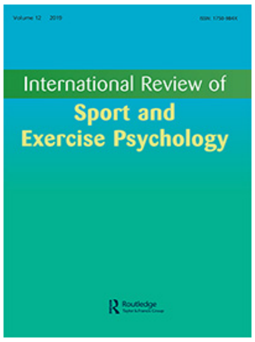

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Choking interventions in sports: A systematic review

Peter Gröpel [a,b] and Christopher Mesagno [c]

[a]Department of Sport and Health Sciences, Technical University of Munich, Munich, Germany; [b]Department of Applied Psychology: Work, Education, Economy, University of Vienna, Vienna, Austria; [c]Faculty of Health, Federation University Australia, Ballarat, Victoria, Australia

ABSTRACT

Choking under pressure describes suboptimal sport performance in stressful situations, which has led to two fundamental 'choking' models: distraction and self-focus. The purpose of this review was to provide an overview of empirical studies that have tested interventions used to alleviate choking. The systematic review includes 47 empirical studies published up to April 2017, including experimental, quasi-experimental, and single-case studies with athletes. These studies encompassed a variety of interventions (*n* = 13) that were either distraction based or self-focus based. In addition, a third group – acclimatisation interventions – was identified. The results indicate that, in general, choking interventions based on both choking models and on acclimatisation provide a benefit to performance under pressure. The most reported effective interventions were pre-performance routines, quiet eye training, left-hand contractions, and acclimatisation training. The use of dual task was beneficial for performance under pressure but harmful when used in training. Mixed evidence was found for analogy learning, and null effects were reported for goal setting, neurofeedback training, and reappraisal cues. These results may help athletes and coaches select and implement effective strategies and methods to improve performance under pressure.

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KEYWORDS
Choking under pressure; skilled performance; self-focus; distraction; intervention

Introduction

Tim Borowski, a German national soccer player, is ready to take a penalty kick. If he fails to score, he would have to serve tonight's dinner to his teammates. Just before he shoots, however, something strange happens: Tim turns to his coach and teammates and shouts where he will kick the ball. To be sure, he also tells the goalkeeper. Another teammate is behind the goal jumping and waving his hands to distract Tim's attention. As Tim strikes the ball, the goalkeeper moves immediately to the corner where Tim shouted and where the ball is kicked, but Tim still scores. This is an example of another training day for the German soccer team. By practising these

CONTACT Peter Gröpel peter.groepel@univie.ac.at
The research began at the Technical University of Munich and concluded at the University of Vienna.

types of situations, the sport psychologist working with the team aims to adapt players to the performance pressure in case the match ends in a penalty shoot-out. Only days later, Germany beat Argentina 4–2 in a penalty shoot-out to reach the semi-final at the 2006 FIFA Men's World Cup. All German shooters, including Borowski, scored (Feikes, Hadding, Kremin, & Spieß, 2006).

This is only one successful pressure-training example, but the intriguing question is whether such interventions typically help performers to achieve their best performance in high-pressure situations. Given the occurrence of decisive moments in almost every competition, the ability to perform successfully under pressure is a crucial aspect of sport performance (Mesagno & Mullane-Grant, 2010). Is there empirical evidence, however, that interventions actually optimise individual performance under pressure? In this paper, we review the existing literature on 'choking under pressure' (referred to simply as *choking* hereafter) interventions and discuss their effectiveness. Generally, choking refers to the occurrence of suboptimal performance in pressure situations (Baumeister, 1984), where pressure is any factor or combination of factors that increases a performer's anxiety and includes features such as competition, the presence of audience, reward or punishment contingency, and ego relevance (Baumeister & Showers, 1986). In sport, choking is commonly linked to motor skill failure in moments when it counts most, such as missing a decisive penalty shot in soccer. In the following paragraphs, we begin by describing choking and underlying mechanisms, and then present a systematic review of choking interventions.

Choking definition

Choking was initially defined as the substandard performance in pressure situations despite the existence of superb skills and individual strivings for best performance (Baumeister, 1984). Two aspects are inherent in this choking definition: an existent skill and motivation to perform well. A performance is labelled choking only if it is obvious that the performer had the intention to do better and that he/she has the skill to perform better. A missed penalty shot by an unskilled novice, therefore, does not constitute choking, whereas a missed shot by an experienced soccer player may constitute choking. Hence, choking is neither a skill problem nor a motivational problem.

Recently, Mesagno and Hill (2013) initiated a choking definition debate, based on Hill, Hanton, Fleming, and Matthews's (2009) study, which questioned whether any performance decrement should be classified as choking. Mesagno and Hill explained that improved clarity in the choking definition was needed. During this debate, Mesagno and Hill defined choking as 'an acute and considerable decrease in skill execution and performance when self-expected standards are normally achievable, which is the result of increased anxiety under perceived pressure' (p. 273). This definition is a further extension of other definitions because it attempts to include key components of choking (e.g. motivation, skilled performance, increases in the performer's anxiety, and a resulting 'acute and considerable' performance decrease). Nevertheless, Mesagno and Hill caution that this is only a minimal step in advancing the choking definition until further research is conducted on under-performance and choking differences. Thus, the subsequent systematic review includes studies that either explicitly mention choking or demonstrate an acute, considerable decrease in skill execution (Mesagno & Hill, 2013) in terms of significantly worsened performance under pressure.

Choking theories and interventions

Optimal performance in sport generally occurs when an athlete focuses attention on relevant information, processes, and behaviours, while concomitantly blocking out irrelevant cues (Moran, 1996; Nideffer, 1992). Accordingly, maintaining focus on relevant cues assists an athlete to optimise performance through appropriate attention processes. The two attention-based models that researchers have formulated are the distraction and self-focus models of choking.[1] Fundamentally, distraction involves attending to task-irrelevant cues (e.g. worries, noisy crowd), whereas self-focus involves attending to procedural, step-by-step rules of motor movement.

Distraction model of choking and distraction-based interventions

Advocates of the *distraction*-based explanations (e.g. Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007; Hardy, Mullen, & Martin, 2001; Hill, Hanton, Matthews, & Fleming, 2010a; Mullen, Hardy, & Tattersall, 2005; Oudejans, Kuijpers, Kooijman, & Bakker, 2011) suggest that choking occurs because attention shifts from task-relevant to irrelevant cues as a result of heightened anxiety. Athletes who experience choking become distracted easily, resulting in the athlete disregarding important task-relevant cues. Distraction model explanations could be either internal or external distractions. Attention could shift from task-relevant cues to internal distractions (e.g. worries about the score in a close game and its consequences), which exceed a threshold of attentional capacity, thereby diminishing the potential attentional space for high-level performance to occur (Hardy et al., 2001; Mullen et al., 2005). Alternatively, external distractions (e.g. distracting fans, crowd noise) could allow shifts in attention to other irrelevant external cues when anxiety increases. Eysenck et al. (2007) believe that cognitive processing is likely to be diverted to task-irrelevant cues automatically despite whether they are external or internal distractions. Support for distraction models comes from qualitative research in which athletes reported worries and negative thoughts under high-pressure situations and attributed their inferior performance to such distracting factors (e.g. Hill & Shaw, 2013; Oudejans et al., 2011).

The distraction model has provided a useful basis for developing '*distraction-based*' interventions to prevent choking (cf. Mesagno, Geukes, & Larkin, 2015). Accordingly, the aim of distraction-based interventions is to prevent internal or external distractions and promote a task-relevant focus of attention during skill execution. These interventions may include the use of pre-performance routines consisting of features such as cognitive and behavioural preparation, deep breathing, cue words, or countdown to performance (Mesagno, Marchant, & Morris, 2008; Mesagno & Mullane-Grant, 2010).

Self-focus model of choking and self-focus-based interventions

Self-focus approaches have largely been extended from Baumeister's (1984) automatic execution hypothesis. Baumeister explains that choking occurs because, when anxiety increases, the athlete allocates conscious attention to movement execution. This conscious attention interferes with otherwise automatic nature of movement execution, which results in performance decrements. Masters (1992) then expanded Baumeister's hypothesis to explicit and implicit motor learning by suggesting that the method in which a skill is learned may affect their ability to 'reinvest' in the explicit knowledge gained. In particular, when a motor skill is learned explicitly (i.e. through specific instructions how to position and move), the performer may reinvest this explicit rule-based knowledge in the skill execution even after the skill becomes fully automated. In contrast, the reinvestment of explicit knowledge is unlikely when motor skills are learned implicitly (or by analogy; Masters, 2000). Masters's (1992) conscious processing hypothesis (or reinvestment theory recently; Masters & Maxwell, 2008) thus proposed that choking occurs because attention shifts toward explicit rule-based knowledge. This supposition was further developed into the explicit monitoring approach (Beilock & Carr, 2001), which proposed that performance decreases under pressure due to an increase in attention paid to step-by-step execution of a well-learned behaviour. Jackson, Ashford, and Norsworthy (2006) explained that poor performance occurs when an athlete attempts to consciously monitor *and* control movements, rather than monitor movements alone. Thus, advocates of self-focus models of choking believe that the combination of monitoring and controlling skilled performance leads to choking. Support for the self-focus model comes from experimental studies in which participants experienced choking after focusing on step-by-step execution of a motor task (e.g. Hossner & Ehrlenspiel, 2010; Liao & Masters, 2002; Snyder & Logan, 2013).

Similar to distraction models, researchers have used the theoretical underpinnings of the self-focus model to propose '*self-focus-based*' choking interventions (cf. Mesagno, Geukes, et al., 2015). A central tenet of self-focus-based interventions is to minimise the reinvestment of explicit knowledge and the conscious control of skill execution. This may be achieved through distal methods such as minimising the accumulation of explicit knowledge during skill acquisition (Liao & Masters, 2001; Masters, 2000) or through ad hoc interventions aimed at diverting attention away from focusing on the step-by-step execution using task-irrelevant dual tasks (Beilock, Carr, MacMahon, & Starkes, 2002; Mesagno, Marchant, & Morris, 2009).

Acclimatisation interventions

In addition to the above intervention groups, Mesagno, Geukes, et al. (2015) described a third group of interventions that aimed to adapt individuals to pressure and its effects. These '*acclimatisation*' interventions may not be explicitly theory matched to choking research, which indicates that they probably did not focus on preventing distractions or minimising self-focus, but rather on reducing the feelings of pressure that otherwise may lead to distraction or self-focus. Acclimatisation interventions may include (but are not limited to) practice under mild anxiety conditions, such as when being videotaped (e.g. Lewis & Linder, 1997; Oudejans & Pijpers, 2009, 2010), with the goal to familiarise participants with pressure. Although acclimatisation interventions affect the experience of pressure rather than the effect of pressure, applied studies repeatedly show that these interventions prevent choking and are therefore included in the present review.

The present review

The aim of this review is to provide an overview of empirical studies that have tested ways to prevent choking in sport. Within the aforementioned choking models, athletes do not 'lose' their physical ability, technical skills, and strategic knowledge during an important competition but adopt maladaptive attentional processes in response to pressure. It is therefore important for both researchers and practitioners working with athletes to have a greater understanding of how to prevent maladaptive attention changes and promote performance under pressure. Previous review papers on choking have primarily focused on choking theories and the rationale for the application of these theories to choking prevention (Beilock & Gray, 2007; Hill et al., 2009; Hill, Hanton, Matthews, & Fleming, 2010b; Mesagno, Geukes, et al., 2015). Empirical research on choking interventions has burgeoned in recent years, which warrants a more comprehensive and systematic review of empirical data. In order to summarise the research findings and to identify potential future directions, we conducted a synthesis of published work using a systematic-review methodology.

The present review includes choking intervention studies published up to April 2017. Following Mesagno, Geukes, et al.'s (2015) classification of interventions, we used the two choking models to categorise choking interventions. Results concerning distraction-based interventions are listed first, followed by reporting the effects of self-focus-based interventions. Acclimatisation interventions, which may not be easily theory matched, are itemised last. The interventions were categorised according to the authors' interpretation of how the intervention fitted within existing choking models. When the authors did not state the intervention-model match, we used the Mesagno et al. categorisation.

Method

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009) to conduct this review.

Study eligibility criteria

Studies were included that used an intervention to prevent choking in the field of sport. The specific inclusion criteria were: (a) contained a high-pressure condition; (b) included skilled individuals or trained novices; (c) tested a motor skill in sport; (d) employed an intervention to prevent choking, and (e) compared how performance changed from before to after an intervention (i.e. pretest–posttest design). The inclusion of a high-pressure condition was fundamental because, per definition, choking only occurs under pressure (Baumeister, 1984; Mesagno & Hill, 2013). Therefore, included studies either reported an effective pressure manipulation (as validated by significantly increased anxiety compared to a baseline; cf. Mesagno & Hill, 2013) or used a 'real-world' pressure (e.g. an actual competition; Baumeister & Showers, 1986). Similarly, a high level of skill is fundamental in most choking definitions. We therefore included studies that sampled experienced athletes. Studies with trained novices were only included when the intervention study design required a sample with no initial knowledge of the skill tested such as when investigating implicit learning or quiet eye (QE) training.

Search strategy

A systematic literature search was undertaken on the computerised psychological and sport databases PsycARTICLES (1894 to present), ScienceDirect (1967 to present), SPORT-Discus (1970 to present), and Web of Science (1898 to present). The aim was to find interventions related to choking (sometimes referred to as 'paradoxical performance' or 'skill failure'; Baumeister & Showers, 1986) and performance under pressure. Therefore, keyword combinations used were: '*choking under pressure*' OR '*performing under pressure*' OR '*performance under pressure*' OR '*paradoxical performance*' OR '*skill failure*' AND *intervention* OR *preventing* OR *prevent* OR *prevention*. Limiters were: scholarly (peer-reviewed) journals, English language, and empirical study. In addition, we hand searched reference lists of relevant reviews (Beilock & Gray, 2007; Hill et al., 2010b; Mesagno, Geukes, et al., 2015) and retrieved articles for other articles.

Study selection and data extraction

We sifted the retrieved studies in two stages. First, the first author screened titles and abstracts, with duplicates and clearly irrelevant records excluded. Second, the full-text papers of the remaining records were retrieved, and the first and second authors independently performed eligibility assessment. Discrepancies in the articles included/excluded for review were resolved through discussion. A data extraction form was developed and pilot-tested. The following characteristics were extracted from each study: (a) authors; (b) publication date; (c) mean age; (d) gender; (e) analysed sample size; (f) participant characteristics (competitive standard and type of sport); (g) study design; (h) pressure manipulation or 'real-world' pressure; (i) performance task; (j) intervention used; and (k) key findings. The first author initially extracted information for each included study, whereby the second author then assessed for accuracy and level of completion. No errors or omissions were identified. During the review process, we were not blind to the author, institution, or journal title.

Quality assessment

To assess the risk of bias of each selected study, we employed Version 11 of the Mixed Methods Appraisal Tool (MMAT; Pluye et al., 2011). The MMAT was developed for complex systematic reviews, which permits researchers to concomitantly appraise the methodological quality of qualitative, quantitative, and mixed methods studies. The tool comprises up to four methodological criteria for each of five types of study design (qualitative studies, randomised controlled trials, non-randomised quantitative studies, quantitative descriptive studies, and mixed methods studies), which are rated on a nominal scale (yes, no, can't tell). The MMAT has been used beneficially in other systematic reviews in sport and exercise psychology (Gayman, Fraser-Thomas, Dionigi, Horton, & Baker, 2016).

In particular, studies retrieved for the present review were randomised controlled trials (experiments), non-randomised controlled trials (quasi-experiments), or case reports (single-case studies). For randomised controlled trials, we assessed methodological quality by examining the quality of randomisation, allocation concealment or blinding (when applicable), outcomes reporting, and drop-out rate, which resulted in a potential total score from 25% (one criterion met) to 100% (all four criteria met). For non-randomised controlled trials, we assessed methodological quality by examining the quality of selection, comparability, appropriate exposure, and outcomes reporting, which resulted in a total score from 25% (one criterion met) to 100% (all four criteria met). For case reports, we assessed methodological quality by examining the quality of sampling, selection, and appropriate measurement, which resulted in a total score from 33% (one criterion met) to 100% (all three criteria met).

Results

Initial search results returned 543 records, which were reduced to 55 records after screening. A total of 36 articles with $K = 47$ separate intervention studies (i.e. eight articles included more than one study) were included in the final qualitative synthesis (Figure 1). The studies (K) were considered as the unit of analysis since they used independent samples (included the studies in the multi-study articles). Sample characteristics, research design, pressure manipulation, and methodological quality are summarised in Table 1, and performance task, type of intervention, and key findings are summarised in Table 2.

Characteristics of samples

In terms of the sample sizes, six studies (13%) were single-subject studies, 37 studies (79%) included between 1 and 50 participants, and only one study (2%) included more than 100 participants. The mean age of participants ranged from 20 to 40 years for over half of the

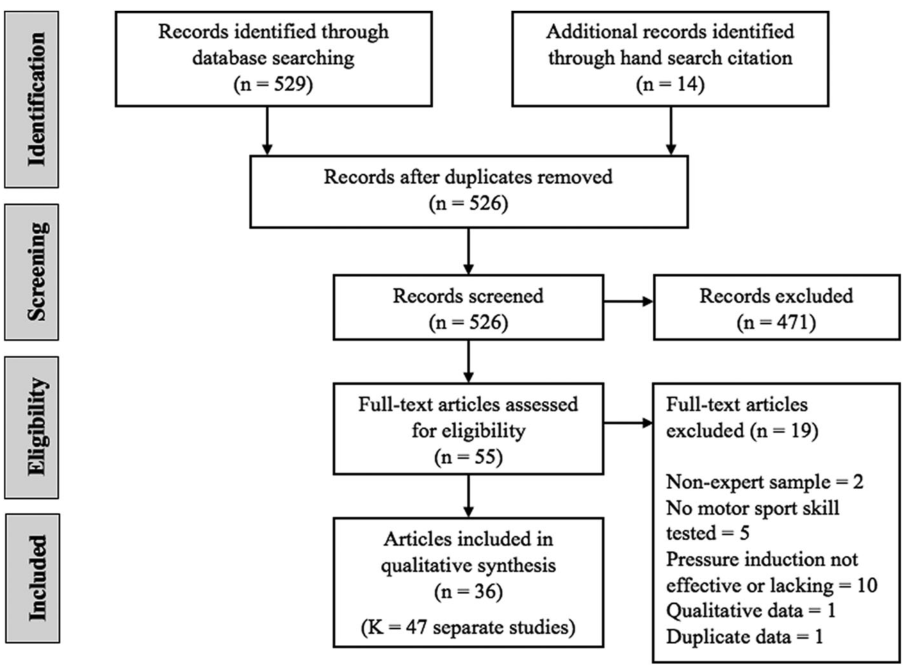

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) chart of search strategy.

Table 1. Summary of included studies.

Reference	Design	Participants	Sample size (Female)	Age (years)	Competitive standard	Pressure manipulation	Quality assessment
I. Distraction-based interventions							
Hazell et al., 2014	Experimental	Soccer players	20 (0)	19.5	Semi-professional	Ego relevance, videotaping	2
Lautenbach et al., 2015	Experimental	Tennis players	29 (14)	24.0	Not reported	Serial subtraction task, number sequencing task	2
Mesagno et al., 2008, Case 1	Single-case design	Tenpin bowler	1 Man	21	Club	Videotaping, audience, rewards	3
Mesagno et al., 2008, Case 2	Single-case design	Tenpin bowler	1 Man	41	Club	Videotaping, audience, rewards	3
Mesagno et al., 2008, Case 3	Single-case design	Tenpin bowler	1 Woman	28	Club	Videotaping, audience, rewards	3
Mesagno & Mullane-Grant, 2010	Experimental	Australian football players	60 (0)	22.9	Regional	Audience, rewards	2
Mesagno, Hill, et al., 2015	Experimental	Tenpin bowlers	36 (not reported)	40.5	Club	Actual competition	2
II. Self-focus-based interventions							
Ashford & Jackson, 2010, Study 1	Experimental	Field-hockey players	34 (18)	22.0	Collegiate	Ego relevance, videotaping	2
Ashford & Jackson, 2010, Study 2	Experimental	Field-hockey players	30 (14)	21.5	Collegiate	Ego relevance, videotaping	2
Balk et al., 2013	Experimental	Golfers	38 (12)	59.6	Club	Ego relevance, videotaping, competition, rewards	2
Beckmann et al., 2013, Study 1	Experimental	Soccer players	29 (0)	24.3	Semi-professional	Audience, competition, rewards	2
Beckmann et al., 2013, Study 2	Experimental	Taekwondo fighters	19 (6)	15.6	Elite	Ego relevance, videotaping	3
Beckmann et al., 2013, Study 3	Experimental	Badminton players	18 (6)	35.6	Regional	Ego relevance, videotaping, competition, rewards	2
Bobrownicki et al., 2015	Experimental	Students	21 (0)	23.7	Trained novices	Heights	2
Gröpel & Beckmann, 2017a, Study 1	Quasi-experimental	Gymnasts	28 (15)	22.9	Collegiate	Actual competition	3
Gröpel & Beckmann, 2017a, Study 2	Experimental	Gymnasts	21 (21)	13.8	Regional	Audience, competition, rewards	3
Gucciardi & Dimmock, 2008	Experimental	Golfers	20 (1)	25.3	Club	Competition, rewards	2
Jackson et al., 2006, Study 1	Experimental	Field-hockey players	34 (19)	22.2	Regional	Ego relevance, videotaping	2
Jackson et al., 2006, Study 2	Experimental	Soccer players	25 (0)	20.4	Collegiate	Ego relevance, videotaping	2
Land & Tenenbaum, 2012	Experimental	Golfers	20 (15)	21.2	Not reported	Ego relevance, videotaping	2
Lewis & Linder, 1997	Experimental	Students	112 (0)	Not reported	Trained novices	Rewards	2
Liao & Masters, 2001, Study 2	Experimental	Students	36 (20)	21.5	Trained novices	Ego relevance	2
Masters, 1992	Experimental	Students	40 (not reported)	27.2	Trained novices	Ego relevance, rewards	2

(*Continued*)

Table 1. Continued.

Reference	Design	Participants	Sample size (Female)	Age (years)	Competitive standard	Pressure manipulation	Quality assessment
Mesagno et al., 2009, Case 1	Single-case design	Basketball player	1 Woman	18	Regional	Videotaping, audience, rewards	3
Mesagno et al., 2009, Case 2	Single-case design	Basketball player	1 Woman	19	Regional	Videotaping, audience, rewards	3
Mesagno et al., 2009, Case 3	Single-case design	Basketball player	1 Woman	20	Regional	Videotaping, audience, rewards	3
Moore et al., 2012	Experimental	Students	40 (not reported)	19.6	Trained novices	Ego relevance, competition, rewards	2
Mullen et al., 2015	Experimental	Students	24 (0)	19.6	Trained novices	Ego relevance, competition	2
Nibbeling et al., 2012	Experimental	Dart players	11 (0)	34.2	Not reported	Heights	2
Ring et al., 2015	Experimental	Golfers	24 (0)	22.0	Club	Ego relevance, competition, rewards	2
Schücker et al., 2010	Experimental	Students	51 (18)	32.7	Trained novices	Ego relevance	2
Schücker et al., 2013	Experimental	Students	41 (18)	21.4	Trained novices	Competition, rewards	2
Vine & Wilson, 2010	Experimental	Students	14 (0)	20.3	Trained novices	Ego relevance, competition, rewards	1
Vine et al., 2011	Experimental	Golfers	22 (0)	21.0	Club	Ego relevance, competition, rewards; actual competition	2
Vine & Wilson, 2011	Experimental	Students	20 (0)	20.5	Trained novices	Ego relevance, competition, rewards	2
Vine et al., 2013	Experimental	Students	45 (not reported)	21.2	Trained novices	Ego relevance, competition, rewards	2
Wood & Wilson, 2011	Experimental	Soccer players	20 (not reported)	20.2	Collegiate	Competition, rewards	2
Wood & Wilson, 2012	Experimental	Soccer players	20 (not reported)	20.2	Collegiate	Competition, rewards	2
Zhu et al., 2011, Study 2	Experimental	Students	18 (not reported)	22.0	Trained novices	Ego relevance, videotaping	2
III. Acclimatisation interventions							
Balk et al., 2013	Experimental	Golfers	38 (12)	59.6	Club	Ego relevance, videotaping, competition, rewards	2
Beilock & Carr, 2001, Study 3	Experimental	Students	54 (not reported)	Not reported	Trained novices	Rewards	2
Beilock & Carr, 2001, Study 4	Experimental	Students	32 (not reported)	Not reported	Trained novices	Rewards	2
Bell et al., 2013	Quasi-experimental	Cricket players	41 (0)	16.9	Elite	Actual competition	3
Beseler et al., 2016	Experimental	Australian football players	12 (0)	20.6	Semi-professional	Ego relevance, videotaping, competition, rewards	1
Lewis & Linder, 1997	Experimental	Students	112 (0)	Not reported	Trained novices	Rewards	2
Oudejans & Pijpers, 2009, Study 1	Quasi-experimental	Basketball players	17 (0)	23.0	Semi-professional	Ego relevance, videotaping, competition, rewards	4
Oudejans & Pijpers, 2009, Study 2	Experimental	Dart players	17 (0)	26.0	Club	Heights	2
Oudejans & Pijpers, 2010	Experimental	Students	24 (8)	22.5	Trained novices	Rewards, heights	2
Reeves et al., 2007	Experimental	Soccer players	37 (37)	17.5	Collegiate	Ego relevance, videotaping, competition, rewards	2

Note: Quality assessment of experimental and quasi-experimental studies: 1 = one methodological criterion met (25%); 2 = two methodological criteria met (50%); 3 = three methodological criteria met (75%); 4 = four (all) methodological criteria met (100%). Quality assessment of single-case studies: 1 = one methodological criterion met (33%); 2 = two methodological criteria met (66%); 3 = three (all) methodological criteria met (100%).

Table 2. Summary of study results.

Reference	Performance task	Intervention	Key findings
I. Distraction-based interventions			
Hazell et al., 2014	Penalty shots (soccer)	PPR	No significant differences between PPR and control groups in shot accuracy.
Lautenbach et al., 2015	Tennis serves	PPR	Tennis players worsened their serving performance in an initial, high-pressure phase with no PPR (when compared with a pressure-free baseline), but the performance remained stable after the introduction of a PPR under pressure.
Mesagno et al., 2008, Case 1	Bowling accuracy	PPR	The athlete improved bowling accuracy (19%) using PPR under pressure compared to an initial, high-pressure phase with no PPR.
Mesagno et al., 2008, Case 2	Bowling accuracy	PPR	The athlete improved bowling accuracy (31%) using PPR under pressure compared to an initial, high-pressure phase with no PPR.
Mesagno et al., 2008, Case 3	Bowling accuracy	PPR	The athlete improved bowling accuracy (38%) using PPR under pressure compared to an initial, high-pressure phase with no PPR.
Mesagno & Mullane-Grant, 2010	Football shots (Australian football)	PPR	Participants in all four PPR conditions (deep breathing, cue words, temporal consistency, and a combination of these) improved shot accuracy under pressure, whereas control participants worsened shot accuracy.
Mesagno, Hill, et al., 2015	In-game performance (bowling)	PPR	Bowling league scores improved in the post-intervention testing, but there were no significant differences between PPR and control groups (no interaction effect).
II. Self-focus-based interventions			
Ashford & Jackson, 2010, Study 1	Field-hockey dribbling	Fluency priming	Participants dribbled significantly faster under pressure when they were primed with fluency words than in a control (non-priming) condition. Dribbling accuracy in the priming condition was better than that in the control condition regardless of pressure.
Ashford & Jackson, 2010, Study 2	Field-hockey dribbling	Fluency priming	Participants dribbled faster when they were primed with fluency words, but also when primed with neutral words, than in non-priming condition (regardless of pressure). The priming manipulations had no effect on dribbling accuracy.
Balk et al., 2013[a]	Golf putt	Task-irrelevant cues	Golfers who focused on task-irrelevant cue (a favourite song) instead of on golf putting improved putting accuracy under pressure, whereas control participants 'choked'.
Beckmann et al., 2013, Study 1	Penalty shots (soccer)	LH contractions	Participants who used LH contractions prior to executing penalty shots under pressure were as accurate as in baseline, whereas control participants decreased shooting accuracy.
Beckmann et al., 2013, Study 2	Taekwondo kicks	LH contractions	Participants who used LH contractions improved performance under pressure, whereas control participants worsened performance.
Beckmann et al., 2013, Study 3	Badminton serves	LH contractions	All participants experienced choking in the first high-pressure phase with no intervention. In the second high-pressure phase using a LH contraction intervention, participants improved serving accuracy, whereas control participants continued to 'choke'.
Bobrownicki et al., 2015	High jump	Analogy learning	No significant differences between analogy learning and explicit learning groups when high jumping under pressure.

(*Continued*)

Table 2. Continued.

Reference	Performance task	Intervention	Key findings
Gröpel & Beckmann, 2017a, Study 1	In-game performance (gymnastics)	LH contractions	LH contractions group performed better than comparison group in the final of the German university championship in artistic gymnastics.
Gröpel & Beckmann, 2017a, Study 2	Beam exercise (gymnastics)	LH contractions	Gymnasts who used LH contractions prior to balance beam exercise performed better than control participants in a simulated competition under pressure.
Gucciardi & Dimmock, 2008[b]	Golf putt	Fluency cues, task-irrelevant cues	Under increased pressure, putting accuracy deteriorated when participants focused on their putting technique, but did not deteriorate when using either fluency or task-irrelevant thoughts. Irrespective of pressure, fluency thoughts were more beneficial for putting accuracy than task-irrelevant thoughts and task-specific (technical) thoughts.
Jackson et al., 2006, Study 1	Field-hockey dribbling	Dual task	Participants dribbled significantly faster in the dual-task condition than in the single-task and skill-focus conditions.
Jackson et al., 2006, Study 2	Soccer dribbling	Process goal	Setting a process goal regarding ball-dribbling behaviour had no differential effect on dribbling performance under pressure.
Land & Tenenbaum, 2012[b]	Golf putt	Dual task (irrelevant), Dual task (relevant)	Golfers made significantly more putts under pressure during both dual-task conditions (irrelevant and relevant to golf putt) than under single-task condition. No differential effect between the task-irrelevant and task-relevant conditions were found.
Lewis & Linder, 1997[a]	Golf putt	Dual task	Participants in dual-task condition made more accurate putts under pressure than control participants.
Liao & Masters, 2001, Study 2	Topspin hitting (table tennis)	Analogy learning	The performance of analogy learning group did not deteriorate under pressure, whereas the performance of explicit learning group declined under pressure.
Masters, 1992	Golf putt	Implicit learning	Implicit learning group showed no degradation of performance in high-pressure pressure, in contrast to the explicit learning and control groups.
Mesagno et al., 2009, Case 1	Basketball free throw	Dual task	The athlete improved shooting percentage by 18% using a dual-task intervention under pressure compared to an initial, high-pressure phase with no intervention.
Mesagno et al., 2009, Case 2	Basketball free throw	Dual task	The athlete improved shooting percentage by 22% using a dual-task intervention under pressure compared to an initial, high-pressure phase with no intervention.
Mesagno et al., 2009, Case 3	Basketball free throw	Dual task	The athlete improved shooting percentage by 18% using a dual-task intervention under pressure compared to an initial, high-pressure phase with no intervention.
Moore et al., 2012	Golf putt	QE training	QE-trained group performed more accurately and displayed more effective gaze control than control group when putting under pressure.
Mullen et al., 2015[b]	Race-driving task	Process goal (holistic), Process goal (part)	Holistic process goal group outperformed the part process goal intervention group under pressure. But there were no significant differences between the intervention groups and a control group.

(*Continued*)

Table 2. Continued.

Reference	Performance task	Intervention	Key findings
Nibbeling et al., 2012	Dart throw	Dual task	Dart scores remained stable under pressure. Dart scores did not differ between dual-task and control conditions.
Ring et al., 2015	Golf putt	Neurofeedback training	No significant differences between neurofeedback and control groups in putting accuracy.
Schücker et al., 2010	Golf swing	Analogy learning	No significant differences between analogy learning and explicit learning groups in the quality of the full swing in golf under pressure.
Schücker et al., 2013	Golf putt	Analogy learning	No significant differences between analogy learning and explicit learning groups in putting accuracy under pressure.
Vine & Wilson, 2010	Golf putt	QE training	QE-trained group maintained more effective attentional control and performed significantly better in the pressure test than a control group.
Vine et al., 2011	Golf putt (lab); In-game performance	QE training	QE-trained group outperformed control group both in a laboratory pressure test and during an actual competition.
Vine & Wilson, 2011	Basketball free throw	QE training	QE-trained participants performed more accurately under pressure and displayed more effective gaze control than control participants.
Vine et al., 2013[b]	Golf putt	QE training, analogy learning	When compared to pre-pressure condition, QE-trained improved putting accuracy under pressure, whereas explicit learning group worsened performance. Analogy learning group maintained performance.
Wood & Wilson, 2011	Penalty shot (soccer)	QE training	No significant differences between QE-trained and control groups in penalty shootout under pressure.
Wood & Wilson, 2012	Penalty shot (soccer)	QE training	QE-trained group improved shooting accuracy under pressure, whereas control group displayed similar performance to baseline.
Zhu et al., 2011, Study 2	Golf putt	Implicit learning	Irrespective of pressure, implicit learning was more beneficial for putting accuracy than explicit learning.
III. Acclimatisation interventions			
Balk et al., 2013[a]	Golf putt	Reappraisal cues	Golfers who used cognitive reappraisal under pressure holed the same number of putts as in baseline, whereas control participants 'choked'.
Beilock & Carr, 2001, Study 3[b]	Golf putt	Distraction training, SC training	SC-trained group improved putting accuracy under pressure (as compared to baseline), whereas both distraction-trained and control groups worsened performance.
Beilock & Carr, 2001, Study 4[b]	Golf putt	Distraction training, SC training	SC-trained group improved putting accuracy under pressure, whereas distraction-trained group 'choked'.
Bell et al., 2013	In-game performance (cricket)	Anxiety training	Participants who had practised under heightened anxiety improved their competitive performance statistics, whereas performance scores for a comparison group did not differ from pretest to posttest.
Beseler et al., 2016	Football shots (Australian football)	Anxiety training	No significant effect of practising under anxiety on goal-kicking accuracy in a pressure posttest.
Lewis & Linder, 1997[a]	Golf putt	SC training	Participants who had practised under heightened self-consciousness made more

(*Continued*)

Table 2. Continued.

Reference	Performance task	Intervention	Key findings
			putts under pressure than non-adapted participants.
Oudejans & Pijpers, 2009, Study 1	Basketball free throw	Anxiety training	After training with anxiety, performance no longer deteriorated during a pressure posttest as compared to a pressure pretest, whereas a control group decreased performance.
Oudejans & Pijpers, 2009, Study 2	Dart throw	Anxiety training	Participants who had practised with anxiety maintained stable performance in a pressure posttest, whereas performance of control group deteriorated.
Oudejans & Pijpers, 2010	Dart throw	Anxiety training	Participants who had trained with anxiety performed equally well on all low-pressure, mild-pressure, and high-pressure tests, while performance of the control group deteriorated with high pressure.
Reeves et al., 2007[b]	Penalty shot, breakaway situation (soccer)	Distraction training, SC training	SC-trained group improved shooting accuracy under pressure (as compared to baseline), whereas both distraction-trained and control groups worsened performance.

Note: PPR = pre-performance routine; LH = left-hand contractions; QE = quiet eye training; SC = self-consciousness training. [a]Studies that tested two interventions in two different categories. [b]Studies that tested two interventions within the same category.

intervention studies (68%). Twenty-nine studies (62%) comprised experienced athletes, recruited mostly from collegiate sports and nonprofessional clubs and leagues. Studies with trained novices ($K = 12$; 32%) were included when the intervention study design required a sample with no initial knowledge of the skill tested such as when investigating implicit learning or quiet eye (QE) training. Three studies (6%) did not provide sufficient information about the competitive standard of the participants but reported that the participants were skilled athletes with approximately 10 years of experience (Land & Tenenbaum, 2012; Lautenbach et al., 2015; Nibbeling, Oudejans, & Daanen, 2012).

Characteristics of studies

The studies eligible for this review included 15 different sports (see Table 2), which were golf ($K = 15$), soccer ($K = 6$), basketball ($K = 5$), tenpin bowling ($K = 4$), field-hockey ($K = 3$), darts ($K = 3$), artistic gymnastics ($K = 2$), Australian football ($K = 2$), badminton ($K = 1$), cricket ($K = 1$), high jump ($K = 1$), motor sport ($K = 1$), tennis ($K = 1$), table tennis ($K = 1$), and taekwondo ($K = 1$). In most of these studies (91%), pressure was induced artificially with a combination of reward contingency ($K = 29$), ego relevance ($K = 23$), videotaping ($K = 19$), simulated competition ($K = 18$), the presence of audience ($K = 9$), performing at height (e.g. from a climbing wall; $K = 4$), and a math task ($K = 1$; see Table 1). Only four studies (9%) analysed in-game performance during an actual competition. When further analysing choking interventions, seven studies (14%) implemented distraction-based interventions, 32 studies (65%) implemented self-focus-based interventions, and 10 studies (20%) used acclimatisation interventions. Two studies (i.e. Balk, Adriaanse, De Ridder, & Evers, 2013; Lewis & Linder, 1997) tested both self-focus-based and acclimatisation interventions, and were therefore included in both intervention categories. In addition, seven studies simultaneously tested two separate interventions within the same intervention category (see Table 2).

An analysis of the research design revealed that 38 studies (81%) used experimental designs. Of the remaining studies, three studies (6%) used quasi-experimental designs, and six studies (13%) used single-case designs. All six single-case studies met all of the MMAT quality criteria (see Table 1 for methodological quality scores). Of the quasi-experimental studies, one met all, and two met 75% of the MMAT criteria. Of the experimental studies, none met all of the MMAT criteria, two met 75%, 34 met 50%, and two met only 25% of criteria. The main reason for the medium quality score of the experimental studies was that most studies did not provide a clear description of the randomisation and allocation concealment procedures, but instead included only a simple statement such as 'participants were randomly allocated', which has been considered insufficient (Pluye et al., 2011).

Distraction-based interventions

All analysed studies within this category ($K = 7$) implemented a pre-performance routine (PPR) to prevent choking (Table 2). A PPR is defined as a set of cognitive and behavioural elements that an athlete systematically engages in prior to performance execution, which helps to maintain task-related attention (Cotterill, 2010). In the analysed studies, the content of PPRs consisted of a combination of the following: relaxing, mental imagery, cue words, external focus, and temporal consistency.

Of the reported distraction-based studies, four were experimental, and three employed single-case designs. Two experimental studies showed no significant effect of PPR on performance under pressure (Hazell, Cotterill, & Hill, 2014; Mesagno, Hill, & Larkin, 2015), whereas studies conducted by Lautenbach et al. (2015) and Mesagno and Mullane-Grant (2010) showed positive effects. In particular, Lautenbach et al. found that tennis players worsened their performance under pressure before they used a PPR, but not after they learned the PPR. Mesagno and Mullane-Grant found that the use of deep breathing, cue words, temporal consistency, and a combination of these (the extensive PPR) improved Australian football players' shot accuracy under pressure, with the extensive PPR having the strongest effect, whereas control participants experienced choking. Regarding the single-case studies, Mesagno et al. (2008) provided three 'choking-susceptible' tenpin bowlers with an individualised PPR. The PPR helped the athletes improve performance by an average of 29% under pressure to an initial, high-pressure phase with no intervention. In sum, performance under pressure was either better or the same, but not worse, after using a PPR than when no PPR was implemented.

Self-focus-based interventions

Within self-focus-based intervention studies ($K = 32$), the content of treatments consisted of dual task, QE training, analogy or implicit learning, left-hand contractions, fluency cues, task-irrelevant cues, process goal, and neurofeedback training. Of those, the most tested were analogy or implicit learning ($K = 7$), QE training ($K = 7$), the use of a dual task or task-irrelevant cues during performing under pressure ($K = 9$), and left-hand contractions ($K = 5$). Key findings are presented in Table 2.

Seven studies tested the benefits of analogy or implicit learning for performance under pressure. Implicit learning represents a distal choking intervention to minimise the accumulation of explicit knowledge during skill acquisition to reduce the likelihood of reinvestment (Masters, 1992). Masters found that golfers who had acquired golf putting skills without any explicit instructions on how to putt a golf ball (i.e. implicit learning) improved their performance under pressure, whereas those who had received specific instructions during the skill acquisition phase (i.e. explicit learning) worsened their performance. Participants, however, in the implicit learning group learned the golf putting skill rather slow in comparison to the explicit learning group. To accelerate motor skill learning while minimising explicit rules, Masters (2000) introduced analogy motor learning, which uses biomechanical metaphors to teach complex actions (e.g. hitting a table tennis forehand as if 'drawing a right-angled triangle'). Teaching novice athletes to hit topspin this way, Liao and Masters (2001; Study 2) found that the analogy learning group showed the same learning rate as the explicit learning group did, but the former outperformed the latter when performing under pressure. Similar findings have also been reported (Vine, Moore, Cooke, Ring, & Wilson, 2013). In contrast, Bobrownicki, MacPherson, Coleman, Collins, and Sproule (2015) found no difference between participants who learned high jump technique using either analogy learning or explicit learning. Other researchers (e.g. Schücker, Ebbing, & Hagemann, 2010; Schücker, Hagemann, & Strauss, 2013) found no effect of analogy learning on performance under pressure among golfers. Finally, Zhu, Poolton, Wilson, Maxwell, and Masters (2011) observed only a general beneficial effect of implicit learning, but no interaction with the pressure manipulation. Irrespective of pressure, golfers putted more accurately if they had learned putting with analogy rather than explicit, technical instructions. In sum, the reported effects of analogy or implicit learning are somewhat inconsistent.

QE training has been proposed as another, rather distal, choking intervention. Quiet eye is defined as the final visual fixation toward a relevant target prior to the execution of a movement (Vickers, 2007). Notably, QE training may be considered as a form of implicit learning that can help to limit the explicit knowledge accumulated over time (Vine et al., 2013), thereby reducing the likelihood of reinvestment and choking. In their initial study, Vine and Wilson (2010) trained novice golfers to putt a golf ball using either QE instructions or technical instructions (the control group). Vine and Wilson found no differences in the learning rate between the groups, but the QE group outperformed the control group when putting under pressure. These findings have been replicated and extended with both novice athletes (Moore, Vine, Cooke, Ring, & Wilson, 2012; Vine et al., 2013; Vine & Wilson, 2011) and experts (Vine, Moore, & Wilson, 2011; Wood & Wilson, 2012) indicating robustness of this intervention. The only inconclusive study (Wood & Wilson, 2011) found that QE-trained soccer players were significantly more accurate than control participants in a pressure-free retention test, but failed to maintain their accuracy advantage in a penalty shootout under pressure.

Researchers have also developed interventions for skilled athletes who have already accumulated explicit knowledge during skill acquisition. These interventions help prevent reinvestment in, and the use of, explicit knowledge under pressure. Of them, the most studied was the use of a dual task under pressure. The dual tasks used involved reacting to a tone that sounded on a variable-interval schedule by verbally generating a random letter of the alphabet during performance (Jackson et al., 2006, Study 1; Land & Tenenbaum, 2012), saying the word 'hit' aloud at the moment a golf club struck the golf ball (Land & Tenenbaum, 2012), counting backwards (Lewis & Linder, 1997; Nibbeling et al., 2012), or focusing attention on the words of a song during basketball free-throw shooting (Mesagno et al., 2009). When performing a dual task, athletes focus attention toward the dual task rather than step-by-step skill execution, which facilitates the smooth execution of the skill without the interference of reinvestment. All studies with the exception of Nibbeling et al. (2012) reported that participants who used a dual task outperformed control participants under pressure; the Nibbeling et al. study showed a null effect. Similar to dual task, researchers have also found that using task-irrelevant cues such as thinking about a favourite song (Balk et al., 2013) or focusing on colours while golf putting (Gucciardi & Dimmock, 2008) optimised performance under pressure.

Furthermore, findings indicate that left-hand contractions (also called 'hemisphere-specific priming'; Beckmann, Gröpel, & Ehrlenspiel, 2013) may be an effective choking intervention. Left-hand contractions have been proposed to prime the visuospatial processes of the right hemisphere necessary for motor performance and to suppress the analytical processes of the left hemisphere linked to the step-by-step control of skill execution (Beckmann et al., 2013; Cross-Villasana, Gröpel, Doppelmayr, & Beckmann, 2015). In all five studies on left-hand contractions, researchers (e.g. Beckmann et al., 2013; Gröpel & Beckmann, 2017a) found that skilled athletes who squeezed a soft ball in their left hand for 30 seconds prior to performing under pressure maintained stable performance or improved under pressure, whereas control participants who squeezed the ball with the right hand experienced choking. Other researchers used fluency cues to prime optimal skill execution (Ashford & Jackson, 2010; Gucciardi & Dimmock, 2008). For example, Ashford and Jackson (2010) asked athletes to form grammatically correct four-word sentences (e.g. 'the movement was smooth') from randomly presented five-word items, each of which included a fluency word (e.g. 'smooth', 'spontaneously', 'balanced'). Using such fluency primes helped to improve performance under pressure in two of three conducted studies.

Of the remaining self-focus-based interventions, goal setting (Jackson et al., 2006, Study 2; Mullen, Faull, Jones, & Kingston, 2015) and neurofeedback training (Ring, Cooke, Kavussanu, McIntyre, & Masters, 2015) have been examined with little success. Jackson et al. (2006) asked soccer players to set a process goal for their ball-dribbling behaviour, but this did not result in better dribbling performance under pressure when compared to a control condition. Similarly, Mullen et al. (2015) found no difference between the goal setting and control conditions in a race-driving task under pressure.

Acclimatisation interventions

Within acclimatisation intervention studies ($K = 10$), the content of treatments consisted of training under mild anxiety, self-consciousness (i.e. self-focus) or distraction conditions, and with reappraisal cues. Findings indicate positive effects only for self-consciousness and anxiety trainings. Self-consciousness training consisted of practising golf putting in front of a video camera (Beilock & Carr, 2001; Lewis & Linder, 1997) and paying attention to what part of the foot was used to kick a soccer ball (Reeves, Tenenbaum, & Lidor, 2007). Anxiety training was more complex and consisted of punishment contingency for disciplinary and performance failures (Bell, Hardy, & Beattie, 2013) or a combination of videotaping, ego relevance, reward contingency, and the presence of audience (Beseler, Mesagno, Young, & Harvey, 2016; Oudejans & Pijpers, 2009, 2010). All studies with the exception of Beseler et al. (2016) reported positive evidence for the effectiveness of practising under self-consciousness and anxiety conditions; the Beseler et al. study showed null effect.

In contrast, studies with distraction training indicated negative effects. Distraction training consisted of practising with a dual task, such as listening to a recorded list of spoken words and reacting to a target word while practising golf putting (Beilock & Carr, 2001), and commenting on distraction cues while practising penalty shots in soccer (Reeves et al., 2007). Each time, athletes worsened their performance in a posttest under pressure. Notably, the number of training trials under a distraction condition was the same as the number of trials under a self-consciousness condition. Beilock and Carr (2001) also tested the process of skill acquisition and found significant skill improvement in both training groups (and no differences between the groups) during the training phase. Taken together, this decreases the likelihood of differences in skill acquisition and therefore performance under pressure occurring.

Discussion

This systematic review summarised current evidence for the use of choking interventions in sport. A total of 47 separate studies across 15 different sports met all inclusion criteria. While these studies have adopted varying methods to prevent suboptimal performance, choking interventions generally benefit performance under pressure. For distraction-based interventions, the use of PPRs, such as deep breathing or cue words, were helpful. Among self-focus-based interventions, quiet eye training, left-hand contractions, and the use of a dual task were mostly reported as effective interventions. Caution should be used when interpreting the results for the neurofeedback training study considering the limited number of studies ($n = 1$). The results of the acclimatisation studies were more equivocal depending on the training purpose, with anxiety and self-consciousness training having positive effects and distraction (dual task) or reappraisal training having a negative or no effect, respectively.

Sample characteristics

When analysing study characteristics, we highlight three key points: experimental design, unequal number of studies examining self-focus models, and limited number of studies using elite athletes and real-world competitions. First, it is not surprising that the experimental design is the most widely used considering all studies are investigating interventions to successfully ameliorate choking. Experimental designs are the best method of answering causal questions such as whether a given intervention affects behaviour. Caution, however, should also be used in making broad conclusions regarding effectiveness of tested interventions, as almost all experimental studies included in the present review were of only medium methodological quality. The studies met the criteria of high outcome-completion rate and low drop-out rate, but failed on randomisation and allocation concealment criteria because they did not provide a clear description of how randomisation and allocation concealments were carried out (Pluye et al., 2011). This does not necessarily mean that randomisation was not completed and that allocation was not concealed in the included studies, but the authors were unaware of the importance of clear description of procedures in order to assess the risk of bias. If, however, randomisation and allocation concealment were not carried out, the majority of these studies are at risk of exaggerating the effects of the interventions they were designed to test (Schulz, Chalmers, Hayes, & Altman, 1995).

Second, it seems from the unbalanced numbers of intervention studies concentrating on self-focused models of choking, researchers have favoured empirical investigations on self-focus explanations more than distraction models. Experimental evidence supports the primary tenets of self-focus explanations (Beilock & Carr, 2001; Gucciardi & Dimmock, 2008; Jackson et al., 2006; Mesagno et al., 2009); however, recent qualitative choking investigations (e.g. Hill et al., 2010b; Oudejans et al., 2011) question the ubiquity of the self-focus model, suggesting that distraction-based explanations remain viable. If distraction-based explanations are still possible, additional distraction-based interventions besides PPRs should be developed and tested to reduce choking. One explanation to why additional distraction interventions have not been tested yet is that research has not progressed far enough to determine what distractions should be included within distraction models.

Finally, most choking intervention studies have used trained novices, or club or collegiate participants, with fewer studies focused on elite athletes. If choking interventions are to progress enough to robustly recommend them to athletes within applied consultations, researchers need to empirically test these interventions with elite athletes in laboratory and real-world competitions, along with assuring (and reporting) the use of proper experimental procedures. Critical moments in an actual competition (e.g. a decisive putt in a major golf tournament) may elicit much stronger pressure responses than an (although significant) pressure induction in laboratory, and it is still unclear which intervention may best help in such real-world situations.

Pressure manipulation

This investigation included choking intervention studies that predominantly induced pressure artificially with the review composed of only studies where pressure manipulations were 'successful' at increasing anxiety. That is, studies that did not show a significant increase in anxiety in a high-pressure compared to a low-pressure condition were not included. These would not technically be choking intervention studies because, by definition (e.g. Mesagno & Hill, 2013), a statistically significant anxiety increase was not evident under high pressure. Furthermore, we included interventions tested in actual competitions because it could be argued that competition is a true pressure situation (Baumeister & Showers, 1986). This inclusion indicates that the effective interventions summarised in this review actually help athletes to perform well under pressure; however, we cannot conclude that the same interventions would also be beneficial in situations where athletes are not anxious or pressured to perform.

Although not the focus of the present review, we observed that the most effective pressure manipulations were reward contingency, ego relevance, simulated competition, and videotaping, which were mostly applied in combination with each other. This 'combination strategy' may be an important implication for choking researchers because single elements such as reward contingency or videotaping per se need not automatically increase anxiety levels (Gröpel, 2016; Mesagno, Harvey, & Janelle, 2011). For example, video analysis has become an integral part of sports training, and thus many athletes have become accustomed to the presence of a video camera. Indeed, Mesagno et al. (2011) demonstrated that the performance-contingent monetary incentives or presence of video camera alone did not sufficiently increase anxiety, whereas the combination and the addition of an ego relevance instruction did.

Another reason to use different pressure manipulations in combination, rather than in isolation, lies in the nature of the pressure manipulation itself. According to DeCaro, Thomas, Albert, and Beilock (2011), pressure induced by performance-contingent outcomes (e.g. rewards and punishment contingency) leads to distraction, whereas pressure involving performance monitoring (e.g. by another person and a video camera) leads to explicit monitoring. DeCaro et al. found that outcome pressure disrupted skills that rely on working memory and attention, whereas monitoring pressure disrupted skills that rely on information-integration category learning. Consequently, to enhance effectiveness of pressure manipulations and to ensure that a choking intervention may have an effect, choking researchers should preferably include both outcome and monitoring pressure elements in their designs. For example, when testing distraction-based interventions such as a PPR, inducing monitoring pressure (e.g. by setting up a video camera) without any outcome pressure manipulation may not be effective.

Based on this review, ego-relevant instructions are an often-used pressure element of current studies. Mesagno et al. (2011) explain that ego-relevant instructions elevate self-presentation concerns about making a good impression on important others or 'losing face' when the instructions relate to social comparison or a threat to athletic identity. An example of ego-relevant instructions is informing the to-be-videotaped performers that the video will be evaluated by their coach and that not performing well may lead to potential devaluation (e.g. not being selected for the next game). Yet another reason for using different pressure manipulations in combination is that the manipulations may vary in their impact on anxiety responses according to the situation and personality. For example, Essl and Jaussi (2017) found that the effect of reward and punishment contingency on choking was moderated by individual loss aversion.

Choking interventions

This review highlights a number of potentially robust choking interventions. The most consistent (and positive) effects were obtained with PPR, quiet eye training, left-hand contractions, the use of dual task, and practising under self-consciousness and mild anxiety conditions. The findings that interventions based on both distraction and self-focus models of choking were effective further supports the validity of both attention-based processes underlying choking in sports (Mesagno, Geukes, et al., 2015). From this perspective, it is also less surprising why setting a process goal was not as effective, since goal setting is considered as a powerful motivational technique (Locke & Latham, 2002) rather than an attention-optimising intervention. Given that choking is due to maladaptive attention and not due to deficits in motivation (Baumeister, 1984), therefore, process goals should have only a limited effect.

The dual-task intervention deserves mention. As summarised already, using a dual task seems to have different effects on performance depending on whether used in training or during a competition. While using a dual task was an effective intervention during actual performance under pressure, it paradoxically had performance-harming effects when used in learning and training phases. Thus, the benefits of task-irrelevant cues seem to be limited to skills that were already automated, but using the same task-irrelevant cues during skill acquisition apparently distracts athletes from learning the skill.

In many of the reviewed interventions (e.g. PPR, left-hand contractions), a short education and development session allowed the researcher to engage the athlete on how to apply the intervention. From an applied perspective, it is essential to educate and convince athletes of the intervention mechanism and benefits when the athlete attempts to use it because some interventions might seem illogical to use. For example, in self-focus interventions (e.g. dual tasks), where diverting attention away from task-relevant thoughts are counterintuitive to an elite athlete's perception of optimal concentration or where it may be difficult for the athlete to understand the reasons for the intervention's effectiveness (e.g. left-hand contraction), educating and persuading the athlete about adoption of the intervention should be managed.

Becoming aware of dysfunctional attentional allocation and applying a more functional method of attentional control may help in acute (i.e. non-clinical and occasional) choking experiences, as indicated by the present results. It is unclear, however, whether the identified interventions may be as effective when an athlete has chronic (i.e. repeated) choking episodes. 'Choking-susceptible' athletes involved in single-case studies (Mesagno et al., 2008, 2009) improved after an intervention, but these studies did not include any follow-up measurement to determine the long-term effect of the intervention. Mesagno and Mullane-Grant (2010) first proposed that perhaps education and development of a PPR, an intervention based largely in attention-based choking models, may not decrease the likelihood of choking re-occurring if potentially clinical, anxiety-based models underlie the choking response. Attention-based models may only be a 'Band-Aid fix' for the underlying clinical origins of the anxiety issues that the chronic 'choker' experiences.

Mesagno and colleagues (Mesagno, Geukes, et al., 2015; Mesagno, Mornell, & Quinn, 2016) further differentiated between attention- and anxiety-based choking models. Attention-based choking models focus on what happens to attention when anxiety increases, whereas anxiety-based models (e.g. self-presentation model; Mesagno et al., 2011, 2012) attempt to explain the origins of the cognitive anxiety increase, which leads to attention shifts and performance decreases. According to the self-presentation model of choking (Mesagno et al., 2011), cognitive anxiety (or self-presentation concerns) originates from an individual's sensitivity to situational cues that can threaten his or her athletic identity. Consequently, adapting the individual to potentially threatening cues in an unpleasant situation may help 'chronic chokers' to compensate for the 'oversensitivity' they may feel from threatening cues and prevent the subsequent maladaptive attentional shifts. This conjecture received some support in the anxiety-acclimatisation studies included in the present review, demonstrating that practising under mild anxiety conditions helped participants to become more resistant to the otherwise harmful effects of pressure. Similarly, research on the impact of emotions on motor performance supports potential benefits of anxiety-based interventions. For example, Coombes, Higgins, Gamble, Cauraugh, and Janelle (2009) found that motor efficiency is compromised in high, relative to low, anxious individuals under elicited anxiety, but suppression of emotional expression buffers the negative effect of pressure (Beatty, Fawver, Hancock, & Janelle, 2014). Thus, anxiety-based choking interventions should be proposed and explored to contest dysfunctional anxiety-based fears that may ruminate in athletes, but could also be partially supplemented by some of the other attention-based models explained in this systematic review.

Limitations

Although we took every effort in ensuring uniformity within our systematic review, we should also highlight some of the possible limitations. First, we included only peer-reviewed published studies with significant anxiety effects in our review, which limits the number of studies we retrieved especially with negative effects. Publication bias (an editorial preference for publishing particular, positive findings, leading authors to not submit negative results for publication; Thornton & Lee, 2000) may have affected our results because articles where interventions did not achieve significant performance results were not reviewed favourably (or published) and thus could have led to different effects if unpublished research was included in the systematic review.

Second, we attempted to categorise the choking interventions based on attention-based models, which was challenging considering that not all studies indicated which model the intervention was best suited to, and we could have debated with the authors the categorisation of the intervention into the model. For example, QE training was categorised into self-focus choking interventions based largely on its link to implicit learning and the authors' categorisation. We could argue, however, that QE training should have to be a distraction-based choking intervention because QE training helps to focus attention to a relevant cue, which is a key deficit within distraction models of choking. However, this is a conceptual issue, which limits the precision of theoretical differentiations (and also points out the potential overlap of the two attention-based choking models; see Mesagno, Geukes, et al., 2015), rather than a methodological issue that would compromise the overall research synthesis.

Future research

Finally, we offer suggestions for future research based on the results of this review. Most of reviewed studies tested the short-term effect of the respective choking intervention, which indicates that performance was measured either immediately or within a few days after learning and applying the intervention. It is unclear whether the intervention effect remain stable over a longitudinal period. Researchers may therefore profitably include follow-up measurements in their designs in future studies. Also, future research should specify whether choking-susceptible athletes benefit from the reviewed choking interventions more than other athletes. A few studies (e.g. Mesagno et al., 2008, 2009) focused on choking-susceptible athletes rather than on the 'general' athlete population, showing that performance improved for these choking-susceptible athletes following the intervention, but a moderation analysis of 'choking-susceptibility' on intervention effect has not yet been examined. Thus, researchers may specify whether choking-susceptible athletes may sufficiently benefit from the attention-based interventions, or whether additional (e.g. anxiety-based) interventions should be developed and applied. Finally, the present review identified a number of effective interventions. The intriguing question is whether a combination of these interventions may have a cumulative positive effect on performance under pressure. For example, distraction-based interventions, such as PPR, could be combined with self-focus-based interventions, such as dual-task or left-hand contractions. Beckmann et al. (2013) reported that athletes perceived left-hand contractions as not being disturbing and easily integrated into their PPRs. Hence, left-hand contractions may become a useful part of athletes' PPRs in addition to imagery, deep breathing, or cue words, which may potentially strengthen the intervention effect.

Note

1. The distraction and self-focus models of choking have been initially viewed as two distinct or competing models (e.g., Beilock & Carr, 2001; Lewis & Linder, 1997). Most recently, however, researchers have begun to suggest that the two choking models are not distinct but may overlap (Gröpel & Beckmann, 2017b; Mesagno, Geukes, et al., 2015; Nieuwenhuys & Oudejans, 2012). For example, Nieuwenhuys and Oudejans argue that self-focus may be viewed as a type of internal distraction. Gröpel and Beckmann suggest that (internal) distraction and self-focus complement each other. Under pressure, performers may start to worry about what the consequences of failing on a task might have, which can result in trying to control the task execution in the step-by-step manner in order to avoid failure, which can in turn result in more distraction because of consuming working memory that would be otherwise used for processing task-relevant information. Because the debate (of whether distraction and self-focus models are separable or should be integrated into one) has not been resolved yet, and choking interventions are still being typically tested based on either distraction or self-focus, we use the distraction and self-focus models of choking as two separate theories in the present review. Within the distraction model of choking, internal distraction involves attending to worries (e.g., about the score in a close game, about consequences) and negative thoughts (e.g., 'I should not . . . '), and external distraction involves attending to task-irrelevant cues in the environment (e.g., distracting fans, crowd noise). Self-focus-based explanation of choking involves attending to procedural, step-by-step rules of motor movement and conscious control of the skill execution.

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ORCID

Peter Gröpel http://orcid.org/0000-0001-8765-176X

References

References preceded by an asterisk (*) were included in the systematic review.

*Ashford, K., & Jackson, R. C. (2010). Priming as a means of preventing skill failure under pressure. *Journal of Sport & Exercise Psychology*, *32*, 518–536.

*Balk, Y. A., Adriaanse, M. A., De Ridder, D. T., & Evers, C. (2013). Coping under pressure: Employing emotion regulation strategies to enhance performance under pressure. *Journal of Sport & Exercise Psychology*, *35*, 408–418.

Baumeister, R. F. (1984). Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology*, *46*, 610–620. doi:10.1037/0022-3514.46.3.610

Baumeister, R. F., & Showers, C. J. (1986). A review of paradoxical performance effects: Choking under pressure in sports and mental tests. *European Journal of Social Psychology*, *16*, 361–383. doi:10.1002/ejsp.2420160405

Beatty, G. F., Fawver, B., Hancock, G. M., & Janelle, C. M. (2014). Regulating emotions uniquely modifies reaction time, rate of force production, and accuracy of a goal-directed motor action. *Human Movement Science*, *33*, 1–13. doi:10.1016/j.humov.2013.12.001

*Beckmann, J., Gröpel, P., & Ehrlenspiel, F. (2013). Preventing motor skill failure through hemisphere-specific priming: Cases from choking under pressure. *Journal of Experimental Psychology: General*, *142*, 679–691. doi:10.1037/a0029852

Beilock, S. L., Carr, T. H., MacMahon, C., & Starkes, J. L. (2002). When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied*, *8*, 6–16. doi:10.1037/1076-898X.8.1.6

Beilock, S. L., & Gray, R. (2007). Why do athletes choke under pressure? In G. Tenenbaum, & R. C. Eklund (Eds.), *Handbook of sport psychology* (3rd ed., pp. 425–444). Hoboken, NJ: John Wiley & Sons.

*Beilock, S. L., & Carr, T. H. (2001). On the fragility of skilled performance: What governs choking under pressure? *Journal of Experimental Psychology: General*, *130*, 701–725. doi:10.1037/0096-3445.130.4.701

*Bell, J. J., Hardy, L., & Beattie, S. (2013). Enhancing mental toughness and performance under pressure in elite young cricketers: A 2-year longitudinal intervention. *Sport, Exercise, and Performance Psychology*, *2*, 281–297. doi:10.1037/a0033129

*Beseler, B., Mesagno, C., Young, W., & Harvey, J. (2016). Igniting the pressure acclimatisation training debate: Contradictory pilot-study evidence from Australian football. *Journal of Sport Behavior*, *39*, 22–38.

*Bobrownicki, R., MacPherson, A. C., Coleman, S. G., Collins, D., & Sproule, J. (2015). Re-examining the effects of verbal instructional type on early stage motor learning. *Human Movement Science*, *44*, 168–181. doi:10.1016/j.humov.2015.08.023

Coombes, S. A., Higgins, T., Gamble, K. M., Cauraugh, J. H., & Janelle, C. M. (2009). Attentional control theory: Anxiety, emotion, and motor planning. *Journal of Anxiety Disorders*, *23*, 1072–1079. doi:10.1016/j.janxdis.2009.07.009

Cotterill, S. (2010). Pre-performance routines in sport: Current understanding and future directions. *International Review of Sport and Exercise Psychology*, *3*, 132–153. doi:10.1080/1750984X.2010.488269

Cross-Villasana, F., Gröpel, P., Doppelmayr, M., & Beckmann, J. (2015). Unilateral left-hand contractions produce widespread depression of cortical activity after their execution. *PLoS ONE*, *10*(12), e0145867. doi:10.1371/journal.pone.0145867

DeCaro, M. S., Thomas, R. D., Albert, N. B., & Beilock, S. L. (2011). Choking under pressure: Multiple routes to skill failure. *Journal of Experimental Psychology: General*, *140*, 390–406. doi:10.1037/a0023466

Essl, A., & Jaussi, S. (2017). Choking under time pressure: The influence of deadline-dependent bonus and malus incentive schemes on performance. *Journal of Economic Behavior & Organization*, *133*, 127–137. doi:10.1016/j.jebo.2016.11.001

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition & Emotion*, *6*, 409–434. doi:10.1080/02699939208409696

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, *7*, 336–353. doi:10.1037/1528-3542.7.2.336

Feikes, S., Hadding, H., Kremin, M., & Spieß, T. (Producers). (2006). *Deutschland. Ein Sommermärchen* [Film]. Köln: Little Shark Entertainment & WDR Mediagroup.

Gayman, A. M., Fraser-Thomas, J., Dionigi, R. A., Horton, S., & Baker, J. (2016). Is sport good for older adults? A systematic review of psychosocial outcomes of older adults' sport participation. *International Review of Sport and Exercise Psychology*, *10*, 164–185. doi:10.1080/1750984X.2016.1199046

Gröpel, P. (2016). Self-focused attention and motor skill failure: The moderating role of action orientation. *Sport, Exercise, and Performance Psychology*, *5*, 206–217. doi:10.1037/spy0000059

Gröpel, P., & Beckmann, J. (2017b). Personality systems interaction in skilled motor performance: Implications for sport psychology. In N. Baumann, M. Kazén, M. Quirin, & S. Koole, (Eds.), *Why people do the things they do: Building on Julius Kuhl's contribution to motivation and volition psychology* (pp. 323–341). Göttingen: Hogrefe.

*Gröpel, P., & Beckmann, J. (2017a). A pre-performance routine to optimize competition performance in artistic gymnastics. *The Sport Psychologist*, *31*, 199–207. doi:10.1123/tsp.2016-0054

*Gucciardi, D. F., & Dimmock, J. A. (2008). Choking under pressure in sensorimotor skills: Conscious processing or depleted attentional resources? *Psychology of Sport and Exercise*, *9*, 45–59. doi:10.1016/j.psychsport.2006.10.007

Hardy, L., Mullen, R., & Martin, N. (2001). Effect of task-relevant cues and state anxiety on motor performance. *Perceptual and Motor Skills*, *92*, 943–946. doi:10.2466/pms.2001.92.3.943

*Hazell, J., Cotterill, S. T., & Hill, D. M. (2014). An exploration of pre-performance routines, self-efficacy, anxiety and performance in semi-professional soccer. *European Journal of Sport Science*, *14*, 603–610. doi:10.1080/17461391.2014.888484

Hill, D. M., Hanton, S., Fleming, S., & Matthews, N. (2009). A re-examination of choking in sport. *European Journal of Sport Science*, *9*, 203–212. doi:10.1080/17461390902818278

Hill, D. M., Hanton, S., Matthews, N., & Fleming, S. (2010a). A qualitative exploration of choking in elite golf. *Journal of Clinical Sport Psychology*, *4*, 221–240.

Hill, D. M., Hanton, S., Matthews, N., & Fleming, S. (2010b). Choking in sport: A review. *International Review of Sport and Exercise Psychology*, *3*, 24–39. doi:10.1080/17509840903301199

Hill, D. M., & Shaw, G. (2013). A qualitative examination of choking under pressure in team sport. *Psychology of Sport and Exercise*, *14*, 103–110. doi:10.1016/j.psychsport.2012.07.008

Hossner, E.-J., & Ehrlenspiel, F. (2010). Time-referenced effects of an internal vs. external focus of attention on muscular activity and compensatory variability. *Frontiers in Psychology*, *1*, 230. doi:10.3389/fpsyg.2010.00230

*Jackson, R. C., Ashford, K. J., & Norsworthy, G. (2006). Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport & Exercise Psychology*, *28*, 49–68.

*Land, W., & Tenenbaum, G. (2012). An outcome- and process-oriented examination of a golf-specific secondary task strategy to prevent choking under pressure. *Journal of Applied Sport Psychology*, *24*, 303–322. doi:10.1080/10413200.2011.642458

*Lautenbach, F., Laborde, S., Mesagno, C., Lobinger, B. H., Achtzehn, S., & Arimond, F. (2015). Nonautomated pre-performance routine in tennis: An intervention study. *Journal of Applied Sport Psychology*, *27*, 123–131. doi:10.1080/10413200.2014.957364

*Lewis, B. P., & Linder, D. E. (1997). Thinking about choking? Attentional processes and paradoxical performance. *Personality and Social Psychology Bulletin*, *23*, 937–944. doi:10.1177/0146167297239003

Liao, C., & Masters, R. W. (2002). Self-focused attention and performance failure under psychological stress. *Journal of Sport & Exercise Psychology*, *24*, 289–305.

*Liao, C., & Masters, R. S. W. (2001). Analogy learning: A means to implicit motor learning. *Journal of Sports Sciences*, *19*, 307–319.

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, *57*, 705–717. doi:10.1037//0003-066X.57.9.705

Masters, R. S. W. (2000). Theoretical aspects of implicit learning in sport. *International Journal of Sport Psychology*, *31*, 530–541.

*Masters, R. S. W. (1992). Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology*, *83*, 343–358. doi:10.1111/j.2044-8295.1992.tb02446.x

Masters, R. S. W., & Maxwell, J. (2008). The theory of reinvestment. *International Review of Sport and Exercise Psychology*, *1*, 160–183. doi:10.1080/17509840802287218

Mesagno, C., Geukes, K., & Larkin, P. (2015). Choking under pressure: A review of current debates, literature, and interventions. In S. Mellalieu, & S. Hanton (Eds.), *Contemporary advances in sport psychology: A review* (pp. 148–174). London: Routledge.

Mesagno, C., Harvey, J. T., & Janelle, C. M. (2011). Self-Presentation origins of choking: Evidence from separate pressure manipulations. *Journal of Sport & Exercise Psychology*, *33*, 441–459.

Mesagno, C., Harvey, J. T., & Janelle, C. M. (2012). Choking under pressure: The role of fear of negative evaluation. *Psychology of Sport and Exercise*, *13*, 60–68. doi:10.1016/j.psychsport.2011.07.007

Mesagno, C., & Hill, D. M. (2013). Definition of choking in sport: Re-conceptualization and debate. *International Journal of Sport Psychology*, *44*, 267–277.

Mesagno, C., Mornell, A., & Quinn, A. L. (2016). Choking under pressure in sport and music: Exploring the benefits of theory transfer across domains. In A. Mornell (Ed.), *Art in motion III. Performing under pressure* (pp. 23–57). Frankfurt: Peter Lang.

*Mesagno, C., Hill, D. M., & Larkin, P. (2015). Examining the accuracy and in-game performance effects between pre- and post-performance routines: A mixed methods study. *Psychology of Sport and Exercise*, *19*, 85–94. doi:10.1016/j.psychsport.2015.03.005

*Mesagno, C., Marchant, D., & Morris, T. (2008). Using a pre-performance routine to alleviate choking under pressure in "choking-susceptible" athletes. *The Sport Psychologist*, *22*, 439–457.

*Mesagno, C., Marchant, D., & Morris, T. (2009). Alleviating choking: The sounds of distraction. *Journal of Applied Sport Psychology*, *21*, 131–147. doi:10.1080/10413200902795091

*Mesagno, C., & Mullane-Grant, T. (2010). A comparison of different pre-performance routines as possible choking interventions. *Journal of Applied Sport Psychology*, *22*, 343–360. doi:10.1080/10413200.2010.491780

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, *6*(7), e1000097. doi:10.1371/journal.pmed.1000097

*Moore, L. J., Vine, S. J., Cooke, A., Ring, C., & Wilson, M. R. (2012). Quiet eye training expedites motor learning and aids performance under heightened anxiety: The roles of response programming and external attention. *Psychophysiology*, *49*, 1005–1015. doi:10.1111/j.1469-8986.2012.01379.x

Moran, A. P. (1996). *The psychology of concentration in sport performers: A cognitive analysis*. London: Taylor and Francis.

Mullen, R., Hardy, L., & Tattersall, A. (2005). State anxiety and motor performance: Testing the conscious processing hypothesis. *Journal of Sports Sciences*, *18*, 785–799.

*Mullen, R., Faull, A., Jones, E. S., & Kingston, K. (2015). Evidence for the effectiveness of holistic process goals for learning and performance under pressure. *Psychology of Sport and Exercise*, *17*, 40–44. doi:10.1016/j.psychsport.2014.11.003

*Nibbeling, N., Oudejans, R. R., & Daanen, H. A. (2012). Effects of anxiety, a cognitive secondary task, and expertise on gaze behavior and performance in a far aiming task. *Psychology of Sport and Exercise*, *13*, 427–435. doi:10.1016/j.psychsport.2012.02.002

Nideffer, R. M. (1992). *Psyched to win*. Champaign, IL: Leisure Press.

Nieuwenhuys, A., & Oudejans, R. R. (2012). Anxiety and perceptual-motor performance: Toward an integrated model of concepts, mechanisms, and processes. *Psychological Research*, *76*, 747–759. doi:10.1007/s00426-011-0384-x

Oudejans, R. R., Kuijpers, W., Kooijman, C. C., & Bakker, F. C. (2011). Thoughts and attention of athletes under pressure: Skill-focus or performance worries? *Anxiety, Stress, and Coping*, *24*, 59–73. doi:10.1080/10615806.2010.481331

*Oudejans, R. R., & Pijpers, J. R. (2009). Training with anxiety has a positive effect on expert perceptual–motor performance under pressure. *The Quarterly Journal of Experimental Psychology*, *62*, 1631–1647. doi:10.1080/17470210802557702

*Oudejans, R. R., & Pijpers, J. R. (2010). Training with mild anxiety may prevent choking under higher levels of anxiety. *Psychology of Sport and Exercise*, *11*, 44–50. doi:10.1016/j.psychsport.2009.05.002

Pluye, P., Robert, E., Cargo, M., Bartlett, G., O'Cathain, A., Griffiths, F., … Rousseau, M. C. (2011). *Proposal: A mixed methods appraisal tool for systematic mixed studies reviews*. Retrieved from http://mixedmethodsappraisaltoolpublic.pbworks.com

*Reeves, J. L., Tenenbaum, G., & Lidor, R. (2007). Choking in front of the goal: The effects of self-consciousness training. *International Journal of Sport and Exercise Psychology*, *5*, 240–254. doi:10.1080/1612197X.2007.9671834

*Ring, C., Cooke, A., Kavussanu, M., McIntyre, D., & Masters, R. (2015). Investigating the efficacy of neurofeedback training for expediting expertise and excellence in sport. *Psychology of Sport and Exercise*, *16*, 118–127. doi:10.1016/j.psychsport.2014.08.005

*Schücker, L., Ebbing, L., & Hagemann, N. (2010). Learning by analogies: Implications for performance and attentional processes under pressure. *Human Movement*, *11*, 191–199. doi:10.2478/v10038-010-0025-z

*Schücker, L., Hagemann, N., & Strauss, B. (2013). Analogy vs. Technical learning in a golf putting task: An analysis of performance outcomes and attentional processes under pressure. *Human Movement*, *14*, 175–184. doi:10.2478/humo-2013-0021

Schulz, K. F., Chalmers, I., Hayes, R. J., & Altman, D. G. (1995). Empirical evidence of bias: Dimensions of methodological quality associated with estimates of treatment effects in controlled trials. *Journal of American Medical Association*, *273*, 408–412. doi:10.1001/jama.1995.03520290060030

Snyder, K. M., & Logan, G. D. (2013). Monitoring-induced disruption in skilled typewriting. *Journal of Experimental Psychology: Human Perception and Performance*, *39*, 1409–1420. doi:10.1037/a0031007

Thornton, A., & Lee, P. (2000). Publication bias in meta-analysis: Its causes and consequences. *Journal of Clinical Epidemiology*, *53*, 207–216. doi:10.1016/S0895-4356(99)00161-4

Vickers, J. N. (2007). *Perception, cognition and decision training: The quiet eye in action*. Champaign, IL: Human Kinetics.

*Vine, S. J., Moore, L. J., Cooke, A., Ring, C., & Wilson, M. R. (2013). Quiet eye training: A means to implicit motor learning. *International Journal of Sport Psychology*, *44*, 367–386. doi:10.7352/IJSP2013.00.000

*Vine, S. J., Moore, L. J., & Wilson, M. R. (2011). Quiet eye training facilitates competitive putting performance in elite golfers. *Frontiers in Psychology*, *2*, 1–9. doi:10.3389/fpsyg.2011.00008

*Vine, S. J., & Wilson, M. R. (2010). Quiet eye training: Effects on learning and performance under pressure. *Journal of Applied Sport Psychology*, *22*, 361–376. doi:10.1080/10413200.2010.495106

*Vine, S. J., & Wilson, M. R. (2011). The influence of quiet eye training and pressure on attention and visuomotor control. *Acta Psychologica*, *136*, 340–346. doi:10.1016/j.actpsy.2010.12.008

*Wood, G., & Wilson, M. R. (2011). Quiet-eye training for soccer penalty kicks. *Cognitive Processing*, *12*, 257–266. doi:10.1007/s10339-011-0393-0

*Wood, G., & Wilson, M. R. (2012). Quiet-eye training, perceived control and performing under pressure. *Psychology of Sport and Exercise*, *13*, 721–728. doi:10.1016/j.psychsport.2012.05.003

*Zhu, F. F., Poolton, J. M., Wilson, M. R., Maxwell, J. P., & Masters, R. S. W. (2011). Neural co-activation as a yardstick of implicit motor learning and the propensity for conscious control of movement. *Biological Psychology*, *87*, 66–73. doi:10.1016/j.biopsycho.2011.02.004