Training under pressure: Current perspectives and Future Directions

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Introduction

Various accounts of cataclysmic errors in judgement litter the annals of sporting history. Matt Emmonds (literally) had a shot at an Olympic gold medal, but he aimed at the wrong target. Sven Kramer thought he had won Olympic speed skating gold before disqualification for skating in the wrong lane. Jean Van De Velde took a three-shot lead into the final hole of The Open Championship, but made a series of poor shot selections that cost him the Claret Jug. Such episodes are most often precipitated by anxiety, although a range of pressures are present within competition that may impact decision making, such as the fatigue experienced during the latter stages of a game or the temporal and spatial constraints imposed by an opponent's defensive press (Casanova, Garganta, Silva, Alves, Oliveira, & Williams, 2013). The capability to deliver desirable results in the face of threats to performance differentiates performers at the highest level (Causer et al., 2011). The significant challenge for practitioners is to design training interventions that adequately prepare athletes for performance under pressure.

A solution commonly offered by sport commentators is to expose athletes to the pressures of competition in training. To varying degrees, this idea is deliberately implemented in modern coaching practice. Recent exponents include England Women's Hockey who engage players in two hours of high pressure physical and mental training as part of "Thinking Thursday" (The Guardian; November, 2016). Pressures common to competition are introduced - a sending off or conceding an early goal - and players are asked to work through solutions as a group. As part of an unlikely rugby collaboration, Wales and England's competed against each other in a training session designed to replicate the technical and tactical demands of international rugby. Such examples imply that practitioners increasingly see the value of training under pressure; but what empirical evidence exists to support this view? In this chapter, we provide an overview of literature that has examined the utility of training under pressure caused by raised levels of anxiety. In so doing, we will introduce prominent conceptual frameworks that help explain key findings, identify the noteworthy limitations of the research to date and offer directions for future empirical work.

Theoretical Frameworks

The popular conceptual frameworks in this area of study are often underpinned by so called distraction models, such as Attentional Control Theory (ACT; Eysenck, Derakshan, Santos & Calvo, 2007). The ACT has several assumptions at its base. First, *worry* is a state-anxiety component that causes reduced processing efficiency and potential negative effects on performance effectiveness. Second, it is the components of a limited-capacity working memory model that are affected by anxiety, specifically the inhibition, shifting and updating functions of the central executive (Baddeley, 2001). Third, anxiety results in a shift between the two attentional control systems: namely the *goal-directed system*, which directs cognitive control of visual attention and response selection, and the *stimulus-driven system*, which detects and directs attention to threatening, salient or conspicuous events (Corbetta & Shulman, 2002). Anxiety inhibits the purposeful functioning of the goal-directed system, increasing the influence of the stimulus-driven system. Wilson et al. (2009) highlighted this effect in a sporting context by examining the mechanisms underpinning the execution of soccer penalty kicks under low- and high-anxiety conditions. Heightened anxiety caused players to exhibit fixations of shorter duration on the target area, inferring reduced goal-directed attention, with longer duration fixations on the context-specific threat of the goalkeeper, reflecting the influence of the stimulus-driven system. The apparent shift in attentional control was accompanied by a decrement in penalty taking performance.

The ACT distinguishes between performance effectiveness (task outcome) and performance efficiency (perceptual-cognitive task demands). The latter denotes the extent of processing resources invested in performing a task (Eysenck & Calvo, 1992). Previous work has shown that conditions that provoke anxiety increase mental effort (Murray & Janelle, 2003) and disrupt visual search (greater fixations of shorter duration, Williams & Elliott, 1999; Wilson et al., 2007), suggesting compromised performance efficiency. This affect appears more pronounced during the quiet eye period - final fixation before the initiation of action (Vickers, 1996) - where anxiety has been shown to prolong the onset and shorten the duration of the final fixation, to the detriment of performance outcome (Wilson, Causer & Vickers, 2015). However, ACT does not specify how extra effort dedicated to the task is distributed.

Nieuwenhuys and Oudejans (2012) proposed an *Integrated Model of Anxiety and Perceptual-Motor Performance*, which suggests that effort could be allocated to a range of tasks facilitated by working memory. For example, resources may be directed to reducing the feelings of anxiety by, for instance, the use of predetermined imagery techniques and/or breathing strategies (Page et al., 1999). Expert athletes should be better placed to mediate anxiety than their lesser skilled counterparts, by making use of ‘spare’ working memory capacity afforded by the automation of perceptual-motor performance with practice (Fitts & Posner, 1967). Alternatively, resources may be directed to the reinforcement of goal-directed attentional strategies introduced in training, such as quiet eye (e.g., Vine et al., 2013). However, Nieuwenhuys and Oudejans (2012) argue that individuals can appear goal-directed by focusing on task-relevant cues, but they may be less able to use the information appropriately; that is, anxiety affects the capability of an individual to interpret visual information effectively. Furthermore, athletes can remain goal-directed, but adopt coping strategies that are neither efficient nor effective. For example, working memory resources may be directed to the recall, manipulation and application of declarative knowledge (Laborde, Furley & Schempp, 2015); however, *reinvestment* in knowledge acquired during learning is thought to regress decision-making performance by interfering with efficient and proficient automated processes (Kinrade et al., 2010). The resource demands of reinvestment may mean that the ways of coping identified by Nieuwenhuys and Oudejans (2012) cannot effectively be administered.

It is clear that anxiety can adversely influence anticipation and decision making, as well as visual search behaviours (Williams et al., 2011). Therefore, a training intervention shown to decrease the effects of anxiety by either refining coping strategies, acclimatising individuals to high-anxiety scenarios and/or developing robust skills, would be valuable to the coaching of sporting excellence.

High-anxiety training

The value of exposing individuals to perceptual-cognitive training interventions that are more representative of the real-world context has been shown in sports such as soccer (Ryu, Kim & Mann, 2013), tennis (Williams, Ward Knowles & Smeeton, 2002) and skeet shooting (Causer, Holmes & Williams, 2011), as well as in other professional domains such as law enforcement (Ward, Ericsson & Williams, 2013), nursing (Larew, Lessans, Spunt, Foster & Covington, 2006) and surgery (Wilson, Vine, Bright, Masters, Defriend & McGrath, 2011). Moreover, these effects have been shown in both the controlled environment of the laboratory and, importantly, the confounding environment of field based testing (Smeeton, Williams, Hodges & Ward, 2005). Training under anxiety extends this approach by training perceptual-motor and perceptual-cognitive skills alongside stressors that are experienced in real-world competition.

With regard to Nieuwenhuys and Oudejans's (2012) model, training under anxiety may help athletes develop strategies to deal more efficiently with sources of anxiety that inoculate them against the impact of common competition stressors in the first instance, as evidenced by lower scores on indices of anxiety (e.g., MRF-3 Krane, 1994). Alternatively, training under anxiety may help players sustain goal-directed attention whilst experiencing the stressor, as evidenced by sustained or extended fixation durations on information rich areas of the visual display. Finally, training under anxiety may increase the athlete's capacity to operate effectively with fewer working memory resources; ensuring that sustained goal-directed attentional control results in the appropriate interpretation of salient information, as evidenced by performance effectiveness. At this point, it is worth reiterating that the testing of these ideas is in its infancy and limited to a small number of empirical studies (for a detailed breakdown, please see Table X). The majority of these studies have focused on perceptual-motor tasks (e.g., basketball free throw) with only one study focused specifically on decision-making (Alder et al., 2016).

The first known attempt to examine training under anxiety was conducted by Oudejans (2008). He investigated the short-term effect of training under anxiety on shooting accuracy in police officers. To induce anxiety, officers shot at a threatening target that returned fire using coloured soap cartridges. Their counterparts in a low-anxiety training condition shot at a passive non-threatening target. In a pre-test, the high-anxiety manipulation led to a relative decrease in shooting accuracy for both training groups; however, after training the shooting accuracy of officers who had trained under anxiety no longer deteriorated, whereas the accuracy of officers who were not exposed to the stressor in training was still affected. The intervention did not seem to affect officers' perception of the stressor as anxiety provoking; scores on the subjective anxiety thermometer (Houtman & Bakker, 1989) were not different pre- to post-test or between the two training groups. The success of the training under anxiety intervention seemed, in part, to be due to officers' maintenance of goal-directed focus in the face of the stressor (Nieuwenhuys & Oudejans, 2012). However, without measurement of the mechanisms underpinning effective performance this interpretation is speculative.

In an attempt to explain the positive impact of training under anxiety, Nieuwenhuys and Oudejans (2011) replicated and extended Oudejans work by including measures of somatic anxiety (heart rate) and processing efficiency (mental effort and gaze fixation number and duration) as potential mechanisms underpinning shooting performance. The pattern of findings relating to shooting accuracy were similar to those reported by Oudejans. Only training under anxiety led to the maintenance of shooting accuracy when officers were faced with a target that returned fire in a high-anxiety post-test. Introduction of the same stressor in the pre-test and the post-test elevated the heart rates of officers in both training groups and to the same degree. Mental effort scores were also raised, although less so in the post-test, suggesting that task-specific training lessened the mental demands of the task. In the pre-test, exposure to the stressor led to a general increase in scan ratio (total number of fixations divided by the total duration of those fixations) and a general decrease in total fixation time, denoting a decrease in the efficiency of visual search. This was also true in the post-test for officers who had trained by shooting to a passive non-threatening target. However, the visual search behaviour of officers who had trained against a target who returned fire tended to be unaffected by the reintroduction of the stressor in the post-test. In sum, Nieuwenhuys and Oudejans (2011) found that training under anxiety did not reduce either the stress response or the mental effort dedicated to the task in the face of a known threat to performance. It did, however, appear to help officers maintain goal-directed attentional control and sustain performance effectiveness. These effects were retained for at least four months after the training sessions.

In an attempt to showcase the generalisability of positive training under anxiety effects to a high-performance sporting context, Oudejans and Pijpers (2009) designed a training intervention for expert basketball players practicing free throws. Anxiety was elevated in training over a 5-week period by: i) grouping players into sub-teams; ii) offering monetary rewards; and iii) provoking evaluation apprehension (sessions filmed and observed by coaches). The same stressors negatively impacted the shooting accuracy of the sample of expert players in the pre-test. Following the training sessions, only the group of expert players who trained under anxiety showed resilient free-throw performance when anxiety was induced. The free-throw performance of a group of players who practiced without anxiety returned to pre-test levels. For both groups the perceived levels of anxiety were just as high in the post-test compared to the pre-test, suggesting that training under anxiety did little to impact players' emotional response to the stressor. The most likely explanation was that training under anxiety led to the maintenance of goal directed attention.

In a second study, Oudejans and Pijpers (2009) attempted to explain the apparent benefits of training under anxiety, this time using expert dart players. They manipulated anxiety by having players throw their darts from the top of a tall ladder (7 metres). The raised platform successfully impacted dart throwing accuracy of the expert sample in the pre-test and the accuracy of the players who practiced without anxiety in the post-test. Players who were exposed to the height stressor throughout practice showed robust performance when the stressor was reintroduced in the post-test. The performance differences between the two training groups were not accompanied by differences in cognitive anxiety, perceived effort or heart rate, which were all raised by performing at height. Therefore, it appears that training under anxiety did not reduce the stress response of players, implying that the maintenance of goal-directed attention was a more likely explanation.

In an effort to alleviate concerns that manipulations of anxiety in practice will never truly replicate the threats to successful performance in competition, Oudejans and Pijpers (2010) tested the benefits of training dart players under only mild levels of anxiety when they were later faced with a stressor that induced higher levels of anxiety. Mild levels of anxiety were experimentally induced in training sessions by filming and by offers of performance-related monetary rewards. To examine the transferability of mild anxiety training, dart throwing accuracy was tested under low-anxiety (no anxiety manipulation), mild-anxiety (as per training) and high-anxiety conditions. The authors again relied on raising the height of the throwing platform to induce higher-levels of anxiety. Cognitive anxiety, perceived mental effort and heart rate increased incrementally across the three testing conditions. The novice players in the training under mild-anxiety group and their training *without* anxiety counterparts both improved dart throwing accuracy as a result of training. Furthermore, the players in the training without anxiety group tended to be able to maintain this performance improvement when faced with the milder stressors. However, experiencing the high-anxiety height stressor tended to lead to less accurate dart throws. In direct contrast, players who trained under mild-anxiety were able to maintain performance effectiveness even when they were much more anxious than they had been in training. These findings suggest that training under mild-anxiety is sufficient to sustain attention to the task goal even when anxiety is further heightened.

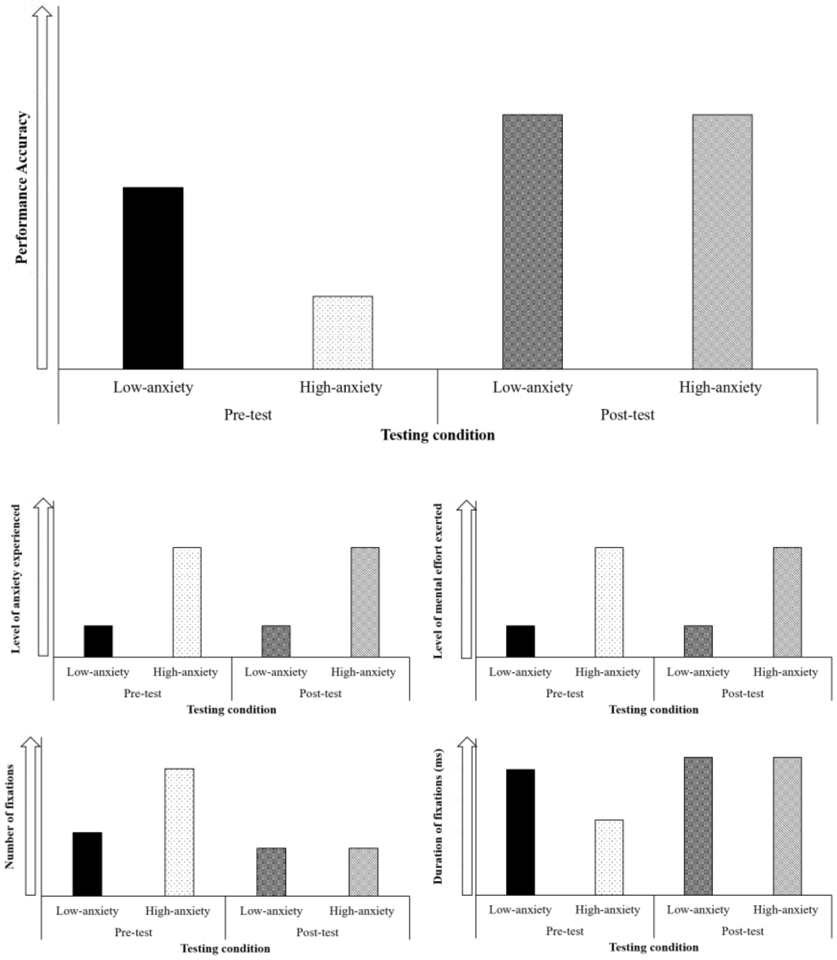

Figure 1: Data trends of dependent variables common to Alder et al. (2016), Oudejans, (2008), Oudejans & Pijper (2009, experiment 1 & 2) and Nieuwenhuys & Oudejans (2011). All papers employed pre-test/post-test experimental designs.

A more recent investigation into the relative benefits of training under anxiety has reported evidence for a specificity of anxiety-level learning effect (Lawrence, Woodman, Hadnett and Gottwald, 2014). Lawrence et al. (2014; Experiment 2) examined the impact of a bout of training under anxiety on the performance and movement efficiency of novice rock climbers. Anxiety was induced by the offer of a prize for the best performer, the suggestion that climbs would be filmed and analysed by a professional climber, and that performance would be publicly advertised. In a high-anxiety transfer test that followed training, the climbers were notified that the greatest improvement in wall traverse time (over 15%) would be awarded a prize; the other stressors that were experienced during practice trials by training under anxiety climbers were not reintroduced. Novice climbers who had not experienced the anxiety manipulation in training tended to produce worse wall traverse times than in a low-anxiety (no stressor) transfer test, which simulated their training experience. This was partly underpinned by a tendency to increase the moves made during the wall traverse and a sharp rise in the search for holds that were subsequently used or not used, suggesting that climbers were less efficient and more indecisive, respectively. The same was not true for climbers who had experienced stressors throughout training who showed no change in transverse time or movement efficiency when the stressor was reintroduced. However, this group of climbers did appear to be negatively affected by the absence of a stressor in the low-anxiety transfer condition. The traverse times increased and there were signs of compromised movement efficiency. The findings from this study imply that training under anxiety gains were context specific. It would seem that learners developed a movement plan that was shaped by the constraints to attentional control imposed by the training environment. Once the constraints changed in the transfer test, novice climbers struggled to effectively adapt.

Ongoing exposure to stressors in training may *then* have a negative impact on the acquisition of novel skills. In an effort to examine whether the positive effects of training under anxiety were dependent on the quantity and/or timing of stressor exposure, Lawrence et al. (2014) included two additional training interventions that exposed novice climbers to the stressors for the first and second half of training (50 of 100 climbs), respectively. Independent of when the stressor was introduced, bouts of training with and without exposure to the stressors resulted in faster wall traverse times in *both* low- and high-anxiety transfer tests (which did not differ) than when novice climbers were exposed to the stressors throughout training. It seems that exposure to stressors for only part of training awarded resilience to anxiety without compromised performance when the stressor was not present. This finding was partially corroborated by the authors in a second experiment (Lawrence et al., 2014; Experiment 1). They showed that exposure to a financial incentive stressor for half of the training phase of a golf putt (150 of 300 putts) returned performance gains in a high-anxiety transfer test that were equivalent to a group of novice players who were exposed to the stressor for the entire 300 training putts.

Thus far, we have reported the benefits to perceptual-motor skill performance of training under anxiety. We are aware of only one study that has deliberately investigated the effect of training under anxiety on the learning of perceptual-cognitive skills, specifically anticipation and decision-making. Alder, Ford, Causer and Williams (2016) asked elite badminton players to anticipate the direction of serves from video of a doubles match, which was filmed from the first person perspective and occluded prior to racket-shuttle contact. Anxiety was successfully induced (elevated ratings of cognitive anxiety) by the threat to players that their performance would be filmed, analysed and presented to their coach, that their performance was unsatisfactory and that their performance would be ranked against their peers (as per Wilson et al., 2009). Prior to training, the anxiety manipulation reduced the response accuracy of the sample who also showed shorter final gaze fixations prior to occlusion and heightened perceived mental effort. The training under anxiety intervention comprised of a series of perceptual-cognitive training sessions during which the anxiety manipulation was ever present and players were directed to salient kinematic information about their opponents' movement, gold standard visual search behaviour and feedback on their own visual search behaviour before performing the video occlusion task. After training, the player's anticipatory judgement was compared to a group of players who had enjoyed the same training without the threat of the anxiety manipulation, as well as a control group of players who did not undergo specific perceptual-cognitive training, but instead completed their regular training. Both groups of players that completed the perceptual-cognitive training sessions showed superior response accuracy accompanied by longer duration final fixations than prior to training, and compared to the control group. Crucially, only players in the training under anxiety group appeared able to maintain response accuracy and critical features of visual search behaviour when anxiety was induced in the post-test, despite reporting higher levels of mental effort. In the context of Nieuwenhuys and Oudejans (2012) model, Alder et al.'s findings suggest that training under anxiety promotes the distribution of mental effort to the maintenance of goal-directed extraction and interpretation of salient visual information.

Figure X: Pre- and post-test experimental set up from Alder et al. (2016). Players, who wore a Tobii eye tracker, were asked to perform shadow shots in response to the server whose action was occluded prior to racket-shuttle contact. During training players then completed a number of perceptual-cognitive interventions in either a normal environment (Low-anxiety training) or a highly anxious environment (High-anxiety training).

Table 1: Summary of relevant papers

Authors	Participants	Measures	Experimental design	Anxiety manipulation	Training	Results
Alder, Ford, Causer & Williams (2016)	International badminton players split into high-anxiety training, low-anxiety training and control groups	Anxiety levels; Mental effort; Anticipation accuracy; Visual search behaviour	Pre-Training-Post-test design; Post-test: Anticipating opponent's serve under high- and low-anxiety conditions	Performance filmed and analysed; negative feedback on performance; ranked against peers	3 sessions 30 minutes per session	High-anxiety negatively impacted performance, decreased efficiency of visual search behaviour and increased mental effort Both training groups improved pre- to post-test Only the high-anxiety group maintained this improvement in a high-anxiety post-test Anxiety levels and mental effort higher for all groups in the high-

						anxiety conditions in both pre- and post-tests.
Lawrence, Woodman, Hadnett & Gottwald, (2014): Experiment 1	Novice golfers split into control, anxiety, control-anxiety and anxiety-control groups	Anxiety levels; Putting accuracy	Acquisition-Post-test design; Acquisition: Golf putting under low-anxiety conditions (control), high-anxiety conditions (anxiety), normal conditions followed by high-anxiety (control-anxiety) or high-anxiety followed by normal conditions (anxiety-control).	Performance filmed and analysed; monetary rewards	300 putts 6 blocks of 50 putts No information regarding duration	All groups except the control group were able to maintain putting accuracy in the high-anxiety transfer condition Anxiety levels higher for all groups in the high-anxiety conditions in both pre- and post-tests.

			Post-test: high- and low-anxiety conditions			
Lawrence, Woodman, Hadnett & Gottwald, (2014): Experiment 2	Novice rock climbers split into control, anxiety, control-anxiety and anxiety-control groups	Anxiety levels; Time of traverse; Range of movement efficiency variables	Acquisition- Transfer to high-anxiety and low-anxiety design Rock climbing under normal conditions (control), high-anxiety conditions (anxiety), normal conditions followed by high-anxiety (control-anxiety or high-anxiety followed by	Performance filmed and analysed; Comparison to other participants; Monetary rewards	100 climbs 10 blocks of 10 climbs 50 climbs per day	All groups except the control group were able to maintain climbing performance in the high-anxiety transfer condition Only the control group able to positively transfer performance into the low-anxiety condition. Anxiety levels greater and all movement efficiency variable lower for all groups in the high-anxiety

			normal conditions (anxiety-control)			conditions in both pre- and post-tests.
Nieuwenhuys & Oudejans (2011)	Police officers split into experimental and control groups	Anxiety levels; Heart rate; Mental effort; Shot Accuracy; Visual search behaviour	Pre-Training-Post-Retention- design Shooting against targets	Targets firing back at participants	4 sessions lasting 1 hour Firing 48 rounds (12 per session)	High-anxiety negatively impacted performance along with increasing heart rate, mental effort and decreasing visual search behaviour efficiency. The experimental group able to maintain performance in high- compared to low-anxiety post-test Improvements after training underpinned by change in visual search behaviour Effects maintained in retention-test

Oudejans (2008)	Police officers split into experimental and control groups	Anxiety levels; Shooting Accuracy	Pre-Training-Post-test design	Targets firing back at participants	3 training sessions Each lasting an hour over 2 weeks	High-anxiety negatively impacted performance The experimental group able to maintain performance in high- compared to low-anxiety post-test
Oudejans & Pijpers (2009): Experiment 1	Expert basketball players split into experimental and control groups	Anxiety levels; Shooting performance	Pre-Training-Post-test design Standard basketball free-throws under high- and low-anxiety conditions	Performance filmed and analysed; Comparison to other participants; Monetary rewards	9 sessions completing 96 free throws Split evenly over 5 weeks	High-anxiety negatively impacted shooting performance Experimental group were able to maintain performance in the high-anxiety post-test

Oudejans & Pijpers (2009): Experiment 2	Experienced dart players split into experimental and control groups	Anxiety levels; Effort scores; Throwing performance	Pre-Training-Post-test design Darts throwing under high- and low-anxiety conditions	Differing heights on a ladder	16 sets of 3 darts One off session lasting 6 minutes	High-anxiety negatively impacted dart throwing performance and increased mental effort The experimental group were able to maintain performance in the high-anxiety post-test compared to low-anxiety post-test although mental effort still increased across conditions.

Future research directions

As with any young area of inquiry, there are significant caveats to attach to the trends summarised in Figure 1. A key question is whether practitioners are required, or indeed able, to reproduce in practice the anxiety levels experienced in real-world competition, in order to reap the rewards of training under anxiety. In anxiety-related research, the use of monetary incentives and evaluation apprehension manipulations are popular, reflect the extrinsic rewards of competition play and, for the most part, are effective in raising the cognitive and somatic anxiety experienced by performers (e.g., Alder et al., 2016; Oudejans and Pijpers, 2009). However, such manipulations almost certainly do not inflate anxiety to the levels experienced at crucial moments in competition. Advocates of specificity of learning principles would suggest this to be problematic.

Oudejans and Pijpers (2009) relied on fear of heights to raise anxiety to levels above those afforded by cash rewards and evaluation. However, it is rare to see a darts player throwing from such a high platform! Does the height manipulation replicate the effect on underpinning mechanisms, such as cognitive effort and visual search, of a championship winning check-out? On face value, Oudejans (2008) use of police targets returning fire of non-lethal soap cartridges was as realistic as ethically possible, but still did not fully simulate the threat of, and most likely the perceptual-cognitive-motor response to, facing live rounds. In future, researchers may find that specificity of learning principles extend to the specific nature of the cause of anxiety.

Recent work implies that the information sources used to formulate a decision also warrant consideration. Dependent on the context of the decision, proficient performance may be more or less reliant on postural cues presented by direct opponents, contextual information about the relative position of players in the environment or the situational probability of certain plays or actions occurring (Roca, Ford, McRobert & Williams, 2013). The use of postural cues are thought to be directed by the bottom-up, stimulus-driven attentional system, whereas the use of contextual and situational probability information is more likely to employ the top-down processing of the goal directed attentional system (Corbetta & Shulman, 2002). Attentional Control Theory predicts that anxiety inhibits the purposeful high-level processing of the goal-directed system (Eysenck et al., 2007). Therefore, anxiety is more likely to reduce the capability of skilled performers to utilise contextual information (Cocks et al., 2016) or to calculate situational probability than to make use of postural cues. For that reason, training under anxiety interventions may be particularly beneficial for decision making tasks that are highly reliant on the use of contextual information and/or situational probability, by forcing learners to acclimatise to the perceptual-cognitive processing constraints imposed by anxiety. This is an important question that merits empirical investigation.

More broadly, it is unknown whether the performance gains associated with training under anxiety documented here are generalisable to other known threats to performance, such as physiological stress (fatigue), distraction, spatial occlusion or temporal constraints. For example, physiological stress, brought on by prolonged levels of physical exertion, is common in competition (Docherty, 1978; Faude, Meyer, Rosenberger, Fries, Huber & Kindermann, 2007) and generally agreed to negatively impact decision making performance, independent of skill level (Casanova et al., 2013). Although understudied relative to its psychological cousin, the perceptual-cognitive mechanisms impacted by exposure to physiological stress may be similar to those affected by anxiety. In the context of Nieuwenhuys and Oudejans's (2012) model, it seems unlikely that deliberately training under physiological stress will recalibrate highly trained athletes' perceptions of perceived exertion.

However, it may help individuals sustain goal-directed attention and/or effectively interpret salient information, in a similar way to training under anxiety.

We are currently collecting data from skilled badminton players to test the effect of training decision making under physiological stress (Badminton World Federation Research Grants 2016-2017). Preliminary findings suggest positive effects, which seem specific to the level of physiological stress experienced during the training intervention. Whether the relative benefits of training under pressure hold when athletes face the synergistic effect of multiple stressors, such as anxiety and fatigue (Vickers & Williams, 2007), or threats to performance that pose a different challenge to perceptual-cognitive processes, such as the constraints of too little or too much time, is uncertain and requires further investigation. Similarly, further work is needed to identify whether gains awarded by training under pressure are specific to the stressor experienced in training or whether some interventions inoculate the performer against a number of threats to performance.

Ultimately, the validity of any training under pressure intervention rests on the demonstration of performance gains in real-world competition. Of particular value, may be the longitudinal tracking of participants who have been included in training under pressure studies or the targeted testing of athletes who happen to have been clearly exposed to such methods of training in their practice history.

To enhance the practical utility of the intervention, it would be helpful for researchers to establish design principles for training under anxiety (or pressure). The specific nature and parameters of these principles is likely to take shape as empirical interest in this area grows. For instance, presumably there is context specific window of exposure to training under anxiety, in which training gains have meaningfully accrued before the anxiety inducing effect of any manipulation begins to wane. Likewise, there is probably an appropriate balance and blend of high- and low-anxiety training sessions within an athletes training programme.

Unfortunately, the research to date cannot reliably inform practitioners of suitable training loads and none of the papers detail the quantity and quality of training experienced alongside the bouts of training under anxiety interventions. It would also be valuable to establish the retention period of any training gains, in order to provide practical guidance on the timing of training under anxiety interventions relative to competition. Reassuringly, most studies show learning retention at least 24-48 hours after training.

Conclusions

In this chapter we have reviewed empirical research in a young and potentially fruitful area of enquiry related to the acquisition of perceptual-cognitive skills. The existing work suggests that training under anxiety affords maintenance of performance effectiveness and efficiency when performers were latter exposed to a perceived threat to performance. The training does not appear to moderate feelings of anxiety when a stressor is introduced, but rather allows learners to develop strategies to fortify goal-directed attentional control, potentially through adapting visual search strategies (as per Alder et al., 2016), and correctly interpret perceptual information. Because the work is in its infancy, it would be unwise to make bold claims about specific implications of the findings for applied practitioners. More broadly, the work reinforces the importance of representative learning design (Pinder et al., 2011). It may be that to facilitate the development of an athlete’s coping “toolbox,” interventions are needed that expose athletes in training to stressors commonly encountered in competition, such as physiological stress, injury, reduced confidence, lowered motivation and different levels of anxiety. Clearly, more systematic programmes of work are needed to validate this proposition and provide specific guidance to coaches. Meanwhile, coaches should endeavour to fully understand the demands that different stressors place upon their athletes and to design learning environments that match the identified demands.

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