



## Development and validation of the metacognitive processes during Performances Questionnaire

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### ABSTRACT

**Objectives:** This study aimed to develop and validate a sport-specific self-report measure of metacognitive processes: The *Metacognitive Processes during Performance Questionnaire* (MPPQ).

**Design:** Three sub studies were used to: a) test the internal validity of the MPPQ in an online athlete sample; b) retest the internal validity of the MPPQ in a triathlete field sample; and c) test the external validity of the MPPQ in an online athlete sample.

**Method:** Firstly, principal components analysis was used to identify an adequate factor structure; secondly, confirmatory factor analysis was used to retest the factor structure; and thirdly, correlations and regressions were used to test concurrent validity. Reliability analyses were also used in each phase to test internal consistency.

**Results:** principal components analysis and reliability tests indicated that a three-factor solution pertaining to: cognitive coordination, cognitive evaluation, and thought control was adequately reliable. Secondly, confirmatory factor analysis on a field sample supported this factor structure and also demonstrated adequate internal consistency. Finally, bivariate correlations and multiple regressions indicated that convergent, discriminate and predictive validity were present, with existing generalised metacognitive measures (the Metacognitions Questionnaire 30, the Metacognitive Awareness Inventory, the Five Facet Mindfulness Questionnaire – Short Form, the Psychological Skills Inventory for Sports, and the Coping Flexibility Scale).

**Conclusion:** Overall, the results have demonstrated that the MPPQ is a sound measure of metacognitive processes that athletes might experience during competitions and presented several considerations for future research.

Attentional processing and self-regulation are concepts currently receiving high interest in research surrounding performance psychology. This is because attention or, the ability to self-regulate it, enables individuals to effectively distribute the required cognitive resources to dedicated tasks during performance (Eysenck, Derakshan, Santos, & Calvo, 2007; Moran, 2016). It is observable that from current literature supporting areas such as mindfulness, flow state dimensions, anxiety-attentional models, choking, self-talk, goal setting, meta-imagery, resiliency, and meta-memory has made advancements in the way performance enhancement is understood and approached. However, research on the metacognitive skills and processes that govern and influence attention, which are theoretically related to these areas, is somewhat limited from a sporting context (Moran, 2016).

Metacognition is a term referring to the experience of cognition about cognition and is considered to primarily operate along two

dimensions: Metacognitive knowledge, referring to memory concerned with the function and effectiveness of cognitive processes; and metacognitive processes, including self-regulatory skills involved in the monitoring, evaluation and control of cognition (i.e., detaching; inhibition; switching; Brick, MacIntyre, & Campbell, 2014, 2015, 2016; Wells, 2005). Wells and Matthews' (1994, 1996) *self-regulatory executive function* (S-REF) model is a well-established clinical model of metacognition, which categorises cognitive components into three levels: a lower level responsible for processing environmental stimuli, a higher meta-level that is responsible for organising and directing cognition (i.e., the executive function), and a store of long term meta-memory about cognition that is interactive with the executive function.

Of these three cognitive levels, Wells and Matthews (1994, 1996) attribute four factors that are responsible for the occurrence of psychological conditions (e.g., worry): a) metacognitive beliefs (e.g.,

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beliefs about the function and effectiveness of cognitive processes); b) the metacognitive mode (the experience when experiencing cognition); c) the executive function; and d) a cognitive attention syndrome (biased responses to cognitions and emotions). Wells and Matthews (1996) explains that a cognitive attention syndrome is responsible for emotional and psychological disturbance because it influences an increased self-focus, reduced efficiency in cognitive functioning, attentional bias, processing limitations, and activation of self-beliefs and appraisals.

When self-regulation is characterised by active worry, processing of information that is incompatible with the associated dysfunctional beliefs is significantly decreased, leading to a reduced flexibility of the executive function to pass attentional control to lower cognitive levels that require less conscious manipulation (Wells & Matthews, 1996). Therefore, cognitive flexibility, which may be defined as the activation and modification of cognitive processes in response to changing task demands (Deak, 2003), plays an important role during task performance. The development of cognitive flexibility not only requires the interpretation of environmental or external occurrences, but the evaluation or organisation of cognitive procedure, via goal-directed top-down meta-processes (Deak, 2003). This is because performers are required to make constant observations and evaluations about their thinking styles, determine what changes to thinking are necessary, and then switch and refocus attention accordingly.

Mindfulness is a concept that heavily resonates around self-regulation and has been met with relative success in sporting research in both theory and interventional formats (Noetel, Ciarrochi, Van Zanden, & Lonsdale, 2017; Buhlmayer, Birrer, Rothlin, Faude, & Donath, 2017). Bishop et al. (2004) claims mindfulness can be best operationalised from two components: a) processes involved in the self-regulation of attention, which consist of sustaining attention, switching attention and the inhibition of elaborative processing, and b) a positive orientation and non-judgemental disposition towards experiences in the present moment. Explained by Baer (2015), by perceiving stimuli non-judgementally and openly, response measures are not processed through existing maladaptive schemas, but reflectively as new information.

From a competitive context, the presence of competitive state anxiety requires athletes to become effective regulators of their attention. Competitive anxiety is thought to affect attention through a) somatic and physiological arousal, leading to a narrow attentional field (Weinberg & Gould, 2015), and b) cognitive anxiety, which inhibits controlled top-down processing that is influenced by goal direction, by activating a stimulus driven bottom-up processing system that directs attention in search of potential threats, as discussed in Eysenk, Derakshan, Santos and Calvo's (2007) attentional control theory. As such, enhanced performance, accelerated learning and expertise may stem from the interaction of cognitive level skills (e.g., self-talk, imagery, relaxation techniques) and the corresponding metacognitive regulatory processes (Eccles & Feltoovich, 2008).

During self-regulation, individuals continuously develop self-goals which are used as reference points to monitor and evaluate their actions, in regard to these points (Carver & Scheier, 2016). Effectively, a person can evaluate when an action, thought or behaviour is not aligning with these references and adjust their behaviours accordingly. However, when reference points are not being met, then an anxiety response is activated as a discrepancy warning (Carver & Scheier, 2016). Carver and Scheier (2016) argue that the difference between regulation and dysfunction in self-focus, is not decided by whether it is present or not, but the purpose of the processes behind it. For example, whether individuals monitor thoughts for learning strategies or for threat monitoring.

Meta-analyses on research projects involving the MCQ-30 (Wells & Cartwright-Hatton, 2004), which is a metacognitive measure based on S-REF theory, have shown strong associations with a variety of psychopathology, and demonstrated to be significant higher in clinical samples (see Sun, So, Zhu, & Leung, 2016). Recently, Love, Kannis-Dymand, and Lovell (2018a, 2018b) have demonstrated applicability of

this research to the sporting domain. They found that metacognitions were significantly associated with: a) competitive anxiety dimensions and concentration (Love et al., 2018a); and b) mindfulness facets and flow state (Love, Kannis-Dymand, & Lovell, 2018b), in competing triathletes. It was also found metacognitions significantly differed across time-to-event intervals and competitiveness. Love et al. (2018a, 2018b) claimed that outcomes such as concentration and flow may be better explained and researched as the underlying cognitive processes that define them.

Currently, there is an availability of self-report measures that pertain to attention and self-regulation in sports. For example, the attention subscales of the Test of Attentional and Interpersonal Style (Nideffer, 1976) measures the ability to develop preferred attention styles in regard to location, intensity and breadth. The Psychological Skills Inventory for Sports (Mahoney, Gabriel, & Perkins, 1987) is another questionnaire, which looks at psychological components that foster athlete performance: anxiety/confidence; motivation; concentration; mental preparation; and team orientation. The Test of Performances strategies (Thomas, Murphy, & Hardy, 1999), provides an effective means of measuring specific strategies such as goal setting; imagery; relaxation techniques; automaticity; emotion and attentional control; and physiological activation. Similarly, the Athlete Coping Inventory (Smith, Schutz, Smoll, & Ptacek, 1995) measures psychological constructs involved with mental preparation; coping strategies; performing under pressure; confidence motivation; coachability; and concentration. Another scale, the Ottawa Mental Skills Assessment Tool (Durand-Bush, Salmela, & Green Demers, 2001), includes skills under three overarching factors: foundation skills, such as goal setting and commitment; psychosomatic skills involving the regulation of physiological arousal; and cognitive skills; involving processes used in sensation, perceptions, learning, memory, thinking and reasoning.

Despite the availability of self-regulatory measures in sports, limitations are present. Firstly, some questionnaires are notably lengthy, which may not be practical for competitive environments requiring small windows for data collection; secondly, some measures are costly and therefore, are not appropriate for all research platforms and athlete circumstances; and thirdly, the ability to measure the underlying sports specific metacognitive processes that athletes incorporate into their competitive routine, is still lacking. Particularly from a perspective that incorporates conceptualisations of attention from leading self-regulatory models (i.e., the S-REF, processing efficiency theory, classical metacognitive theory, mindfulness theory).

By developing such a measure, research could begin to better understand the underlying relationships between sporting related factors (e.g., flow state) with performance, while enabling practitioners, coaches and athletes to identify which areas of attention are in need of intervention (e.g., the ability to evaluate thinking strategies), within the context of influential metacognitive beliefs (e.g., “my thinking strategies are not very effective for my performance; my thinking during competitions is uncontrollable”). Therefore, the purpose of this study was to develop a validate a new self-report questionnaire that can assess sports specific metacognitive processes: The *Metacognitive Processes during Performances Questionnaire* (MPPQ). Three sub-studies were constructed to a) test the MPPQ's internal validity in an online athlete sample; b) re-test the internal validity of the MPPQ in a triathlete field sample; and c) test the external validity of the MPPQ.

## 1. Study 1

The research aim of this first study was to develop and test the internal validity of the MPPQ. Specifically, two aims were constructed: first, we aimed to test the factorial structure through *principal components analysis* (PCA); and second, we aimed to test the internal consistency of the final factors with reliability analyses.

## 2. Method

### 2.1. Participants and procedure

After institutional ethical approval, athlete participants ( $N = 350$ ) were recruited via an online survey shared on various social networking sites (e.g., Facebook, Sports forums, participant recruitment websites). As an incentive, participants were entered into a random draw to win one of three \$100 vouchers. Of the total sample, 60.6% were male and the mean age reported was 30.8 ( $SD = 9.5$ ) years old. Of the different sporting types, 15.4% competed in football, 11.7% competed in basketball, 8.6% competed in tennis, 8.6% competed in athletics, 8.0% competed in soccer, 7.7% competed in volleyball, while the remaining 40.0% competed in variety of different sports (i.e., cricket; marathon running; swimming; baseball; golf; softball; badminton; dance; hockey; martial arts; rowing; kabaddi; bowling; cycling; JiuJitsu; mixed martial arts; skiing; table tennis; baton twirling; bike racing; boxing; disc golf; karate; lacrosse; netball; rock climbing; roller derby; squash; surfing; water polo; water skiing; weight lifting; wrestling). Regarding competitive level, 50.9% of the participants competed at a club level, 20.0% at a regional level, 22.3% at a state level, and 6.9% at a national level or above. 64.6% of the sample resided in America, 22.3% resided in Asia, 10.3% resided in Australia, and 2.9% resided in Europe.

### 2.2. Measures

**Performance based Metacognitions.** The measure being tested; the MPPQ, was a questionnaire designed during this study, which measures sports specific metacognitive processes that athletes might experience during competitions. Four sources of information were utilised to construct the initial 30 items: a) the scales and items from existing metacognitive (e.g., the Metacognitions Questionnaire; Wells & Cartwright-Hatton, 2004) and sporting measures concerned with attentional processes in competitions (e.g., the Test of Performance Strategies; Thomas et al., 1999); b) expert opinions of the second and third authors, who are established researchers in the fields of metacognition and sports psychology respectively; c) existing metacognitive and sporting literature revolving around self-regulation; cognitive inflexibility; mindfulness; resiliency; attentional processing models; and performance based mental states; and d) responses to metacognitive interview questions at a triathlon, by both elite and casual competitors. The open-ended interview questionnaire was concerned with participants' previous experiences on coping with performance anxiety. Questions (e.g., "how did you use your memory from past experiences to deal with this situation") were based on Wells (2006) metacognitive interview questions, but adapted appropriately, to the context of performance anxiety in sport.

Based on the information collected, thirty items concerned with metacognitive self-regulatory processes were generated evenly across six domains: a) cognitive planning (e.g., "prior to my events, I visualise how I will think and perform"); b) cognitive evaluation (e.g., "after I perform, I ask myself how well I maintained my mental state"); c) thought control (e.g., negative events during competition, have little effect on my focus"); d) cognitive detachment (e.g., "when I experience negative thoughts during a competition, I can just notice them without reacting"); e) cognitive presence (e.g., "when I perform, I find it difficult to stay focused on what's happening in the present moment"); and f) cognitive monitoring (e.g., "I am constantly aware of my thoughts and feelings during competitions"). Each item was scored on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither, 4 = agree, and 5 = strongly agree), with higher scores indicating a stronger tendency to engage in the corresponding process. A five-point Likert scale was chosen as a method of scoring, because it is a minimum recommendation in new scales for creating the necessary variance across items and scales; and determining adequate coefficient alphas (Hinkin, Tracey, & Enz, 1997).

**Demographics Information.** Participants' gender, age, sport, country of residence, and competition level were recorded.

### 2.3. Data analyses

Following collection, data were transferred into SPSS (version 25). *Principal components analysis* (PCA) was conducted on the initial 30 item scale, as it has been found to be a comprehensive method of data reduction (Costello & Osborne, 2005). While there is no universally agreed upon sample size standard for variants of factor analysis due to varying psychometric circumstances, it was determined a sample of 200 was an adequate minimum, based on Pearson and Mudforms suggestions (2010). The Kaiser-Meyer-Olkin measure and inter-item correlations were examined for suitability of the data. Factor retentions and loadings were based on suggestions by Howard's (2016) review on factor analytical procedures, which entailed eigenvalues  $> 1$  and scree plot variance for factor retentions, minimum factor loadings of 0.40, maximum alternative factor loadings of 0.30 and a 0.20 difference between primary and alternative loadings. Item retention was also based on items with communalities higher than 0.4 (Costello & Osborne, 2005). An oblique rotation (Promax) was used, as previous metacognitive subscales have shown to be correlated in the past (Cartwright-Hatton & Wells, 1997).

## 3. Results

### 3.1. Research aim 1: factor structure and reliability of the MPPQ

A PCA was performed on the 30 items to test the factor structure of the MPPQ. The Kaiser-Meyer-Olkin (KMO) measure of sampling accuracy was 0.899,  $p < .001$ , and correlations remained below 0.8, with each item consisting of a correlation of at least 0.3 with other items of the MPPQ. However, all items that had reverse orientations strongly loaded on a single factor, indicating that this was not truly representative of a theoretical factor. These items were removed and left 24 items with a KMO of 0.916,  $p < .001$ . Both the scree plot and Eigen values indicated a three-factor solution. Adhering to the data cut-off intervals described, four further items were removed. Due to the MPPQ being a sports measure, where time restrictions are often involved, five further items were removed based on communality and factor loadings scores to improve the efficiency and factor balancing of the MPPQ, and reduce questionnaire fatigue and item redundancy.

The final factor structure revealed 15 items equally spread across three factors: a) thought control and detachment (MPPQ-TC; factor 1), which involved items describing a non-reactivity to negative events, and the ability to inhibit and shift attention; b) cognitive evaluation and monitoring (MPPQ-CE; factor 2), which included items describing the tendency to monitor and evaluate cognitive processes during and after a competition; and c) cognitive coordination (MPPQ-CC; factor 3), which contained items relating to the planning of cognition and maintaining awareness to new environmental information. The KMO (0.873), Scree plot, Eigenvalues ( $\geq 1.3$ ) and explained variance  $\geq 8.75\%$  of each factor indicated that the data supported this structure.

Reliability analyses indicated that all three subscales had adequate internal consistencies: MPPQ-TC = 0.81; MPPQ-CE = 0.79; MPPQ-CC = 0.72, as well as the total scale ( $\alpha = 0.85$ ). the component correlation matrix showed that the subscales were moderately and positively related ( $r = 0.36 - 0.48$ ). The communalities, factor loadings, explained variance and reliability coefficients are displayed in Table 1.

## 4. Study 2

The aim of the second study was to confirm the MPPQ's psychometric properties in a field sample of competitive triathletes. Specifically, we aimed to test the factorial structure of the MPPQ, using confirmatory factor analysis, and to retest the internal consistency of

**Table 1**  
Communalities, factor loadings, Eigenvalues, explained variance and reliability coefficients of the remaining MPPQ items for the principal components analysis.

Item	Communalities	Factor 1 (MPPQ-TC)	Factor 2 (MPPQ-CE)	Factor 4 (MPPQ-CC)
1	.592	.802		
2	.574	.801		
3	.595	.736		
4	.583	.723		
5	.592	.674		
6	.666		.856	
7	.607		.835	
8	.541		.691	
9	.500		.620	
10	.480		.499	
11	.551			.750
12	.534			.677
13	.420			.677
14	.431			.660
15	.408			.630
$\alpha$	–	.810	.788	.717
Eigenvalues		4.91	1.85	1.31
% variance	–	32.72	12.35	8.75

Note: Factor loadings < .30 not shown.

the MPPQ subscales, using reliability analyses.

#### 4.1. Participants and procedure

After institutional ethics approval, 196 triathletes were recruited at the event check-in, prior to two Australian triathlons. Of the total sample, 59.7% were males and the mean age was 38.8 (SD = 11.7). Participants completed the MPPQ and demographic questions, and were given the option to enter a draw for one of three \$100 vouchers. All data was imported into SPSS AMOS (v22) where a model was drawn representing the factor structure found in the PCA.

#### 5. Results

A CFA in SPSS AMOS (v22) using maximum likelihood estimation was performed to re-test the factorial structure of the MPPQ in a field sample. The results showed that the 15 item three-factor model was significantly different from the data  $X^2 = 138.80$ ,  $Df = 84$ ,  $p < .001$ . However, given the sample consisted of approximately 200 participants, chi square was expected to be significant (Schumacker & Lomax, 1996), and therefore, alternative fit indices were examined. Cut-off values proposed by Hair, Black, Babin, Anderson and Tatham (2014) were used, including: Good fit index (GFI; 0.90), root mean squared error of approximation (RMSEA; < 0.07), standardised root mean square residual (SRMR < 0.08), and a comparative fit index/Tucker-Lewis index (CFI/TLI; 0.92). Based off these values, the results showed that the model was an adequate fit to the data (GFI = 0.918, TLI = 0.930, CFI = 0.944, RMSEA = 0.058, SRMR = 0.062).

Factor loadings of the final model were also acceptable, ranging from 0.41 to 0.83. Finally, reliability tests were performed on the final factor solution, which showed an adequate internal consistency for all the subscales: MPPQ-CC ( $\alpha = 0.73$ ); MPPQ-TC ( $\alpha = 0.78$ ); MPPQ-CE ( $\alpha = 0.85$ ), and the total scale ( $\alpha = 0.85$ ). The final questionnaire is displayed in Table 2.

#### 6. Study 3

The third study aimed to test the concurrent validity of the MPPQ. Specifically, it was aimed to investigate convergent and discriminant

validity through bivariate correlations with existing measures relating to metacognitive processes (i.e., the Metacognitions Questionnaire; the Five Facet Mindfulness Questionnaire; the Metacognitive Awareness Inventory), and predictive validity through bivariate correlations and multiple regressions with existing measures of cognitive flexibility and concentration (i.e., the Coping Flexibility Scale; the Psychological Skills Inventory for Sports).

#### 7. Method

##### 7.1. Participants

One hundred and seventy-one participants were recruited from via an online survey shared on various social networking sites (e.g., Facebook, Sports forums, participant recruitment websites). As an incentive, participants were entered into a random draw to win one of three \$100 vouchers. Of the total sample, 56.7% were male and the mean age reported was 28.8 (SD = 8.0) years old. Of the different sport types, 18.1% competed in football, 11.1% competed in athletics, 8.8% competed in tennis, 8.2% competed in volleyball, 7.0% competed in basketball, 7.0% competed in cricket, 7.0% competed in distance running, while the remaining 32.8% competed in variety of different sports (i.e., soccer; badminton; hockey; martial arts; baseball; dance; golf; kabaddi; rowing; table tennis; mountain biking; netball; rock climbing; skiing; softball; squash; surfing; water polo; laser tag). Regarding competitive level, 46.2% of the participants competed at a club level, 18.7% at a regional level, 26.3% at a state level, and 8.8% at a national level or above. Regarding country of residence, 45.0% of the sample resided in Asia, 29.8% resided in America, 21.1% resided in Australia, and 4.1% resided in Europe.

##### 7.2. Measures

**Cognitive Monitoring.** The cognitive self-consciousness subscale of the 30-item *Metacognitions Questionnaire* (MCQ-30; Wells & Cartwright-Hatton, 2004) was used as a measure of general cognitive monitoring. Each item (e.g., “I think a lot about my thoughts”) was scored on a four-point Likert scale, regarding the agreeableness toward each statement (1 = “do not agree”, 4 = “agree very much”). The MCQ-30 has shown good internal consistencies across each subscale, ranging from 0.72 to 0.93, and for the total measure ( $\alpha = 0.93$ ; Wells & Cartwright-Hatton, 2004).

**Metacognitive Regulation.** Two subscales from Schraw and Dennison’s (1994) 52-item *Metacognitive Awareness Inventory* (MAI) were used to measure participant’s metacognitive planning (MAI-P) and evaluations (MAI-E). The MAI presented participants with statements, such as “I set specific goals before I begin a task” and were then asked to rate each item as either “true” or “false”. The MAI has been noted to have a strong internal consistency ( $\alpha = 0.93$ ; Schraw & Dennison, 1994) and has been used in a multitude of research, since its development.

**Mindfulness.** One subscale, which was concerned with a non-reactivity to inner experiences (FFMQ-NR; e.g., “I watch my feelings without getting carried away by them”), was used from the *Five Facet Mindfulness Questionnaire – Short Form* (FFMQ-SF; Bohlmeijer, ten Klooster, Fledderus, Veehof, & Baer, 2011), a shortened version of the 39-item Five Facet Mindfulness Questionnaire (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). The subscale included items. Each item was scored on a scale of 1 (never or rarely true) to 5 (very often or always true), relating to how much the participant agrees with the given statement, with higher scores represent higher levels of mindfulness. The FFMQ-SF has shown acceptable model fit, high correlations to its predecessor and good reliability, displaying alpha’s ranging from 0.75 to 0.87 (Baer, Smith, Hopkins, Krietemeyer, & Toney., 2006).

**Concentration.** To measure attentional focus, the concentration subscale of the Psychological Skills Inventory for Sports (PSI; Wheaton,

**Table 2**

The Metacognitive Processes during Performances Questionnaire. The following questionnaire is concerned with the traits and strategies that athletes may experience during a competition. Please carefully read each item and indicate how much you agree with the statements, by choosing a corresponding number. There are no right or wrong answers.

Metacognitive Processes	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. I set specific goals before approaching a competition.	1	2	3	4	5
2. While performing, I evaluate which thoughts are good and bad for my performance.	1	2	3	4	5
3. I have no problem shifting my attention away from negative events when competing.	1	2	3	4	5
4. Prior to competing, I make the best of my time, mentally preparing myself for the event.	1	2	3	4	5
5. After I perform, I ask myself how well I maintained my mental state.	1	2	3	4	5
6. When something bad happens during a competition, I can easily refocus my attention back towards the event.	1	2	3	4	5
7. When I perform, I am constantly aware of my actions.	1	2	3	4	5
8. After an event, I am able to determine what thinking strategies were good for my performance.	1	2	3	4	5
9. During a competition, I am able to have a negative thought without worrying about it.	1	2	3	4	5
10. To prepare for an event, I talk myself through my upcoming performance.	1	2	3	4	5
11. I monitor what thoughts I am experiencing throughout the length of a competition.	1	2	3	4	5
12. When I experience negative thoughts during a competition, I can just notice them without reacting	1	2	3	4	5
13. I am usually attentive to my actions and the environment during a competition.	1	2	3	4	5
14. I summarise what I've learnt about my thinking strategies after a competition.	1	2	3	4	5
15. Negative events during competition, have little effect on my focus.	1	2	3	4	5

#### Scoring:

Cognitive coordination; **MPPQ-CC** – 1, 4, 7, 10 & 13.

Cognitive Evaluation; **MPPQ-CE** – 2, 5, 8, 11 & 14.

Thought Control; **MPPQ-TC** – 3, 6, 9, 12 & 15.

1998) was used. The concentration scale (PSI-C) is measured over ten items (e.g., “I can effectively block out negative thoughts during important competitions”) and scored on a 5-point Likert scale, ranging from ‘never’ to ‘always’. Higher scores on the PSI indicate higher levels of concentration. The PSI has shown good validity to the Test of Attentional and Interpersonal Styles (Nideffer, 1976) attentional subscales and demonstrated a test-retest correlation of 0.91.

**Cognitive Flexibility.** The adaptive coping subscale from *Coping Flexibility Scale* (CFS; Kato, 2012) was used as a measure of cognitive flexibility. The subscale includes items relating to the flexibility of cognitive processes involved with coping styles (e.g., “I only use certain ways to cope with stress”; CFS-A) across five items. Participants scored each item on its applicability to their own flexibility (1 = “not applicable”, 4 = “not applicable”). The CFS has demonstrated good psychometric properties, through extensive developmental and test studies (Kato, 2012).

**Demographics Information.** Demographic information was also collected, which included the participants’ gender, age, sport, country of residence and competition level.

### 7.3. Data analyses

After collection of the data, it was imported into SPSS (v25). Using the command function, the MPPQ variables were computed using mean scores, along with variables of the existing measures (i.e., MCQ-30; FFMQ; MAI; PSI; CFS). Explore function was used to assess normality and showed that all variables were adequate for analysis. First, bivariate correlations were run to test criterion-related validity (convergent, discriminant, and predictive), in which interpretations were made based on suggestions by Cohen (1988), and J Cohen, Cohen, West, and Aiken (2003): Pearson’s  $r$  as 0.10 = small, 0.30 = medium, and 0.50 = large, and partial eta squared margins as 0.02 = small, 0.06 = medium, and 0.14 = large. Multiple regressions were used to investigate the contributions that the MPPQ subscales had towards CFS-A and PSI-C, in which effect size margins were interpreted as: Cohens  $f^2$  (0.10 = small, 0.25 = medium, 0.40 = large); and partial  $r$  squared (small = 0.02, medium = 0.13, large = 0.26, as suggested by Cohen (1988), and J Cohen et al. (2003). Priori based calculations using GPower (v3.1.9.2) indicated that the current sample was capable of accurately detecting correlations of approximately  $r = .21$  and effect sizes of  $F^2 = 0.05$ , with a power of 0.8.

### 7.4. Research aim 1: concurrent validity of the MPPQ

To test the convergent, discriminant and predictive validity of the MPPQ, bivariate correlations were run on the MPPQ’s subscales with: MCQ-CSC; FFMQ-NR; MAI-P; MAI-E; PSI-C; and CFS-A. Firstly, evidence of convergent validity was present, as MPPQ-CC, which had items relating to cognitive planning and cognitive presence, positively correlated with MAI-P ( $r = 0.31$ ) and MCQ-CSC; MPPQ-CE, which had items relating to the monitoring and evaluating of cognition, was positively and moderately related to MAI-E ( $r = 0.36$ ) and MCQ-CSC ( $r = 0.49$ ); and MPPQ-TC, which contained items relating to both a non-reactivity to thoughts and thought control, was positively and moderately correlated to PSI-C ( $r = 0.33$ ) and strongly with FFMQ-NR ( $r = 0.69$ ).

Evidence of divergent validity was also present in that MCQ-CSC was most strongly correlated to MPPQ-CE; FFMQ-NR was most strongly correlated to MPPQ-TC, MAI-P was most strongly related to MPPQ-CC; MAI-E was most strongly correlated with MPPQ-CE. Conversely, PSI-C showed similarly strong positive correlations with both MPPQ-CC, which contained items relating a sustained attention to actions and the environment; and MPPQ-TC, which had items relating to the inhibition and switching of attention. As a method of testing predictive validity, correlations with CFS-A were examined. Results showed that CFS-A was positively and moderately related to all the MPPQ variables ( $r = .34 - 0.40$ ). Regarding intercorrelations between the MPPQ subscales, moderate positive correlations were present among each variable ( $r = 0.32 - 0.46$ ). Descriptive statistics, correlations and reliability coefficients can be found in Table 3.

### 7.5. Research aim 2: contributions and relationships of the MPPQ towards CFS-A

To investigate what individual and combined contributions that the MPPQ subscales had towards CFS-A and PSI-C, two multiple regression were run with the MPPQ subscales as independent variables, and with PSI-C and CFS-A as dependant variables. Assumptions of linearity, and collinearity were deemed acceptable after inspection of the VIF, Durban-Watson, and tolerance values, and residual plots. For the regression predicting CFS-A, the results showed that the main effect was medium in size (Cohen’s  $f^2 = 0.30$ ), significant ( $F(3, 170) = 16.16$ ,  $p < .001$ ), and explained 22.5% of the total variance. Coefficients indicated that MPPQ-CC ( $\beta = 0.24$ ,  $t = 3.13$ ,  $p = .002$ ,  $r^2 = 0.06$ );

**Table 3**  
Descriptive statistics, bivariate correlations and reliability coefficients between the MPPQ subscales with the MCQ-30, FFMQ, MAI, PSI, CFS scales and age.

Variables	M	SD	$\alpha$	MPPQ-CC	MPPQ-CE	MPPQ-TC
MPPQ-CC	3.88	.61	.72			
MPPQ-CE	3.62	.75	.76	.47**		
MPPQ-TC	3.40	.81	.79	.33**	.46**	
MCQ-CSC	18.52	3.69	.83	.40**	.49**	.14
FFMQ-NR	17.08	4.18	.84	.28**	.35**	.69**
MAI-P	3.92	1.24	.67	.31**	.27**	-.13
MAI-E	4.52	1.44	.56	.20*	.36**	.24**
PSI-C	32.35	6.22	.79	.33**	.01	.33**
CFS-A	14.38	2.77	.76	.40**	.40**	.34**
Age	28.81	8.01	–	-.09*	-.12	.08

Note: \* $p < .05$ , \*\* $p < .001$ .

MPPQ-CE ( $\beta = 0.21, t = 2.54, p = .012, r^2 = 0.04$ ); and MPPQ-TC ( $\beta = 0.15, t = 2.00, p = .047, r^2 = 0.02$ ) were all significant predictors, with small individual effects. Secondly, for the regression predicting PSI-C, the main effect was significant ( $F(3, 170) = 17.74, p < .001$ ), medium in size (Cohen's  $f^2 = 0.32$ ) and explained 24.2% of the total variance. Individually, MPPQ-CC ( $\beta = 0.37, t = 4.85, p < .001, r^2 = 0.12$ ); MPPQ-CE ( $\beta = -0.34, t = -4.15, p < .001, r^2 = 0.09$ ) and MPPQ-TC ( $\beta = 0.36, t = 4.70, p < .001, r^2 = 0.12$ ) were found as significant predictors, with small to medium effect sizes.

Two follow up preliminary curvilinear regressions were performed on the dependant variables, with MPPQ-CE as the independent variable. This was because metacognitive theory behind the S-REF and sporting, explains that the monitoring and evaluation of thoughts can be both a) functional, because it allows individuals to update knowledge about the effectiveness of cognitive processes, and b) dysfunctional, because excessive monitoring is associated with worry, and lead to conscious interference. For the curvilinear regression predicting CFS-A, the results showed that a curvilinear model predicted an additional 4.9% of the total variance on top of a linear model (linear:  $R^2 = 0.151, F(1, 170) = 30.05, p < .001$ ; quadratic:  $R^2 = 0.200, F(2, 170) = 21.05, p < .001$ ). For the curvilinear regression predicting PSI-C, the results showed that the curvilinear model predicted an additional 2.9% of the variance (linear:  $R^2 = 0.000, F(1, 170) = 0.01, p = .933$ ; quadratic:  $R^2 = 0.029, F(2, 270) = 2.53, p = .083$ ). The results from all regressions can be seen in Table 4.

**Table 4**  
Multiple and Curvilinear Regressions with the MPPQ subscales predicting the CFS-A and PSI-C.

Dependants	Predictors	B	SE	$\beta$	t	p	r	R <sup>2</sup>	F
CFS-A						< .001		.225	16.16
	MPPQ-CC	1.11	.35	.24	3.13	.002	.24		
	MPPQ-CE	.77	.30	.21	2.54	.012	.19		
	MPPQ-TC	.53	.26	.15	2.00	.047	.15		
Linear						< .001		.151	30.05
	MPPQ-CE	1.43	.26	.39	5.48	< .001			
						< .001		.200	21.05
Quadratic	MPPQ-CE	-4.55	1.87	-1.24	-2.43	.016			
	MPPQ-CE <sup>2</sup>	.86	.27	1.64	3.22	.002			
PSI-C						< .001		.242	17.74
	MPPQ-CC	3.84	.79	.37	4.85	< .001	.35		
	MPPQ-CE	-2.80	.67	-.34	-4.15	< .001	-.31		
	MPPQ-TC	2.77	.59	.36	4.70	< .001	.34		
Linear						.933		.000	.01
	MPPQ-CE	-.05	.64	-.01	-.08	.933			
						.083		.029	2.53
Quadratic	MPPQ-CE	-10.44	4.66	-1.26	-2.24	.027			
	MPPQ-CE <sup>2</sup>	1.50	.67	1.26	2.25	.026			

## 8. Discussion

This paper aimed to develop and validate a new self-report questionnaire that can measure sports specific metacognitive processes that athletes might experience and utilise during competitions. In the first study, a PCA was used to assess an adequate factorial structure, while reliability analyses were used to assess the internal consistency of the MPPQ. The second study intended to retest the factorial structure of the MPPQ subscales using CFA and internal consistency with reliability analyses. Finally, the third study aimed to test the convergent, discriminant and predictive validity of the MPPQ with existing metacognitive related variables.

### 8.1. Internal validity of the MPPQ

For study 1, PCA was performed on the MPPQ items and revealed that three factor solutions, equally split across fifteen items: a) cognitive coordination, which was concerned with planning cognitions before a competition and maintaining an awareness to actions and the environment; b) cognitive evaluation, which encompassed the monitoring and evaluation of cognitive processes during and after a competition; and c) thought control, which contained items relating to the detachment, inhibition and switching of attention. Each subscale and the total scale demonstrated adequate reliability and a normal distribution.

In study 2, the factorial structure was retested on a field sample of triathletes prior to a competition using CFA. The results showed that the model proposed from the PCA, was a good fit to the new data and demonstrated a sound reliability across all subscales and the total scale. Finally, in the third study, reliability tests were performed again and showed that all subscales were adequately reliable. Overall, the factors demonstrated by the MPPQ are supportive towards Brick et al. (2014, 2015, 2016); metacognitive theory (Wells, 2005); and mindfulness literature (Noetel et al., 2017), in that self-regulation is influenced from the planning, monitoring and evaluating of thoughts during the experience of tasks; and requires the ability to: a) detach from thoughts; b) inhibit and switch attention; and c) refocus attention to the present moment.

### 8.2. External validity of the MPPQ

The third study investigated the concurrent validity of the MPPQ. Firstly, through bivariate correlations, convergent validity was evident, as each of the subscales were positively correlated to their generalised

counterparts. Secondly, divergent validity was also present, with each of the generalised validation measures being more strongly correlated to their MPPQ counterparts. Notably, concentration was equally related to thought control and direction. This is because thought control contained items relating to refocusing and cognitive coordination had items relating to maintain awareness on actions and the environment, a necessary process to search the environment for changes in strategy (Carver & Scheier, 2016). Thirdly, predictive validity was also evident, as all three MPPQ subscales were positively related to adaptive coping flexibility.

In order to further predictive validity and investigate the contributions that the MPPQ subscales had towards, multiple regressions were run with the MPPQ subscales predicting cognitive flexibility and concentration. The results showed that all MPPQ subscales positively predicted cognitive flexibility with a medium effect size. These findings are consistent to Wells and Matthews' (1994, 1996) S-REF model in that cognitive flexibility is influenced from the metacognitive knowledge developed and moderated through cognitive processes involved in self-regulation. This result also suggests that the processes measured by the MPPQ and are adaptive configurations (i.e., top-down processing) of the executive function and cognitive attention syndrome.

Alternatively, the results for the regression predicting concentration, showed that while cognitive coordination and control had positive associations, cognitive evaluation negatively predicted concentration. This finding was contrary to the bivariate correlations showing a near nil relationship between cognitive evaluation and concentration, indicating that after controlling for the adaptive functions of planning and controlling cognitions, evaluating and monitoring cognition leads to disruptions in task focus. This may be because after controlling for the functional effects of planning and control, the residual variance may have been explained by a tendency to monitor and evaluate thoughts due to self-consciousness or worry. This would align with metacognitive literature, which distinguishes the differences between monitoring thoughts to influence cognitive coordination and for threat monitoring (see Carver & Scheier, 2016; Wells & Matthews, 1994; 1996).

### 8.3. Further considerations for the interactions of sports specific metacognitions

Due to the discrepancy of the results surrounding cognitive evaluation and metacognitive literature explaining that excessive monitoring can be dysfunctional, two follow up preliminary curvilinear regressions were performed with cognitive evaluation predicting cognitive flexibility and concentration. It was found a curvilinear relationship was significant in both cases and explained a significant amount of additional variance over linear models. However, both relationships were in a fashion where low and high scores in cognitive evaluation led to more flexibility and concentration, than those who scored moderately in cognitive evaluation. This may be interpreted as those who do not evaluate their thoughts, are likely to have less conscious interference (for concentration) and more freedom of thought (for flexibility), while those who scored higher are more attuned to the functionality of particular strategies. However, this is an area of study that warrants a need for further investigation.

Alternatively, the MPPQ shows promise for research involving components of the S-REF, in particular, the interactive nature between the executive function and the higher-order store of metacognitive knowledge. For example, evaluating (MPPQ-CE) the functionality of processes during performances, updates metacognitive knowledge in the form of metacognitive beliefs, which can help guide cognitive coordination (MPPQ-CC) when approaching a future competition. Adaptive attempts at regulating these processes, will enable an individual to recognise when thoughts are not functional to performance and shift attention towards (MPPQ-TC) to alternative sources. From this perspective, the MPPQ components can also be considered as part of the top-down influences found in attentional control theory (Eysenck et al.,

2007).

## 9. Conclusion

Overall the MPPQ appears to be a reliable, valid and useful self-report measure, for identifying sports specific metacognitive processes that athletes might experience or utilise during a competition. Preliminary support was evident for this in the current study, as the MPPQ demonstrated sound validity in an online sample to an field sample of pre-competition triathletes, and demonstrated appropriate relationships with well-established generalised measures of metacognitions. The MPPQ also demonstrates support for existing literature relating to attention, self-regulation and metacognition.

Implications therefore show potential for the MPPQ to be used in a variety of sports and performance related settings; may help reveal a better understanding of how metacognitive processes are associated with performances related factors (e.g., motivation, choking, resiliency); and help practitioners identify processes that are inhibiting performances in athletes. The MPPQ also offers an efficient means of measurement of self-regulatory processes in athletes that's foundation is grounded in metacognitive models, and more relative to the underlying cognitive processes involved in self-regulation, than other current measurements of psychological skills in sports, discussed earlier.

While potential implications are present for the MPPQ, several limitations are present in the current study. Firstly, the measure is of self-report nature, which in itself is subject to levels of bias (Paulhus & Vazire, 2007). However, currently there remains no method of measuring the specific cognitive processes that individuals exhibit, particularly in time restrictive environments such as sporting competitions. Secondly, as comes with the nature of self-report questionnaires, the generation of items included in the MPPQ were subject to bias from the researchers and the athletes' responses from the metacognitive interview questions. Thirdly, the samples used in this research consisted of a mixed athlete online sample for PCA and concurrent validation, and a field triathlete sample for CFA. This presents limitations, as the field sample was not widely generalisable, whilst the online sample presented opposing issues. Nonetheless, the practicality of validating a psychological measure across every sport, and because the questionnaire aims to capture metacognitive processes that are implemented in all competitive scenarios, this issue is likely negligent. Finally, the current study used a manifest variable approach for testing concurrent validity, rather than a latent variable approach, which accompanies several advantages over the latter. It is therefore recommended that future research investigating the MPPQ properties, with more robust sample sizes, implement a latent variable approach.

Evidently, there is still need for further psychometric testing and investigation, to properly ground the MPPQ as an empirically supported measure. This paper suggests several possible directions: a) future research could benefit from examining how metacognitive processes differ between sporting types, where different attentional resources are required; b) both qualitative and quantitative methods may help better explain the curvilinear relationship between the evaluation subscale with performance related factors, and c) investigating how different components of the S-REF, (i.e., metacognitive beliefs) are associated with the MPPQ subscales, will bring support for this model in a sporting context, but also lay way for further interactions to be considered by research and practitioners. The final questionnaire can be found in Table 2 and is freely available for use with permission of the lead author.

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