

Anxiety and perceptual-motor performance: toward an integrated model of concepts, mechanisms, and processes

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Abstract Under anxiety, people sometimes perform poorly. This concerns cognitive performance (e.g., taking an important exam) as well as perceptual-motor performance (e.g., picking up a cup from a table). There is still much debate about how anxiety affects perceptual-motor performance. In the current paper we review the experimental literature on anxiety and perceptual-motor performance, thereby focusing on how anxiety affects the perception, selection, and realization of action possibilities. Based on this review we discuss the merits of two opposing theoretical explanations and build on existing frameworks of anxiety and cognitive performance to develop an integrated model that explains the various ways in which anxiety may specifically affect perceptual-motor performance. This model distinguishes between positive and negative effects of anxiety and, moving beyond previous approaches, recognizes three operational levels (i.e., attentional, interpretational, and behavioral) at which anxiety may affect different aspects of goal-directed action. Finally, predictions are formulated and directions for future research suggested.

Introduction

Emotions, and anxiety in particular, figure prominently in our everyday lives. Think, for instance, about the tension you may experience when asking your boss for a pay raise,

the hesitation when finally approaching that boy or girl that you like, or the nervousness before taking an important exam. Sometimes, emotions can be so strong that they seem to alter the way in which we perceive and act upon the world around us (cf., Oudejans & Nieuwenhuys, 2009; Proffitt, 2006). As such, the study of emotion, and especially the impact that emotions may have on various aspects of our behavior, has received much attention in the literature.

While there are many different kinds of emotions, the present paper focuses on state anxiety, which, according to Schwenkmezger and Steffgen (1989), “can be regarded as a broad concept for a number of very complex emotional and motivational states and processes that occur as a result of threat. This threat is related to the subjective evaluation of a situation, and concerns jeopardy to one’s self-esteem during performance or social situations, physical danger, or insecurity and uncertainty.” (pp. 78–79).

In past decades, much has been written about the effects of anxiety on cognitive functioning (e.g., taking an important exam; Eysenck, 1992; Mathews, 1990; Sarason, 1988; Wine, 1971), thereby revealing several mechanisms that explain *how* anxiety influences cognitive performance (see Beilock, 2008a; Bishop, 2007; Eysenck, Derakshan, Santos, & Calvo, 2007, for recent overviews and theoretical advancements). Similarly, on a behavioral level, many studies have looked at the relationship between anxiety and perceptual-motor performance (e.g., taking a decisive penalty during a world-championship final; see Hardy, 1996; Spence & Spence, 1966; Yerkes & Dodson, 1908). However, despite recent theoretical advancements (e.g., Beilock & Gray, 2007; Wilson, 2008) empirical findings are still scattered, and an overarching framework to explain the mechanisms underlying this relationship does not yet exist.

Cognitive accounts of anxiety and performance show that under anxiety, increases in activation of the amygdala

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(an important emotional center in the brain) are coupled to decreases in the recruitment of prefrontal control mechanisms (e.g., Bishop, Duncan, & Lawrence, 2004a, b; Kim, Somerville, Johnstone, Polis, & Alexander, 2004; Somerville, Kim, Johnstone, Alexander, & Whalen, 2004). As a result, anxious individuals show increased attention for threat (i.e., attentional bias), and are more likely to interpret emotionally ambiguous stimuli in a threat-related manner (i.e., interpretational bias; see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & IJzendoorn, 2007; Bishop, 2007, for an overview of this literature). Generally, this means that when people are anxious, it becomes harder for them to concentrate on a task and efficiently process task-relevant information, which often leads to a decrease in cognitive performance (e.g., Eysenck & Calvo, 1992; Eysenck et al., 2007).

In the perceptual-motor literature, similar mechanisms have been proposed to account for the effects of anxiety on perceptual-motor performance, the general consensus being that through its effect on attention, anxiety affects the degree to which we (are able to) control our movements (Beilock & Gray, 2007). With respect to how this process takes place, however, opinions are divided. On one hand, so-called *distraction* models (e.g., attentional control theory, Eysenck et al., 2007; see Wilson, 2008) argue that if attention is drawn towards task-irrelevant (threat-related) stimuli under anxiety, this should mean that less attention is available for movement execution. After all, perceptual-motor tasks require an appropriate adjustment of movements on the basis of available perceptual information (e.g., about the location of a target). This implies that as a result of anxiety, people's movements may become less accurate, and they may need more attempts or more time to successfully perform a certain task (e.g., Behan & Wilson, 2008; Causer, Holmes, Smith, & Williams, 2011; Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008; Nieuwenhuys & Oudejans, 2011; Vickers & Williams, 2007; Wilson, Vine, & Wood, 2009).

At the same time, it is well known that expert performers have practiced movements so often that their execution is highly automatized. In this regard, *execution focus* models (e.g., explicit monitoring, Beilock & Carr, 2001; reinvestment, Masters, 1992) argue that limited attentional resources cannot explain the negative effects of anxiety upon performance. Rather, anxiety may cause attention to be drawn inwards, and lead to attempts to explicitly control or monitor ones movements. For expert performers this disrupts the automatic execution of the task at hand and seriously harms performance (e.g., Beilock & Carr, 2001; Gray, 2004; Gucciardi & Dimmock, 2008; Lam, Maxwell, & Masters, 2009; Masters, 1992).

Given these contrasting views, in the current paper we will aim to shed more light on the relation between anxiety and perceptual-motor performance. To this end we will

provide a structured review of the available literature and discuss the scope and opposing predictions of both distraction and execution focus models. Based on this review and discussion we will then propose an integrated model that describes the various concepts, mechanisms, and processes that are involved. This model is strongly based on distraction principles (i.e., attentional control theory; Eysenck et al., 2007) but extends previous approaches by recognizing separate operational levels (i.e., attentional, interpretational, and behavioral) at which anxiety may affect different aspects of goal-directed action. Finally, predictions are formulated and directions for future research are suggested.

Perceptual-motor performance

In our review of the literature we will bring together a broad range of experimental studies, which have been conducted on the basis of a variety of (theoretical) approaches to anxiety and perceptual-motor behavior. Our own approach to perceptual-motor behavior can be considered embodied (e.g., Beilock, 2008b; Proffitt, 2006; Wilson, 2002), and ultimately has its origins in ecological psychology (Gibson, 1979). Essentially, the embodied approach holds that information is a product of our interaction with the world and, hence, inherently specifies the behavioral possibilities of an environment taken with reference to a particular actor (e.g., Proffitt, 2006). Based on these claims, the embodied approach differs from more traditional information-processing approaches (e.g., Fodor, 1983) with respect to the nature of information that we detect (i.e., abstract vs. relational) and the amount of internal processing that is needed to perceive and act upon the environment (i.e., direct vs. indirect perception; e.g., Wilson, 2002).

Although within the embodied approach visual stimuli are believed to be inherently meaningful, this does not mean that people do not require attention to detect this kind of information and use it to guide their actions. For example, one has to attend to the proper information in order to successfully calibrate and adjust movements in relation to a target (e.g., in catching a fly-ball; Jacobs, Runeson, & Michaels, 2001; Oudejans, Michaels, Bakker, & Davids, 1999; Withagen & Michaels, 2005). Additionally, in many situations (e.g., in sports) there are multiple possibilities for action, and several stimuli that compete for attention. As such, relevant information concerning a preferred action should be singled-out (selected) and used to perform the action(s), while irrelevant information is ignored.

By describing information in terms of the behavioral possibilities of an environment, perceptual-motor behavior can be conceptualized as a process of perceiving, selecting, and realizing possibilities for action (Pijpers, Oudejans,

Bakker, & Beek, 2006; see Williams, Davids, & Williams, 1999, for a more traditionally structured equivalent). In the current paper we will use this conceptualization to structure our review of the literature on anxiety and perceptual-motor performance, starting with the detection of task-relevant information (*perception*), continuing with the selection of action possibilities (*selection*), and ending with the actual execution of movement itself (*action*). The intention of this review is not to be complete or exhaustive in any way, but to provide a relatively clear and comprehensive overview of the various ways in which anxiety may affect goal-directed action, thereby providing an adequate background for the more theoretical discussion that follows.

Anxiety and perceptual-motor performance

Perception of task-relevant information

Although the majority of experimental studies that have been conducted, focused on how anxiety may affect the actual execution of movements, several studies have shown that even before one engages in action, anxiety affects how we visually scan our environments. Typically it is shown that when people are anxious, their scanning behavior becomes less efficient. That is, they are more easily distracted by task-irrelevant information and, in general, execute more fixations of shorter duration (see Janelle, 2002, for an overview). In addition, several studies have shown that under anxiety, threatening stimuli tend to attract extra attention (e.g., Amir, Elias, Klumpp, & Przeworski, 2003) and are particularly difficult to disengage from (e.g., Fox, Russo, Bowles, & Dutton, 2001). For instance, in a recent experiment, Nieuwenhuys and Oudejans (2011) showed that when police officers executed a shooting exercise against a threatening opponent that shot back with colored-soap cartridges (high-anxiety), they executed more and longer fixations to the head and gun of the opponent (i.e., threat-related sources of information) than when the opponent did not shoot back (low-anxiety). With more attention for threat-related information, the officers spent less time fixating the targets they were supposed to hit. As such, one way in which anxiety may affect the perception of action possibilities is by causing people to attend to different information (e.g., threat-related vs. task-relevant).

In addition, recent work on embodied perception suggests that even when we do attend to the same information, anxiety may lead to changes in visual perception (Proffitt, 2006). For example, individuals who are afraid of heights, tend to see heights as higher than people who are not afraid of heights (Teachman, Stefanucci, Clerkin, Cody, & Proffitt, 2008). Similarly, perceived reaching ability decreases as individuals are high above the ground and

experience more anxiety (Pijpers et al., 2006). According to Proffitt (2006), changes in our psychological or physiological state influence the costs we associate with performing an intended action, and thus, strongly affect our perception of task-specific variables. Recently, Proffitt and colleagues provided evidence that this effect already occurs at the initial level of perception, that is, before any post-perceptual processing takes place (e.g., Witt, Proffitt, & Epstein, 2010).

In a similar vein (but from an information-processing perspective), several studies have suggested that anxiety influences how we interpret information (see Bishop, 2007; Blanchette & Richards, 2010, for an overview of this literature). That is, when people have to judge the meaning of a particular situation or stimulus (e.g., threatening or not threatening), anxiety makes the selection of a threat-related interpretation more likely, potentially because it strengthens the output of our threat-evaluation mechanism and inhibits the influence of pre-frontal control mechanisms (Bishop, 2007; Mathews & Mackintosh, 1998). For instance, when individuals listen to a voice recording and are asked whether they heard the word ‘die’ or ‘dye’, anxious individuals more often report that they heard the word ‘die’ (e.g., Calvo & Castillo, 2001). Likewise, when police officers are asked to judge whether a suspect has a gun or not, a combination of stereotype threat and time pressure causes them to report guns more often (e.g., Correll, Park, Judd, & Wittenbrink, 2002; Payne, 2001). As such, besides causing people to attend to different information (e.g., threat-related vs. task-relevant), anxiety may also affect the perception of action possibilities by altering *how* we perceive and interpret our environment.

Selection of action possibilities

Knowing that anxiety may alter the *perception* of action possibilities, it can be argued that these changes also promote changes in the *selection* of action possibilities (Oudejans & Nieuwenhuys, 2009). That is, when people pick up different information or perceive the environment differently based on their current state, it is possible that action possibilities are not always recognized, or that people become biased towards specific (threat-related) alternatives. For example, in a study of Pijpers et al. (2006), decreases in perceived reaching ability under anxiety influenced the number of holds that participants used when they had to climb from one end of a climbing wall to the other. That is, participants used more holds, and made arm and leg movements over shorter distances, when they were anxious (high on the wall) compared with when they were not anxious (low on the wall; cf. Nieuwenhuys, Pijpers, et al., 2008).

In a more recent experiment, Nieuwenhuys, Savelsbergh, and Oudejans (2011) measured police officers’ gaze behavior during the execution of a shooting task (i.e., shoot or don’t

shoot) and specifically tested whether effects of anxiety on decision-making may be attributed either to changes in gaze behavior (i.e., which information is picked up) or to how the environment is perceived or interpreted when people are anxious. Using a video-simulation environment, Nieuwenhuys et al. asked police officers to shoot or not shoot at rapidly appearing suspects that either had a gun and ‘shot’, or had no gun and ‘surrendered’, while anxiety was manipulated by turning on (high-anxiety) or turning off (low-anxiety) a ‘shootback canon’ that could fire small plastic bullets at the officers. When the officers were anxious (under the threat of being hit) they showed a response bias towards shooting, implying that they accidentally shot more often at suspects that surrendered. Underlying this effect, Nieuwenhuys et al. found no differences in gaze behavior between correct and incorrect shooting responses. That is, the officers scanned the environment at an equal pace, fixated the same locations, and detected the suspect equally fast in both situations. Nevertheless, incorrect shooting responses were accompanied by response times that were almost 20% shorter than correct shooting responses. These results suggested that under anxiety, the officers were more inclined to quickly respond on the basis of threat-related inferences and expectations rather than using task-relevant visual information that showed whether the suspect had a gun or not (cf. Correll et al., 2002; Payne, 2001). As such, by affecting *how* people perceive or interpret their environment (Bishop, 2007; Mathews & Mackintosh, 1998; Proffitt, 2006), anxiety may seriously alter the selection of action possibilities (e.g., shoot or don’t shoot).

Movement execution

Finally, when it comes to movement execution, people need perceptual information to establish the coordination patterns and muscle activity that make their actions possible.

Perceptual information to guide movements

In goal-directed action (e.g., far aiming), the amount of time that one continuously looks at a target appears to be strongly correlated with performance (see Vickers, 2007, for an overview). That is, to be successful, people need enough information about a target to accurately calibrate and adjust their movements in relation to that target. For example, in basketball jump-shooting, players need to focus on the rim and, as they jump, execute their shot on the basis of their (changing) position in relation to the rim (e.g., Oudejans, Van de Langeberg, & Hutter, 2002). In line with distraction models (e.g., attentional control theory; Eysenck et al., 2007), several studies showed that the time that people

fixate on such a target is significantly reduced under anxiety, which allows less time to fine-tune movements on the basis of visual information, and causes a considerable decrease in performance (e.g., Behan & Wilson, 2008; Causer et al., 2011; Nieuwenhuys & Oudejans, 2010, 2011; Vickers & Williams, 2007; Wilson, Vine, et al., 2009).

Additionally, with less time spent fixating targets, anxious individuals tend to spend more time looking at other (threat-related) sources of information (e.g., Nieuwenhuys & Oudejans, 2011). Because vision is often used to inform action (e.g., Land, 2009), the mere fact that one looks at task-irrelevant (threat-related) sources of information under anxiety, may already be enough for movements to deviate in that direction. Indeed, Wilson, Wood, and Vine (2009) showed that when participants performed a soccer penalty kick under conditions of high-anxiety, they tended to increase the number and duration of fixations to the goalkeeper (a potential source of threat), and actually ended up shooting closer to the goalkeeper’s position (see also Binsch, Oudejans, Bakker, & Savelsbergh, 2010).

Besides aiming tasks, reductions in on-task attention have been shown to also affect movement efficiency in endurance tasks. For instance, in a recent experiment Nibbeling, Daanen, Gerritsma, Hofland, and Oudejans (2011) had participants run on a treadmill at different heights above the ground. In line with distraction models (e.g., attentional control theory; Eysenck et al., 2007), when participants ran high above the ground (high-anxiety), they reported that their thoughts were strongly captured by their fear of falling—suggesting that less task-relevant attention was available for efficient running. Indeed, participants appeared to make shorter steps, showed higher step frequencies, and showed longer contact times when they were anxious compared with when they were not anxious. As a result of these changes, heart rate and oxygen uptake increased, indicating that (in several ways) running efficiency was lower under anxiety (cf. Brown, Doan, McKenzie, & Cooper, 2006).

Finally, in line with execution focus models (e.g., explicit monitoring, Beilock and Carr, 2001; reinvestment, Masters, 1992), there are also studies that show how paying too much attention to a task can be counterproductive. When expert performers are asked to explicitly focus on their movement execution, this seems to disrupt the otherwise automatic execution of a task, leading to less efficient (more rigid) movement behavior, and reduced performance (e.g., Beilock & Carr, 2001; Beilock, Carr, MacMahon, & Starkes, 2002; Gray, 2004; Gucciardi & Dimmock 2008; Lam et al., 2009; Masters 1992). For example, Beilock et al., (2002) showed that when expert soccer players had to perform a dribble task and explicitly attended to the side of their foot with which they touched

the ball, their performance (execution time) was significantly worse than when they attended to task-irrelevant tones. Although there is no direct evidence yet, execution focus models claim that this is also what happens under anxiety (e.g., Beilock & Carr, 2001; Masters, 1992).

Action readiness and behavioral responses

Although anxiety often affects action by altering how movements are calibrated and adjusted based on perceptual information, it can also affect movement execution directly. That is, under anxiety, the excitability of the corticospinal motor tract is increased (potentially to enable quick responses in relation to threat), which leads to higher levels of muscle activation and more force production when performers are anxious (e.g., Coombes, Higgins, Gamble, Cauraugh, & Janelle, 2009; Schutter, Hofman, & Van Honk, 2008). Obviously, such changes in *action readiness* have an impact on how movements are performed. For instance, Pijpers, Oudejans, Holsheimer, and Bakker (2003) showed that when participants climbed high on a climbing wall (and thus experienced more anxiety), they showed higher levels of muscle activation, more co-activation, stronger fatigue, and higher blood lactate concentrations. These changes in muscle activity promoted changes in movement execution, in the sense that movements became slower, less fluent, and were more rigid under anxiety, leading to consequent decreases in performance (see also Beuter & Duda, 1985; Yoshie, Kudo, Murakoshi, & Ohtsuki, 2009).

In addition, emotional (e.g., threatening) stimuli give rise to motivational orientations that facilitate specific *behavioral responses* (e.g., Frijda, 1988; Zajonc, 1980). When responding to the onset of emotional cues (e.g., words, pictures), positive stimuli tend to facilitate approach movements (e.g., moving toward the stimulus), whereas negative stimuli tend to facilitate avoidance movements (e.g., moving away from the stimulus; Krieglmeier, Deutsch, De Houwer, & De Raedt, 2010; Krieglmeier, De Houwer, & Deutsch, 2011; Lavender & Hommel, 2007; Stins, Roelofs, Villan, Kooijman, Hagens, & Beek, 2011). Also, several studies have shown that people are more likely to make response errors when performing on emotion-incongruent trials (e.g., moving toward a positive stimulus when the instruction is to move away from this type of stimulus; Krieglmeier et al., 2011; Stins et al., 2011). Although preliminary, these findings point to an overall tendency to perform emotion-congruent behavior and, with that, indicate that besides facilitating emotion-congruent responses, motivational orientations may interfere with task execution when the intended behavior is not in line with the emotion that is experienced (e.g., a forced approach).

Toward an integrated understanding of concepts, mechanisms and processes

To summarize the above, it is clear that anxiety not only affects perceptual-motor performance during movement execution, but—in fact—also exerts its influence during the perception and selection of action possibilities (cf. Pijpers et al., 2006). Under anxiety, attention is drawn away from task-relevant information, towards threat-related information (i.e., *attentional bias*), and people are more likely to perceive or interpret their environment as threatening (i.e., *interpretational bias*). As a result, possibilities for action may not be recognized, or people may become biased towards specific (threat-related) alternatives, leading to changes in action selection (i.e., *which* movements are performed). In addition, reductions in on-task attention and increases in threat-related attention may also affect *how* movements are performed. That is, movements may become less accurate because too little time is spent fixating a target, or they may deviate from their original path because other (threat-related) locations are attended to as well. Finally, besides attentional effects, anxiety may influence movement execution as a result of changes in action readiness (e.g., increased cortical excitability and muscle activity) and an overall tendency to implement emotion-congruent (e.g., threat-related) behavioral responses.

Based on this overview, we will now return to the two competing models of anxiety and perceptual-motor performance: *distraction* models (e.g., Wilson, 2008) and *execution focus* models (e.g., Beilock & Carr, 2001; Masters, 1992)—shortly reiterate their distinctive hypotheses, and discuss the extent to which they are (a) able to account for the variety of effects that are observed in the literature (scope); (b) naturally occurring in performance settings; and (c) mutually exclusive or not.

Distraction versus execution focus

Based on cognitive theories of anxiety and performance, most notably attentional control theory (ACT; Eysenck et al., 2007), distraction models suggest that anxious individuals may have too little attention available to calibrate and adjust movements in relation to task-relevant information (e.g., Wilson, 2008). As shown in the previous sections, studies that tested this hypothesis have usually provided supportive results and indicated that, as a result of anxiety, task-relevant fixations are reduced at the cost of increases in task-irrelevant (threat-related) fixations, thereby causing a decrease in performance (e.g., Behan & Wilson, 2008; Causer et al., 2011; Nieuwenhuys, Pijpers, et al., 2008; Nieuwenhuys and Oudejans, 2011; Vickers and Williams, 2007; Wilson, Vine, et al., 2009). Arguing against this view, however, execution focus models maintain that rather than

reducing on-task attention, anxiety causes attention to be drawn inwards, leading to explicit attempts to monitor or control ones movements (e.g., Beilock and Carr, 2001; Masters, 1992). For expert performers, this leads to a disruption of automatic processes and, hence, causes a decrease in performance. Experimental studies that tested this hypothesis have provided supportive results. That is, when expert performers are asked to explicitly focus on their movement execution, this consistently leads to a degradation of performance (e.g., Gray, 2004; Gucciardi and Dimmock, 2008; Lam et al., 2009).

Scope

With respect to the variety of effects that anxiety may have on perceptual-motor performance (e.g., attentional, interpretational, or behavioral), and the different phases of goal-directed action during which this may occur (i.e., perception, selection, action), it should be noted that the scope of both models is limited. Although distraction models may also account for some of the effects of anxiety that are observed during earlier phases of goal-directed action, both distraction and execution focus models primarily concentrate on the final, executive, phase of the process: movement execution. In addition, regarding the nature of effects, both models are restricted to effects of anxiety on attention, and—hence—do not account for what we have labeled ‘interpretational’ effects (i.e., *how* the environment is perceived; Proffitt, 2006; Bishop, 2007; Mathews & Mackintosh, 1998) and ‘behavioral’ effects (i.e., increases in action readiness and behavioral response tendencies).

Natural occurrence

While each of the studies that supported distraction models had their participants perform under natural (unconstrained) attentional instructions (e.g., Behan and Wilson, 2008; Causer et al., 2011; Nieuwenhuys, Pijpers, et al., 2008; Nieuwenhuys & Oudejans, 2011; Vickers and Williams, 2007; Wilson, Vine, et al., 2009), each of the studies that supported execution focus models experimentally manipulated their participants’ direction of attention (either directly, e.g., Gucciardi & Dimmock, 2008; Lam et al., 2009; or indirectly, e.g., Gray, 2004). Consequently, although it is clear that explicitly trying to monitor or control movements can be devastating for experts’ performance, a causal relation between anxiety and this specific type of attentional focus remains unsupported and, as of yet, uninvestigated (Oudejans & Nieuwenhuys, 2009; Oudejans, Kuijpers, Kooijman, & Bakker, 2011).

While it is certainly possible that—within performance settings—people respond to anxiety by explicitly focusing on their movement execution, it is questionable whether

this would typically occur. In fact, within the sports literature, many qualitative studies that examined elite athletes’ thoughts during competition showed that rather than explicitly focusing on movement execution, all kinds of distracting thoughts and worries occur naturally when people perform under pressure (e.g., Gucciardi, Longbottom, Jackson & Dimmock, 2010; Hatzigeorgiadis & Biddle, 2000, 2001; Oudejans et al., 2011; Wilson & Smith, 2007). For example, Oudejans and colleagues employed retrospective verbal reports to investigate elite athletes’ focus of attention during high-pressure moments in sports. Among more than 70 elite athletes from different sports and disciplines they found that, as a category, “explicit attention to movement execution” represented only 4% of the data that was reported. Instead, “worries” represented over 25% of the data, suggesting that at least with respect to the attentional focus of athletes, circumstances of pressure and anxiety more often lead to distraction than explicit attention to movement execution (see Gucciardi et al., 2010, for similar results).

Mutually exclusive?

Although execution focus does not seem to occur very often, from a theoretical perspective, it is still important to explore the extent to which its effect and occurrence may be explained on the basis of distraction principles. Because in performance settings movement execution may be explicitly evaluated, it is not strange that specific circumstances (e.g., monitoring pressure or fear of failure; DeCaro, Thomas, Albert, & Beilock, 2011) draw extra attention to movements. For example, when a tennis player performs an important match and (for some reason) believes that her backhand is weak, her attention may be drawn towards the execution of this stroke. However, although this explains how execution focus may arise, if one is to call this distraction, one has to acknowledge that in some cases, movement execution is task-irrelevant rather than task-relevant.

A key issue here is that what is considered to be task-relevant is defined based on the experience of the performer in question. That is, while paying explicit attention to movement execution is important and task-relevant in the early phases of motor learning (e.g., Bernstein, 1996; Whiting, 1984), this is no longer the case for experts. In perceptual-motor tasks, expert skill execution is often highly automatized, and requires a more “external”, goal-oriented focus in order to attain the best possible performance (e.g., Beilock et al., 2002). Therefore, for expert performers, explicit attention to movement execution might be considered “task-irrelevant” (see Lam et al., 2009, for a similar suggestion), it leaves too little attention for task-relevant information (e.g., the target in an aiming

action) and, hence, seriously harms the quality of performance.

An integrated perspective

To summarize, although distraction and execution focus models have proposed different mechanisms concerning how anxiety may affect movement execution, they can both be explained with the same (distraction) principles. That is, under anxiety, attention is biased toward threat-related stimuli, which typically leaves less attention to adjust and calibrate movements on the basis of task-relevant information (e.g., Wilson, 2008). In specific cases (e.g., under monitoring pressure; DeCaro et al., 2011), this may involve execution focus, which—for expert performers—is not task-relevant and may be particularly debilitating to performance (e.g., Beilock & Carr, 2001; Masters, 1992).

Regarding their scope, distraction and execution focus models are restricted to effects of anxiety on attention, and mainly concentrate on how changes in attention affect movement execution. Although movement execution covers an important part of goal-directed action, our review of the literature showed that this constitutes a rather limited approach. Within the complete process of perception, selection and action (Pijpers et al., 2006), movement execution is the final phase, which makes it subsidiary or subject to changes (i.e., effects of anxiety) in earlier phases. That is, if anxiety already causes one to perceive and select different (less optimal) action possibilities, it is of little value whether the execution of action is subsequently affected or not.

Finally, anxiety has been shown to not only affect attention (e.g., *which* information is picked up), but also influence our interpretation of information (e.g., *how* the environment is perceived), and promote specific behavioral responses (e.g., increases in action readiness and avoidance tendencies). As such, there is a clear need to extend previous approaches and develop a model that involves the interrelations between each of these mechanisms and processes, thereby providing an integrated perspective on the various ways through which anxiety may affect goal-directed action.

An integrated model of anxiety and perceptual-motor performance

The model that we propose is depicted in Fig. 1 and relies heavily on some of the central tenets of existing models of distraction, particularly attentional control theory (ACT, Eysenck et al., 2007; for a review of ACT applied to perceptual-motor contexts the reader is referred to Wilson,

2008). Similar to other distraction models, ACT posits that anxiety affects performance negatively because top-down (goal-directed) control is reduced at the cost of increases in bottom-up (stimulus-driven) processing (see also Bishop, 2007). Based on our perceptual-motor perspective (i.e., perception, selection, action), however, we propose that this imbalance not only affects attentional control—in a sense that one becomes biased toward threat-related information (Eysenck et al., 2007)—but also affects interpretational processes (Bishop, 2007; Blanchette & Richards, 2010) and facilitates emotion-specific behavioral responses (Frijda, 1988; Zajonc, 1980; see also Krieglmeier et al., 2010, 2011; Lavender & Hommel, 2007; Schutter et al., 2008; Stins et al., 2011). In our model these effects are represented by means of three operational levels at which anxiety may exert its influence: threat-related *attention*, threat-related *interpretation*, and threat-related *response tendencies* (see Fig. 1). In turn, each operational level is connected to more or less specific phases of goal-directed action, which are depicted as a perception–selection–action cycle.

A second assumption within ACT (Eysenck et al., 2007) is that besides having negative effects on performance, anxiety also serves a motivational function (see also Eysenck & Calvo, 1992). Individuals may try to compensate for the debilitating effects of anxiety through increases in mental effort. In this way, anxiety will always affect the “efficiency” of performance (as more effort is needed to obtain the same result) but the outcome (i.e., effectiveness) of performance may remain unchanged or might even improve. Based on the aforementioned distinction between goal-directed and stimulus-driven processes (Eysenck et al., 2007; Bishop, 2007), our model recognizes three broad directions regarding how individuals may effectively channel their mental effort (see Fig. 1). That is, people may try to enforce goal-directed behavior, actively inhibit or prevent stimulus-driven responses (i.e., attentional, interpretational, or behavioral), or attempt to reduce their feelings of anxiety.

Finally, in line with DeCaro et al. (2011), the specific stressors that cause anxiety, the operational level at which anxiety affects behavior (i.e., attentional, interpretational, or behavioral), and the strategies that people use to compensate for negative effects, are supposed to be dependent on situational factors (e.g., task characteristics, environmental constraints) and dispositional factors (e.g., trait anxiety, state or action orientation; dispositional reinvestment; see Fig. 1).

To further clarify our model we will shortly describe each of these aspects, including: (1) how different operational effects of anxiety may specifically interfere with goal-directed action; (2) how different strategies to channel extra mental effort may exert different effects in terms of

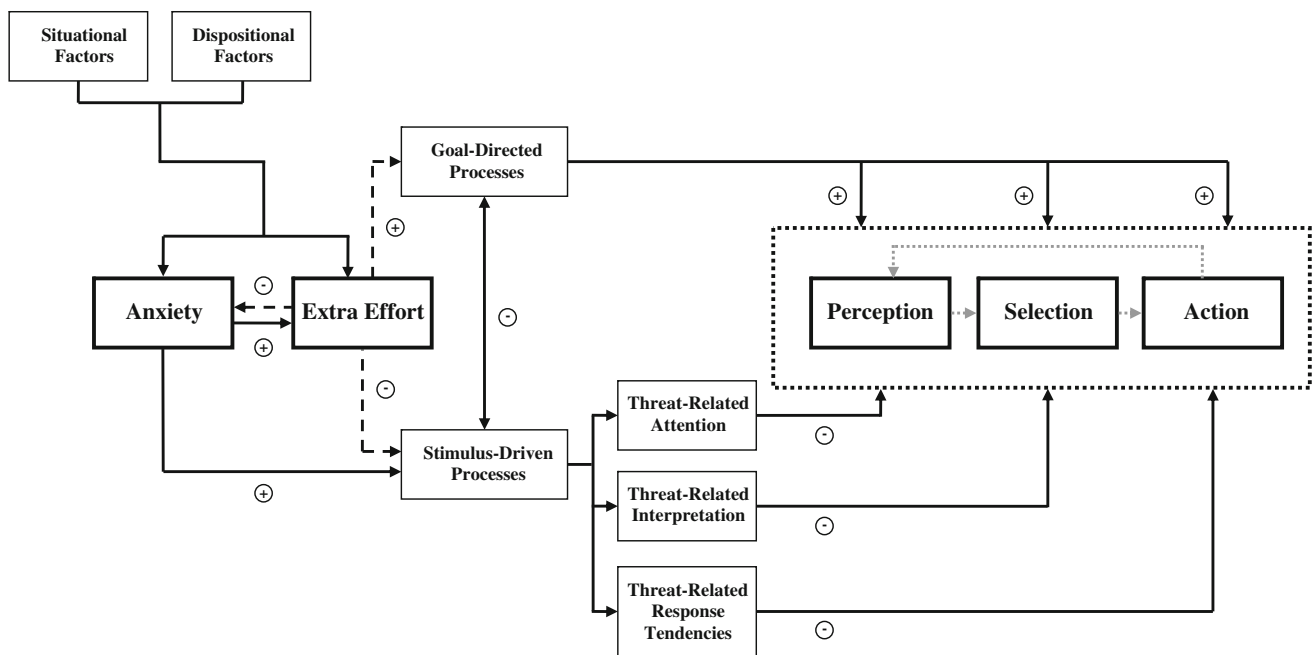


Fig. 1 An integrated model of anxiety and perceptual-motor performance

maintaining performance; and (3) how situational and dispositional factors may determine the operational level at which anxiety interferes with performance and the strategies that are employed to compensate for negative effects.

Negative effects of anxiety on perceptual-motor performance

Threat-related attention

First of all, anxiety increases the amount of attention that is paid to threat-related sources of information (i.e., attentional bias; Eysenck et al., 2007) and leaves less attention to perceive, select, and realize possibilities for action (see Fig. 1). For instance, in climbing on a climbing wall, anxiety has been shown to cause people to execute more (and shorter) explorative fixations to a larger number of handholds, thereby leading to changes in option selection (moving over shorter distances), and slower, more rigid, movements (Nieuwenhuys, Pijpers, et al., 2008; see also Pijpers et al., 2006). In addition, in other contexts (e.g., taking a penalty kick in soccer) it has been shown that threat-related stimuli (e.g., the goalkeeper) can serve as attractors, and cause movements to deviate in their direction (e.g., Wilson, Wood et al., 2009; Binsch et al., 2010). Finally, when attended stimuli directly concern movement execution (i.e., execution focus) anxiety may lead to a breakdown of automatic control processes and, as such, seriously harm performance (e.g., Beilock & Carr, 2001; Masters, 1992).

Threat-related interpretation

Anxiety also leads to threat-related interpretation (Bishop, 2007; Blanchette & Richards, 2010), meaning that although one is visually attending to task-relevant information, this information may be perceived differently (e.g., Proffitt, 2006), or may be misinterpreted (e.g., Nieuwenhuys, Savelsbergh, et al., 2011) based on one's current feeling or state. For instance, individuals who are afraid of heights, tend to see heights as being higher than individuals who are not afraid of heights (e.g., Teachman et al., 2008), and police officers who are afraid to get shot are more prone to recognize a suspect's weapon, even when there is none (e.g., Correll et al., 2002; Nieuwenhuys, Savelsbergh, et al., 2011; Payne, 2001). Although such effects may clearly lead to suboptimal response selection (e.g., shooting an innocent suspect) it may also mean that possibilities for action are not perceived, or that movements are not properly calibrated in relation to a target. For instance, Nieuwenhuys, Savelsbergh, et al., (2011) showed that when they were afraid of being hit, threat-related expectations prevented police officers from using visual information, caused them to take less time for their decisions, and made them shoot less accurately.

Threat-related response tendencies

Finally, on a behavioral level, anxiety may lead to changes in action readiness and create a tendency to perform emotion-congruent responses. For instance, heart rate,

blood pressure, breath frequency, muscle activity and energy expenditure all increase under anxiety, causing movements to become less efficient (e.g., Nibbeling et al., 2011; Pijpers et al., 2006). In addition, as shown nicely by Stins et al. (2011), increases in action readiness, together with motivational response tendencies (i.e., avoidance), make it harder to initiate (emotion-incongruent) approach movements in relation to a threatening stimulus (see also Lavender & Hommel, 2007; Krieglmeier et al., 2010), and cause people to make more executive mistakes when the intended (goal-directed) behavior is not in line with the emotion that is experienced (cf. Krieglmeier et al., 2011).

How extra mental effort may help to maintain performance under anxiety

Besides affecting performance negatively, anxiety also serves a motivational function that enables people to try and maintain performance through increases in mental effort (Eysenck & Calvo, 1992; Eysenck et al., 2007).

Enforce goal-directed processing

First of all, individuals may try to re-enforce or maintain task-relevant processes (see Fig. 1). Although in principle this can be done at each operational level (attentional, interpretational, behavioral), the maintenance of goal-directed attention seems most apparent. For instance, a surgeon who is executing a life-saving operation may force him or herself to focus on properly executing an incision, instead of thinking about the terrible consequences of making a mistake. While this may be hard to achieve without any experience, recent experimental work by Wilson, Vine, Masters, and McGrath (2011) showed that deliberate visual attention training, in which medical trainees watched video's that showed the gaze pattern of experienced surgeons, can be effective in protecting technical laparoscopic skills under distracting multi-tasking conditions. Alternatively, Nieuwenhuys and Oudejans (2011) showed that merely getting used to the pressure and anxiety that accompanies performance, may exert a similar positive effect on visual attentional processes (see also Oudejans, 2008; Oudejans & Pijpers, 2009, 2010).

Inhibit stimulus-driven processing

Negative effects of anxiety may also be compensated by inhibiting stimulus-driven processes (see Fig. 1). For instance, individuals may try to deliberately stop thinking about or attending to threat-related sources of information. However, although such attempts can be very successful, a potential caveat is that trying hard not to attend (or respond) to something may ironically draw more attention

towards it (or make the unwanted response more likely; Wegner, 1994). For example, deliberate attempts to not shoot close to the keeper in taking a penalty kick in soccer have been shown to lead to longer fixations on the keeper (a potential source of threat) and, consequently, caused participants to shoot closer to the keeper (Binsch et al., 2010). Alternatively, individuals may also try to distract themselves from the threat they experience. For instance, recent work by DeCaro et al. (2011) showed that when little attention is required to perform a certain task, distraction strategies may help to prevent pressure-induced increases in execution focus.

Reduce anxiety

Finally, individuals may try to reduce or prevent the experience of anxiety itself (see Fig. 1). For instance, a talented musician, who is anxious before an important concert, may use breathing techniques or imagery to calm down before she gets on stage (e.g., Gould & Udry, 1994). By using such strategies, the experience of anxiety may be reduced, thereby reducing stimulus-driven processing and facilitating performance.

Situational and dispositional factors

The operational level(s) at which anxiety will eventually affect goal-directed action, as well as the strategies that people may employ to try and maintain performance, are not supposed to be fixed, but highly dependent on situational factors (e.g., task characteristics) and dispositional factors (e.g., individual differences; see Fig. 1). For example, as shown by DeCaro et al. (2011), the degree of attentional control that is required to perform a certain task and the specific type of pressure that people are imposed with, strongly determine if and how (e.g., through distraction or execution focus) performance is affected or not. In addition, people are most likely to be affected by those aspects of a pressure situation that are most salient to them and will react to situations in a manner that fits with their previous experiences and actions (i.e., dispositional factors). For example, individuals who tend to be action oriented are more likely to reinforce goal-directed attention, whereas individuals that are state oriented are more likely to concentrate on their feelings of anxiety (e.g., Jostmann & Koole, 2007). Similarly, individuals who score high on dispositional reinvestment are more likely to consciously control their movements than individuals who score low on dispositional reinvestment (e.g., Masters, Polman, & Hammond, 1993; Jackson, Ashford, & Norsworthy, 2006). Although to date, several studies have rendered important findings regarding specific factors that influence the relation between anxiety and (perceptual-motor) performance,

more work is needed to compare across different factors and to extend these findings to each operational level at which anxiety may exert its influence (i.e., attentional, interpretational, behavioral).

Discussion and directions for future research

In the current paper we aimed to shed more light on the concepts, mechanisms, and processes that underlie the relation between anxiety and perceptual-motor performance. Based on a structured review of the available literature, we discussed the scope of two competing hypotheses (i.e., distraction vs. execution focus), and proposed an integrated model that describes the various concepts, mechanisms, and processes that are involved. This model is strongly based on distraction principles (i.e., attentional control theory; Eysenck et al., 2007) but extends previous approaches by recognizing separate operational levels (i.e., attentional, interpretational, and behavioral) at which anxiety may affect different aspects of goal-directed action (i.e., perception, selection, and action).

Although the conceptualization of goal-directed action as a process of perceiving, selecting, and realizing possibilities for action is not new (Pijpers et al., 2006), effects of anxiety on perceptual-motor performance are rarely studied from this perspective. That is, most studies have paid little attention to anxiety-induced effects on perceiving and selecting possibilities for action and concentrated exclusively on movement execution (cf. Beilock & Gray, 2007). Although in experimental settings, it is easy to isolate movement execution (e.g., through task instructions), in real-life situations, movements are often initiated in a context, on the basis of action possibilities that are perceived in and selected from the environment. Consequently, effects of anxiety on *how* movements are executed will often be subsidiary to effects of anxiety on processes that determine *which* movements are executed. Based on this argument, we believe that including the perception and selection of action possibilities in our model constitutes an important advancement with respect to earlier approaches (e.g., Beilock & Carr, 2001; Masters, 1992; Wilson, 2008).

Furthermore, besides recognizing that perceptual-motor behavior constitutes a process of perceiving, selecting, and realizing possibilities for action, our model distinguishes three operational levels at which anxiety may exert its influence: attentional, interpretational, and behavioral. Although a distinction between these operational levels seems justified based on the literature, more work is needed to properly understand their respective impacts on performance.

By proposing separate levels at which anxiety may exert its influence, our model inherently asks the question to what degree each operational level is responsible for an

eventual breakdown in performance. Although it is likely that individual differences are of influence, we hypothesize that in this respect task characteristics may prove to be a major determinant (see also DeCaro et al., 2011). That is, precision tasks that require a great deal of online (visual) control will be strongly affected at the attentional level, tasks that involve a great deal of uncertainty will be strongly affected at the interpretational level, and tasks that are mainly executive will be strongly affected at the behavioral level.

In a similar vein, we would like to propose that the ways in which individuals can compensate for negative effects of anxiety (through increases in mental effort), are restricted by the behavioral possibilities of the environment and the time that is available to respond to (or deal with) a specific stressor. That is, if there is much time (e.g., during the perception and selection of action possibilities), individuals may still try to reduce their feelings of anxiety or inhibit stimulus-driven processing, whereas if there is little or no time (e.g., during movement execution) they may simply attempt to enforce goal-directed behavior. In addition, it is likely that the effectiveness of specific strategies is dependent on the operational level at which anxiety exerts its effect. For example, employing a specific gaze strategy may help to prevent attentional effects of anxiety (i.e., what information we attend to), but may be less useful to counter effects on an interpretational level (i.e., how we perceive or interpret our environment).

At present, little is known about the effectiveness of different strategies that individuals may use (Nicholls & Polman, 2007). Nevertheless, learning about the specific threats that people are confronted with in a given context, and the operational level(s) at which these threats interfere with performance, may prove to be a fruitful endeavor (e.g., Nieuwenhuys, Hanin, & Bakker, 2008; Nieuwenhuys, Vos, Pijpstra, & Bakker, 2011). In our view, the current model offers a useful framework along the lines of which this may be done.

In conclusion, we believe that our integrated model provides a relatively complete and comprehensive understanding of the relation between anxiety and perceptual-motor performance. By conceptualizing perceptual-motor behavior as a process of perception, selection, and action rather than movement execution per se, and by distinguishing between attentional, interpretational, and behavioral effects of anxiety rather than focusing on attentional effects alone, the model extends previous approaches and closely matches the wide range of findings that is observed in the literature. It is important to note that by extending previous approaches our model does not necessarily invalidate existing hypotheses (e.g., distraction, execution focus). Rather, it places different approaches into a unified perspective, thereby showing the interrelations between

various concepts, mechanisms and processes. Based on this integrated approach, the model allows testing the relative contributions of separate mechanisms, and provides specific predictions regarding the factors that determine how anxiety may affect performance. Finally, by also recognizing positive (motivational) effects of anxiety our model features important practical implications. As such, it may provide starting points for alleviating the negative effects of anxiety on perceptual-motor performance, and provide performers with the tools they need to secure their performance under anxiety.

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