nuances of MT (e.g., Gucciardi et al., 2008; Thelwell et al., 2005). However, notwithstanding critiques elsewhere in the literature (Gucciardi et al., 2012, 2013), it is suggested that most characteristics of MT reconcile with Clough et al.'s 4C's model (e.g., Jackman et al., 2017, 2020). As such, a prominent approach that has been broadly used within the MT literature is the 4C's model and Mental Toughness Questionnaire 48 (MTQ48; Clough et al., 2002). Clough & Strycharczyk, (2012, p.1) proposed that MT is "the quality which determines in large part how people deal effectively with challenge, stressors and pressure…irrespective of prevailing circumstances". For the purposes of the current investigation, we aligned with this conceptualisation of MT as it closely adheres to the dynamics of snooker whereby players must be able to remain unaffected by situational stressors (see Welsh et al., 2018).

Briefly, the 4C's model comprises measures of challenge,

* Corresponding author. School of Psychology, Liverpool John Moores University, Byrom Street, L3 3AF, UK.
E-mail address: J.C.Welsh@ljmu.ac.uk (J.C. Welsh).

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commitment, control (life and emotion) and confidence (interpersonal and in one's abilities). According to Clough et al. (2002), challenge is defined as the tendency to see problems as opportunities, and commitment as the ability to involve oneself in the task (not alienated). Life control relates to the belief that individuals have sufficient control over the factors that influence their behaviour and their performances (i.e., capable of achieving what they set out to achieve) and emotional control is the ability to keep one's anxieties in check. Finally, confidence in one's abilities relates to self-belief and less reliance on external validation, whereas interpersonal confidence is demonstrating assertiveness and preparedness to deal with challenge or ridicule. This multidimensional approach affords the opportunity to measure the ability to remain focused on the task at hand irrespective of outcomes (e.g., Dewhurst et al., 2012; Jones et al., 2007).

Some recent studies have attempted to identify the cognitive mechanisms that underpin MT. For example, Dewhurst et al. (2012; see also Dewhurst et al., 2019) used the directed forgetting (DF) paradigm (e.g., Bjork, 1970; Block, 1971) to examine the relationship between MT (as measured by the MTQ48) and the ability to forget unwanted information. Dewhurst et al. (2012) discovered that participants with higher scores on the Commitment subscale of the MTQ48 showed better recall of a to-be-remembered list following instructions to forget the previous list. That is, individuals with higher commitment were more successful at preventing old information from interfering with the acquisition of new information. In contrast, Dewhurst et al. (2019) found a positive correlation between the correct recognition of remember words and the Emotional Control subscale of the MTQ48 when using the item-method DF paradigm (in which the instruction to remember or forget is presented after each word). Dewhurst et al. (2019) concluded that individuals with higher MT have enhanced cognitive control relative to individuals with lower MT. It is important to acknowledge that none of the other subscales of the MTQ48 provided any additional variance across both studies, nor did the Sport Mental Toughness Questionnaire (SMTQ; Sheard et al., 2009) or the Big Five Inventory (BFI; McCrae & Costa, 1987) in the study by Dewhurst et al. (2019). Conceptually however, the findings from both studies highlight the importance of considering the role of different dimensions of MT.

Within sport and performance contexts, receiving feedback (e.g., from a coach) is crucial for the development of MT and performance progression (e.g., Gucciardi et al., 2009a, 2009b; Gucciardi et al., 2015; Hardy et al., 2014; Weinberg et al., 2011). The broader literature has also shown feedback to be a powerful way of influencing motor learning and performance in a practical, non-invasive manner (e.g., García et al., 2019; Jones et al., 2016; Stoate et al., 2012). For instance, García et al. (2019) found that participants given positive feedback before a handball throwing task (in comparison to those who received negative or no feedback) were the only participants to show increased levels of competence. Stoate et al. (2012) also discovered that positive feedback improved the running economy of trained runners, in comparison to a control group who received no performance feedback.

Researchers have also investigated whether performance can be influenced by feedback deception, in which participants are led to believe that they are performing better or worse than expected. Faulkner et al. (2011) found no effects of deceptive feedback in the performance of runners in treadmill time trails. Similar null effects were reported by Wilson et al. (2012) in the performance of cyclists. In addition, Halperin et al. (2019) reported null results of deceptive feedback on the punching forces and pacing of elite boxers. However, Halperin et al. reasoned that their null findings may relate to their elite cohort of participants already having greater levels of MT and superior inhibitory control. Although these studies found no effects of deceptive feedback on performance, other studies suggest deceptive feedback might have psychological effects on athletes. For example, Jones et al. (2016) found that, while deceptive feedback had no additional effect on a cycling time trial performance in the presence of a visual pacer, the deceived group experienced more negative affect and higher rates of perceived exertion. Based on the inconsistencies within the above feedback studies, further consideration of other psychological factors that are associated with MT is warranted.

A number of studies have shown MT to be associated with high-performance states. For example, Jackman et al. (2017) found MT to be associated with characteristics of flow; namely, the ability to concentrate on the task at hand and have a sense of control, irrespective of the positive effects of proximal conditions of flow (see Csikszentmihalyi, 2002). A mediation model additionally showed that other dimensions of The Dispositional Flow Scale-2 (DFS-2; Jackson & Eklund, 2002) - chiefly, challenge-skills balance, clear goals, and unambiguous feedback - to be mediators of the significant indirect effects of MT in relation to concentration on the task at hand and sense of control. Following on from Jackman et al. (2017), Jackman et al. (2020) found results that paralleled the experimental research by Dewhurst et al. (2012). That is, individuals with higher MT were able to put aside past information and focus on the current task, thus having better ability to cope more effectively with negative feedback (adversity) and avoid dwelling on the past. These findings suggest that MT is related to a psychological state that underpins excellent performance. Nevertheless, whilst these studies add value, the use of self-report measures and cross-sectional designs impede inferences of causality, hence underscoring the need for methodological advancements to assess these relationships further.

As discussed earlier, a key conceptual tenet to arise from the MT literature is the ability to remain focused on the task at hand irrespective of outcomes (e.g., moving on from errors). Findings from qualitative studies suggest that athletes with higher MT can move on from errors more effectively (e.g., Jones et al., 2007). However, there has been little experimental research to investigate the cognitive mechanisms of MT during sporting performance. Whilst there have been conceptual and theoretical inroads regarding the association of MT and forgetting unwanted information (Dewhurst et al., 2012, 2019; see Welsh et al., 2018), to our knowledge, no naturalistic research exists in terms of examining the influence of MT on feedback during performance. In the current study, we investigated the impact of MT on forgetting within the context of snooker. Snooker was chosen because it allows us to examine the role of MT in overcoming negative feedback during a real-time, cognitively demanding, closed-skill sport.

We report two experiments examining the influence of MT on sporting performance following the receipt of deceptive feedback (positive or negative) during real-time snooker performances (i.e., break-offs). Players performed a set of break-off shots and then received deceptive feedback (either positive or negative) about their performance relative to other players. Then they performed a second set of break-offs. We predicted that performance on the second set of break-offs would be affected by feedback on the first set. Our main interest was in the role of MT in responding to feedback. Specifically, we hypothesized that the effects of feedback would be reduced in players with high MT. Ultimately, by understanding the relationships between MT, feedback, and performance, this could have important practical implications for coaching practices, players, practitioners, and psychological wellbeing.

2. Experiment 1

2.1. Method

2.1.1. Participants

Participants were 40 English UK male snooker players ($M = 30.6$ years, $SD = 11.19$), with playing level statuses of club ($n = 4$), amateur ($n = 11$), national ($n = 10$), and professional ($n = 15$). National players were those who were currently part of their national teams at the time of investigation. The sample size was sufficient only to detect a large effect in an ANCOVA. As such, we ran a sensitivity analysis in G*Power 3.1.9.7 assuming power of .80, meaning an effect size of $f > 0.55$ was required to yield a statistically significant finding.

2.1.2. Measures

The MTQ48 (Clough et al., 2002) was utilized to measure participants' MT scores. The MTQ48 contains statements to which participants respond on a Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Examples include "Challenges usually bring out the best in me" (challenge), "I usually find something to motivate me" (commitment), "I generally feel in control" (control), and "I generally feel that I am worthwhile person" (confidence). Furthermore, the control subscale is divided into control emotion and life control, and the confidence subscale into confidence in abilities and confidence interpersonal. The quantitative measurement of MT is a source of academic debate. Gucciardi et al. (2012, 2013) raised significant concerns of the factorial validity of the MTQ48. Recently, Perry et al. (2021) examined the factorial structure on a sample of 78,947. While the overall structure was supported, some concerns were highlighted, particularly with regards to the stability of the emotional control subscale.

With regards to participants' snooker performances, a full-size snooker table located within the matchroom of a snooker club in the North-West of England (UK) was used. The table was fitted with steel block cushions and had match table lighting. In addition, a single set of tournament match balls was used throughout the collection of snooker performances. All players were permitted to use their own cues and chalks (both various makes). A tape-measure was used to measure the distances of the cueball to a desired piece of card (i.e., two ball lengths). This card was placed directly behind the green or yellow spots (depending on which side the players break-off from) and was rooted firmly against the baulk cushion. For brevity, the break-off shot in snooker is the initial shot taken by a player at the beginning of a game and/or frame of snooker in which the triangle of 15 reds are broken with the cueball returning to an area of safety (i.e., baulk cushion).

2.1.3. Procedures

Ethical approval was granted by the Faculty Ethics Committee prior to the commencement of the study. All participants were known to the first author and initially contacted by phone. Thereafter, participants were given a participant information sheet to read and a brief demographic questionnaire to fill in, with written informed consent subsequently provided by all participants. Snooker club owners were also known to the first author and spoken to face-to-face, with written consent given for data collection and approval of facilities use. The participant information sheet informed participants that they were required to break-off for a maximum of 10 break-offs. Prior to the start of each individual testing procedure, each participant was instructed to work through the MTQ48 (i.e., first to last item) and informed not to spend more than a few seconds on each item. This took approximately 5–8 min to complete.

2.1.4. Task

All participants were tasked with performing 10 break-offs, with feedback (positive and negative) given after the initial five break-offs. Beforehand, all participants were given a free practice session consisting of 10 break-offs to accustom themselves to the speed and "throw" of the cloth, cushions, and balls. Briefly, throw refers to the cueball pathway reactions (including the use of left- and/or right-hand side-spin across the cloth) relative to the striking of object balls (i.e., cueball distances) in relation to subsequent angle cushion outcomes (e.g., narrow/broad, slow/fast cueball acceleration). Moreover, all participants were told (verbally) prior to the task that each of their break-off performance outcomes were to be measured and used within a competitive ranking list, with performance feedback evaluations given after five break-offs. Participants remained unaware of the true nature of the study. That is, there was no real competitive ranking list and feedback was deceptive. Thereafter, all participants were tasked to break-off (i.e., normal break-off for a frame of snooker) for 10 breaks and from their normal break-off position (i.e., either from the yellow or green sides of the baulk line), whilst trying to land the cueball on or as close to the piece of card located directly behind the green or yellow ball (a location where players tend to prefer to finish after a break-off shot in competition). Following each break-off, a measure was taken from the landing position of the cueball to the front of the piece of card and subsequently tallied against the false competitive ranking list. All measurements were taken and recorded by hand by the lead researcher who was present throughout all data collection.

2.1.5. False competitive ranking list

A false competitive ranking list was used to investigate the effects of MT in overcoming feedback (positive or negative). Twenty players received positive verbal feedback informing them that, based on their first five break-off outcomes, they were positioned in the top 10 of the rankings. The remaining 20 players received false negative feedback indicating that they were in the bottom 10 of the rankings. It was not possible to allocate participants to the positive or negative feedback group entirely at random, as some would have realized that their performance was particularly strong or weak. For example, a participant who regularly sees the cueball finishing very close to the target is unlikely to believe that they are in the bottom 10 of the rankings. Therefore, while participants were randomly allocated prior to performing, the lead author used discretion to change this if a player had performed exceptionally well or poorly in their first five break-offs. Following data collection, a debrief took place in a private room of the snooker club at which participants were informed of the true deceptive nature of the study.

3. Results

Descriptive statistics were used to screen for any missing data and outliers, insofar as assessing normality of all variables and internal consistency of the MTQ48. One participant presented as a clear outlier throughout the data, as this participant was much worse at the task than any other (i.e., occurred as an outlier at every shot taken), and was therefore removed from data analyses. Descriptive statistics are presented in Table 1. Internal consistency for MTQ48 scales was assessed using McDonald's omega (Hayes & Coutts, 2020), which presented acceptable values for all subscales, except for the challenge ($\omega = 0.63$) and the emotional control subscale; the latter subscale demonstrated a very weak value ($\omega = 0.41$). Other researchers have found internal consistency issues with the emotional control subscale, particularly items 26 and 34, and have thus sought to remove these items from MTQ48 analyses (e.g., Perry et al., 2013; St Clair-Thompson et al., 2015; Stamp et al., 2015). This was also the most significant limitation of the MTQ48 outlined by Perry et al. (2021). Therefore, we removed these two items from calculations. This moderately improved internal consistency, but not to an acceptable level ($\omega = 0.52$). Therefore, caution was applied to the interpretation of this subscale (see Table 1).

Overall, break-off accuracy was worse after feedback ($t(38) = -2.28$, $p = .03$, $d = -0.37$ (-0.69, -0.04). To determine the effect of feedback,

Table 1
Descriptive statistics for Experiment 1.

Variable	Mean	SD	Min	Max	Skew	Kurt	ω
Challenge	5.57	0.46	2.75	4.63	0.43	−0.45	.63
Commitment	3.86	0.51	2.73	4.73	−0.44	−0.64	.77
Control – emotion	3.48	0.59	2.40	4.80	0.38	0.04	.52
Control – life	3.68	0.61	2.14	4.71	−0.19	−0.58	.77
Confidence – abilities	3.63	0.55	2.22	4.44	−0.64	−0.18	.76
Confidence – interpersonal	3.85	0.57	2.83	5.00	0.09	−0.37	.74
Overall MT	3.69	0.42	3.00	4.57	−0.10	−0.72	.92
Pre-feedback performance	12.90	10.81	2.86	51.96	2.20	5.05	–
Post-feedback performance	17.98	18.07	1.22	64.58	1.46	1.03	–

we ran an ANCOVA with post-feedback performance as the dependent variable, accounting for pre-feedback performance, playing level, and MT variables as covariates. The effect of feedback was not significant ($F(1,30) = 0.80$, $p = .38$, $\eta_p^2 = 0.03$), nor were any of the covariates. Examination of plots (Fig. 1) illustrates that the high accuracy of the positive feedback group pre-feedback effectively meant that their performance could only be significantly worse or not affected following feedback.

Finally, we investigated whether individuals with higher MT were less affected by feedback. We expected that individuals with higher MT would be less affected by feedback (positive or negative) and would present less change in performance between pre-vs. post-feedback. We tested this hypothesis using multiple regression, with change in performance post-feedback as the dependent variable, and MT factors as predictors. The model was not statistically significant ($F(6,32) = 0.40$, $p = .87$, $R^2 = -0.10$).

4. Discussion

The purpose of the current experiment was to understand how MT influences an individual's response to feedback during performances in snooker. Specifically, we did this by examining the effects of feedback on snooker players' break-off performances using a false ranking list. Results showed there were significant differences between the first five vs. last five break-off shots, though no overall significant interaction effect was found between the MT and feedback group. Specifically, MT did not influence performance change following positive or negative feedback.

Although this experiment was primarily concerned with responses to failure, it appears that despite the feedback being performance-related (false competitive ranking), it did not significantly alter the break-off performances overall. Thus, the feedback seemingly did not impact upon goal outcome or changes in performance to achieve the goal. A clear limiting factor in the results was the lack of variance in break-off performance pre-feedback for the group receiving positive feedback (see Figure 1). Consequently, it is not possible to infer much from the apparent decline in performance post-feedback. It could simply be a regression towards the mean or perhaps an effect of attentional interference.

One possible explanation for the null results is that the effect of feedback was influenced by the source of that feedback (i.e., the researcher). Previous research has shown that contextual stressors such as coach evaluations (e.g., controlling interpersonal styles) are more influential as a facilitator and/or debilitator of MT (e.g., Gucciardi et al., 2009b; Gucciardi et al., 2017; Nicholls et al., 2016b). Hence it is proposed that informative and constructive feedback from a coach can aid in the growth of MT (e.g., Beattie et al., 2017; Bull et al., 2005; Gucciardi et al., 2015; Levy et al., 2012; Weinberg et al., 2018), as well as supporting the development of motor skills, coping mechanisms, happiness, success, and psychological variables such as motivation and thriving (e.g., Gucciardi et al., 2017; Mahoney et al., 2016; Nicholls et al., 2016a).

There has been little experimental research exploring the impact of MT on the forgetting of unwanted information (i.e., negative feedback) delivered by a coach during real-time performances in sport. Although MT and coaching behaviour have been investigated in other sports (e.g., Anthony et al., 2018; Gucciardi et al., 2009b; Gucciardi et al., 2017; Mahoney et al., 2016), no naturalistic research exists in terms of examining the influence of mental MT upon feedback delivered by a coach within the sport of snooker. According to Gucciardi et al., (2017, p.719), such sport-specific MT research is warranted because it gives license to testing the "buffering effects of MT when the stressor and indicator of functioning are captured within the same context". The findings of the current study will inform other investigations into the role of MT in coping with the stressors experienced during live performance. Therefore, we conducted experiment 2 in which we employed a trusted source (i.e., coach) to provide feedback to players. As in experiment 1, our focus was on the effect of MT in responding to positive and negative feedback.

5. Experiment 2

5.1. Method

The method from experiment 1 was replicated in experiment 2 with the following modifications: Participants were 40 English UK male snooker players ($M = 33.02$ years, $SD = 13.35$) who participated voluntarily for this study. Participants' playing levels were club ($n = 15$), amateur ($n = 12$), national ($n = 6$), and professional ($n = 7$). As in experiment 1, national players were those who were part of their national teams at the time of investigation. All participants and club owners were known to the first author and initially contacted by phone, with written informed consent subsequently provided by all participants and club owners. Due to the timings of data collection and individual player commitments, it was not possible to use the same cohort as experiment 1, although most players ($n = 28$) were retained from experiment 1. The playing levels of these participants were club ($n = 4$), amateur ($n = 11$), national ($n = 6$), and professional ($n = 7$).

In addition to the players, a male World Professional Billiards and Snooker Association (WPBSA) coach ($n = 1$), aged 37 years also voluntarily participated for the purposes of this study in order to deliver the feedback. The coach was known to the first author and initially contacted by phone, with written consent subsequently provided. The coach was familiar with some of the players due to his previous involvement in snooker but, importantly, had not directly coached any of them. A coach would typically be present to give feedback to players during practice sessions and tournaments, thus having a coach to deliver the feedback provided ecological validity. The false competitive ranking

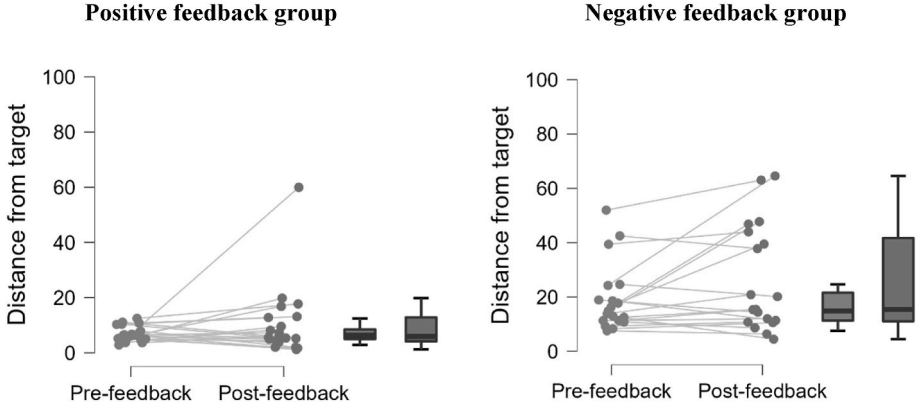

Fig. 1. Distribution of break-off accuracy pre- and post-feedback for each group for Experiment 1.

list used in experiment 1 was used again, but this time the feedback was provided by the coach.

6. Results

Preliminary analyses followed the same procedure as experiment 1. There were no missing data, problematic outliers, or deviations from normality. Internal consistency estimates for MTQ48 scales were consistent with findings from experiment 1, as scores were largely acceptable ($\omega > 0.70$). However, as in experiment 1, the internal consistency for the challenge subscale was slightly lower than expected ($\omega = 0.65$). In a similar vein, items 26 and 34 of the emotional control subscale again demonstrated very weak values and were removed from calculations, with the remaining items still producing unsatisfactory internal consistency ($\omega = 0.57$). Caution was observed in interpreting scores from this subscale (see Table 2).

Overall break-off accuracy did not change following feedback ($t(39) = 0.08$, $p = .93$, $d = 0.01$) (−0.30, 0.32). An ANCOVA revealed a statistically significant effect for feedback on break-off accuracy ($F(1,30) = 8.56$, $p < .01$, $\eta_p^2 = 0.22$), albeit not in the expected direction, with performance improving following negative feedback ($M_{diff} = -9.93$) and declining after positive feedback ($M_{diff} = 9.30$; Figure 2). Of the MT subscales, only Life Control ($F(1,30) = 4.36$, $p < .05$, $\eta_p^2 = 0.13$) presented a statistically significant effect. As in experiment 1, we examined a multiple regression model to measure overall change in performance following feedback as a result of the MT variables. The model was not statistically significant ($F(6,33) = 0.35$, $p = .91$, $R^2 = -0.11$).

7. Discussion

The aim of experiment 2 was to examine the influence of MT upon feedback (positive and negative) given by a coach during real-time break-off performances of snooker players. Results showed that feedback did appear to manipulate performance, though negative feedback was the driver for enhanced performance. Post-feedback performance was also influenced by the Life Control subscale of the MTQ48. While the effects are fairly small, it is interesting to observe that participants demonstrated improved performance after negative feedback, and weaker performance after positive feedback.

8. General discussion

The ability to overcome unwanted information in order to remain focused on the task at hand (e.g., Jones et al., 2002, 2007) is purportedly an attribute of MT. Yet, there has been little attention given to experimentally testing this mechanism in sport, despite calls elsewhere in the literature (e.g., Dewhurst et al., 2012, 2019). Hence, the overall purpose of the current investigation was to investigate whether MT influences an individual's ability to overcome feedback during snooker performance. In experiment 1, our main finding showed no effect of the type of feedback (positive versus negative) on performance, although overall, participants in both groups performed significantly worse after feedback. MT did not influence performance. Conversely, however, the results of experiment 2 yielded a significant interaction between performance and coach feedback. Specifically, performance improved after receiving negative feedback from the coach and worsened after receiving positive feedback. Overall, findings from the two studies extend our understanding of MT by offering novel insights into the role of MT and qualitatively different forms of feedback in sport performance using an experimental approach.

Table 2
Descriptive statistics for Experiment 2.

Variable	Mean	SD	Min	Max	Skew	Kurt	ω
Challenge	3.46	0.41	2.50	4.13	−0.16	−0.75	.65
Commitment	3.59	0.48	2.73	4.73	0.09	−0.96	.79
Control – emotion	3.10	0.59	2.00	4.80	0.62	0.59	.57
Control – life	3.38	0.52	2.14	4.71	0.37	0.41	.72
Confidence – abilities	3.33	0.54	2.22	4.44	0.09	−0.27	.77
Confidence – interpersonal	3.54	0.63	2.50	5.00	0.29	−0.87	.76
Overall MT	3.42	0.42	2.80	4.57	0.64	−0.25	.93
Pre-feedback performance	33.41	25.43	2.76	104.32	0.88	0.04	–
Post-feedback performance	33.10	20.68	8.86	93.10	1.23	1.35	–

8.1. Negative feedback

The finding that negative coach evaluations in experiment 2 led to better break-off performance accuracy is consistent with the extant literature, with individuals expressing that they can be more receptive to coach criticism (e.g., Gucciardi et al., 2009a), particularly when delivered in a challenging yet supportive way (e.g., Cook et al., 2014). As such, this may account for why the negatively-oriented feedback from the coach was deemed helpful by the players. It is suggested that attributing failure (e.g., negative-orientated feedback) to one's own performance is more likely to intensify an internal locus of control and maintenance of self-belief, self-efficacy, and confidence (e.g., Meggs & Chen, 2018), all of which align with the Confidence in Ability component of MT (Clough et al., 2002). In terms of the current findings, negative feedback might motivate greater effort and energy expenditure (see Gucciardi et al., 2009a; Kaiseler et al., 2009; Nicholls et al., 2008) in snooker players with higher MT and guide them towards performance improvement (i.e., a focus on the specific changes needed).

Self-reflection and self-insight (e.g., Coulter et al., 2010; Cowden, 2017; Gucciardi et al., 2009a; Madrigal et al., 2017; Meggs & Chen, 2018) following feedback from others can provide individuals with increased investment (e.g., evaluative information) towards achieving goals. Indeed, researchers (e.g., Madrigal et al., 2017; Meggs & Chen, 2018) argued that the content and nature of self-reflection has a critical effect upon psychological factors such as problem-focused coping (see Welsh et al., 2018), because they help preserve motivation following the occasional failure and/or resounding defeat. Thus, as snooker players with higher MT strive to comprehend competitive outcomes, their ability to rebound from performance setbacks (e.g., Cook et al., 2014) may play a crucial role in determining future performance by influencing MT (e.g., Brand et al., 2014; Cowden, 2017; Jones et al., 2007; Madrigal et al., 2017; Meggs & Chen, 2018). Taken together, these studies suggest that feedback might promote other characteristics that are synergistic with MT. For example, self-belief, perseverance, and confidence might be stabilised and/or reinforced by feedback (e.g., Gucciardi et al., 2009b; Gucciardi et al., 2015; Meggs & Chen, 2018). This is reflected in the research by Jackman et al. (2020) in terms of clutch responses whereby individuals with higher MT reported clutch states during pressured situations.

Pressure-induced and motoric-focused actions are not always detrimental to the execution of acts, because focusing attention on skills can result in performance enhancements (e.g., Bertollo et al., 2015; Buchanan et al., 2018; Carson & Collins, 2016; Hanin & Hanina, 2009). It is possible that higher level snooker players' attentional resources were shifted to being more motorically-invested, thereby acting as a buffer to emotional investment. This offers support for the theoretical distinction made by Dewhurst et al. (2019, p.948), in that it is the "control of cognitive processes, rather than purely emotional processes" that underpin high level performances in pressurised domains. It is of course highly plausible that snooker players used visual feedback (i.e., visual-motor-cognitive expertise) to enhance performances, even to the point of being affected by negative cueball outcomes following break-offs. That is, visual feedback may have impacted more upon players adaptational processes (i.e., implicit motor processes). Such a pattern is consistent with existing MT literature, whereby individuals

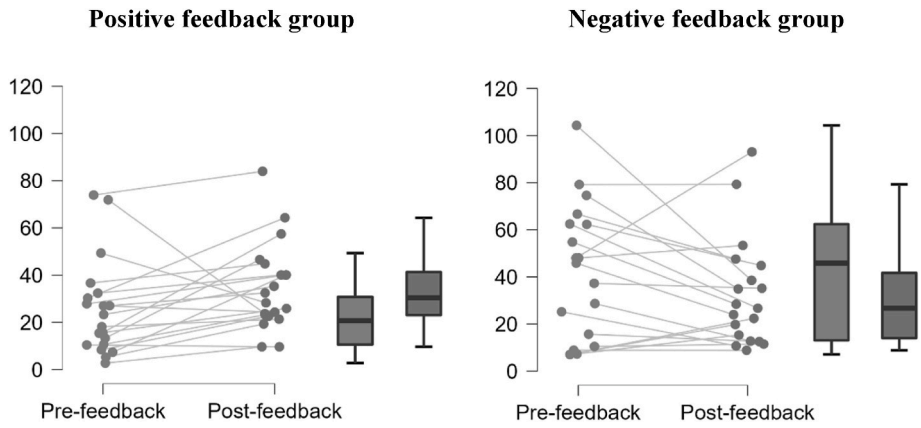

Fig. 2. Distribution of break-off accuracy pre- and post-feedback for each group for Experiment 2.

with lower MT can become overly focused on negative events and unable to put them behind them (e.g., Clough et al., 2002; Dewhurst et al., 2012; Jones et al., 2007). Although literature does exist on the visual expertise of snooker and billiard players (e.g., Abernethy et al., 1994; Williams et al., 2002), not much is known about the relationship between MT and its visual-motor-cognitive mechanisms. Given this assumption, it would be fruitful to examine this relatively untouched area of MT in the future.

8.2. Limitations and future directions

The current study had a number of limitations. For example, the participant cohort used across both experiments was relatively small and comprised players of varying levels (i.e., club, amateur, national, and professional). In addition, our design was unable to truly capture the intra- and inter-individual differences between the players, in terms of their playing levels. Using a specific playing level (e.g., just professional) may have afforded a more precise understanding of the mechanisms by which MT is operationalized. This could help in many ways, from advancing our theoretical, developmental, and applied perspectives, to confirming key differences between individual playing levels. Certainly, differences in skill and in the ability to forget unwanted feedback are likely to vary highly across the playing levels used within this investigation.

Notwithstanding individual player and coach commitments at the time of data collections, another limiting factor was the inability to recruit the same cohort for both experiments, even though over half of the players (54%, $n = 28$) took part in both experiments. However, the breadth of players can also be seen as a strength of this investigation, especially in terms of generalizability and sport-specific MT psychological interventions that could be used broadly across snooker (both player and coach) and cue sports generally. Despite the differences between participants, the overall results may be 'hedged' (see Chenail, 2010) as generalizable to a greater extent given the breadth of players involved (see Welsh et al., 2018). In future, it would be highly advantageous to replicate this investigation with female snooker players to develop an understanding of MT more broadly (i.e., theoretically and applied practices), particularly as the literature on females has revealed complex interactions between MT and other constructs, such as coping effectiveness (Kaiseler et al., 2009) and self-compassion (Wilson et al., 2019). Such advances would assist in generalizing to other sporting populations. Understandably, our findings may pertain to other aspects of MT that are not accounted for in the MTQ48, such as attentional control, as well as factors relating to age, personality, culture, or the natural tendency to cope with pressurised situations (e.g., Kaiseler et al., 2009; Welsh et al., 2018). In line with other MT studies (e.g., Dewhurst et al., 2019; Horsburgh et al., 2009), it may have been useful to employ a personality survey such as the BFI (McCrae & Costa, 1987). We encourage future studies to consider these recommendations.

As reported elsewhere in the literature, the MTQ48 (Clough et al., 2002) is not without its criticisms (e.g., Gucciardi et al., 2012, 2013). Our analysis highlighted problems in the challenge and emotional control subscales, which has been found in other studies (Jackman et al., 2017; Perry et al., 2013). However, as referred to earlier, Dewhurst et al. (2019) suggested that cognitive control rather than emotional control may be more central in the operationalization of MT. The MTQ48 does not include a dimension of attentional control, so using a measure that incorporates this aspect or indeed a measure of attentional control in tandem with the MTQ48 might be informative. It may also be the case that a snooker-specific inventory needs to be generated from a qualitative understanding of MT in snooker (analogous to the Cricket Mental Toughness Inventory developed by Gucciardi & Gordon, 2009). The aspect of challenge also requires further investigation due to the levels of challenge felt within a given situation not being reflected by overall MT scores. This may be counteracted using measures from within the challenge and threat (e.g., Uphill et al., 2019) and clutch performance literature (e.g., Swann et al., 2022). The MTQ48 has, however, been extensively used as a reliable measure of MT across a range of studies (e.g., Dewhurst et al., 2012, 2019; Jackman et al., 2017, 2020; Nicholls et al., 2011; Perry et al., 2021), hence the inclusion of the MTQ48 in the current study.

In terms of future research, longitudinal studies may provide information on the effectiveness of MT over a competitive season (e.g., Cooper et al., 2018, 2019; Tibbert et al., 2015). Not only could they identify differences between individuals, but they may also help in tailoring feedback to the MT of the individual player. This could be pivotal for developing new coaching practices and maintaining coach-player relationships, since not much is known about how MT develops within a relationship. Research shows that understanding relational resources (e.g., social-cognitive aspects of the coach-player relationship) are key to the developmental aspects (e.g., bio-psychosocial, bioecological) of MT in general (see Harmison, 2011; Mahoney et al., 2014).

Within motor learning studies, it is recognised that participants completing a task they are familiar with are less susceptible to the influence of feedback. Hence, even though there are clear differences in playing levels within the cohorts used in the current study, a break-off shot (i.e., the motor-task) in snooker is something that will have been regular practiced and performed by the participants under varying pressure situations (e.g., club, amateur, national, and professional matches). It is possible, therefore, that this motor task, as it was already mastered, was not affected by positive or negative feedback. Accordingly, the false competitive ranking list may not have induced enough pressure to allow differences in MT to influence participants' responses to feedback, despite feedback across both experiments having been minimal and delivered in a professional manner. Consequently, the

extent to which the real-time MT data generated from this study accurately captured a central cognitive mechanism of MT is also questionable. However, future MT experiments may look to studies elsewhere that not only use differing timings (e.g., concurrently vs. immediately after movement execution) of feedback delivery, but also other types of visual feedback based on our findings.

It is possible that harsher criticism (from oneself or a coach) is needed before the effects of MT emerge, as studies have determined this to be fundamental to athletes' MT enactment (e.g., Beattie et al., 2017; Gucciardi et al., 2009a; Levy et al., 2012; Nicholls et al., 2016b). In this way, MT may have expanded the players' capacity to extract, monitor, and manage performance feedback to enhance perceptions of skill, and subsequently increase cognitive flexibility (e.g., Jackman et al., 2020). More explicitly, MT may have acted as a buffer to the coach's interpersonal style (e.g., Gucciardi et al., 2017; Nicholls et al., 2016b). We did not directly examine the effects of interpersonal coaching styles within the current investigation, but the coach's familiarity with some of some of the players in experiment 2 may have subtly influenced the performance outcomes. Further research is needed to substantiate this suggestion.

It may be productive for future studies to consider exploiting other pivotal shots (e.g., last black for a 147 from 'easy' and 'difficult' cueball positions). Nevertheless, we do consider the procedure of this study a strength with the break-off shot being highly analogous to what is expected during real-time practices and matchplay snooker. Players are likely to experience a wide range of emotions before this shot is taken; for example, during situations that include having lost a frame they should have won or breaking off in a final decider. Still, it would be advantageous to collect real-time data during tournament practice allocations and in between tournaments to better measure fluctuations in MT. Measuring the relationship between attributions of failure (and success) and MT at different stages of a competitive snooker season would also be informative (e.g., Beattie et al., 2018; Meggs & Chen, 2018; Tibbert et al., 2015), as would autoethnographic accounts and/or coach-player interviews, obtained through longitudinal or single-case designs (e.g., Cooper et al., 2018, 2019; Jackman et al., 2020; Tibbert et al., 2015).

8.3. Conclusions

The purpose of this investigation was to test the influence of MT on the ability to overcome feedback during real-time snooker performances. Overall, our findings supported our hypothesis that MT would be substantively negatively associated with performance change following feedback. Findings showed that negative feedback was more conducive than positive feedback, but only when the feedback was provided by a coach. Thus, our investigation highlights the importance of using appropriate sources of feedback when examining the relationship between feedback and MT. This task specificity may go some way to explaining the inconsistent findings from feedback studies in general.

Whilst this study produced some interesting findings, it must be acknowledged that experimental designs only form part of the broader picture of research strategies and methods that attempt to understand the MT phenomenon (e.g., Gucciardi & Gordon, 2011; Rutter, 2001). Therefore, we agree that experimental designs are not the 'holy grail' of causal evidence based on our findings (e.g., Gucciardi & Gordon, 2011; Hagger & Chatzisarantis, 2009). We have nevertheless signposted potential new areas in which MT can progress theoretically (e.g., visual-motor-cognitive expertise), signifying that there are other possible mechanisms by which individuals overcome unwanted information (i.e., feedback) to stay focused on the task at hand in closed-skill sports (e.g., Cowden, 2017; Jackman et al., 2017, 2020). For the reasons outlined above, we advocate researchers in sport psychology to provide more live experimental data from other sports to corroborate the current insights into the cognitive mechanisms underpinning MT. This is likely to be a favourable avenue for future research.

As discussed elsewhere (e.g., Gucciardi et al., 2009a; Nicholls et al., 2016b), generalizing sport-specific research to the general MT literature can be precarious for theoretical, conceptual, and applied reasons. However, drawing on the process of analytical generalization (see Chenail, 2010), we have attempted to generalize our results within the existing conceptual definitions and theory of MT, irrespective of different populations and contexts. Consequently, we believe our findings have extended our understandings of MT more generally by testing a key conceptual tenet, namely the ability to focus on the task at hand irrespective of outcomes, which reconciles with the characteristics under the umbrella of most MT studies and 4C's model (e.g., Clough et al., 2002; Jackman et al., 2017, 2020).

Declaration of competing interest

There are no conflicts of interest regarding this manuscript.

Data availability

Data will be made available on request.

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