Chapter 12
Attentional Control Theory of Anxiety: Recent Developments

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Introduction

There have been relatively few attempts to understand the effects of anxiety (whether regarded as a personality dimension or as a mood state) on task performance directly from the perspective of cognitive psychology. However, attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007) is an attempt to do precisely that. As is discussed in this chapter, it is assumed that there is an important distinction between positive attentional control and negative attentional control. It is also assumed that anxiety impairs the efficiency of both forms of attentional control. However, the adverse effects of such impaired efficiency on performance can be reduced or eliminated when anxious individuals utilise additional resources or effort. Research that provides general support for these assumptions is discussed, and implications for future research are discussed.

Previous Theorising of Anxiety Effects on Performance

There have been various attempts theoretically to try to explain the effects of anxiety on the performance of various tasks of a cognitive nature, but most of these theories were not framed within the context of cognitive psychology. It is important to note at the outset that anxiety can be regarded either as a personality dimension (i.e. trait anxiety as assessed, for example, by Spielberger's State-Trait Anxiety Inventory (STAI): Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) or as a mood state (state anxiety, which can also be assessed by the STAI) that varies between individuals. In practice, most research in this area has focused on trait anxiety. However, it should be emphasised that trait anxiety and state anxiety typically correlate moderately positively with each other. The precise magnitude of the correlation varies from study to study but is typically about +0.5 (Eysenck, 1982). As a consequence, it has proved difficult in practice to disentangle their effects on performance. This ambiguity in much of the evidence should be borne in mind in the following section.

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Cognitive Interference Theory

In principle, there are several different parts of the cognitive system (e.g. basic perceptual processes; long-term memory) that could be affected by anxiety when individuals are instructed to perform complex tasks involving neutral stimuli. However, there is a reasonable consensus that the most consequential effects of anxiety are on the attentional system rather than on other information-processing systems. Historically, one of the most influential approaches was the cognitive interference theory put forward by Sarason (e.g. 1988). According to Sarason (1988, p. 5), "Proneness to self-preoccupation and, most specifically, to worry over evaluation is a powerful component of what is referred to as test anxiety". The implication of this theory in more contemporary terminology is that anxiety impairs attentional control with respect to task-irrelevant internal stimuli (e.g. self-relevant worries).

There are various predictions that follow from the hypothesis that anxiety leads to self-preoccupation and worry over evaluation. First, it is predicted that the effects of anxiety on performance will typically be adverse given that task-irrelevant processing reduces the attentional resources available for the processing of task-relevant stimuli. Second, it is predicted that the adverse effects of anxiety on performance should be greater when evaluative instructions are used than when non-evaluative instructions are used, because the former instructions are more likely to activate task-irrelevant worries. Third, it is predicted that the adverse effects of anxiety on performance should be greater when the task in question is complex and highly attentionally demanding than when it is not. The argument here is that any loss of attentional resources will have a greater effect on attentionally demanding tasks (originally suggested by Kahneman, 1973).

In broad terms, there is support for all three of the main predictions of cognitive interference theory (see Eysenck, 1992, for a review). For example, Morris, Davis, and Hutchings (1981) reviewed research on test anxiety and task performance. They pointed out that test anxiety consists of two major components, namely, worry and emotionality. The research consistently indicates that the negative effects of anxiety on performance are due almost entirely to worry rather than to emotionality.

In spite of the fact that there is compelling evidence that Sarason's emphasis on the role of the attentional system in mediating the effects of anxiety on performance, his approach possesses several limitations. First, it was assumed within cognitive interference theory that the direction of causality is from worry and self-preoccupation to task processing. However, there is some evidence suggesting that the causality can also proceed in the opposite direction. Rapee (1993) compared the effects of several tasks on worry-related thoughts. He found that random-letter generation (a demanding task that places high demands on attentional processes) reduced the incidence of worry-related thoughts. In contrast, tasks that placed minimal demands on the attentional system (word repetition; fixed-order key presses) did not reduce worry-related thoughts.

Second, cognitive interference theory exaggerates the role played by worry and self-preoccupation. According to the theory, anxious individuals should perform worse than non-anxious ones when they experience more task-irrelevant thoughts. However, there are several studies in which that was not the case. For example, Blankstein, Toner, and Flett (1989) and Blankstein, Flett, Boase, and Toner (1990) compared the performance of low and high test-anxious groups on an anagram task. They found that there was no group difference in anagram performance in spite of the fact that the anxious group reported substantially more negative task-irrelevant thoughts.

Third, and of direct relevance to the central theme of this book, Sarason failed to specify precisely how anxiety affects the attentional system. As a consequence, it is often difficult to make specific predictions from the theory. In addition, studies designed to test cognitive interference theory provide only indirect support for the theory. For example, the finding that anxiety impairs performance with evaluative instructions but not with non-evaluative instructions is entirely consistent with the hypothesis that anxiety reduces the availability of attentional resources, but this interpretation is by no means the only possible one.

Processing Efficiency Theory

The first systematic attempt to specify more clearly the effects of anxiety on the cognitive system was contained within processing efficiency theory (Eysenck & Calvo, 1992). One of the main starting points of processing efficiency theory was the assumption that the effects of anxiety should be considered within the context of Baddeley's (1986) working memory system. According to Baddeley, this system consists of three main components (recently increased to four: Baddeley, 2001), which are arranged hierarchically. The central executive (an attention-like, domain-free system) is at the top of the hierarchy, and is believed to be much involved in functions such as planning, strategy selection, and attentional control. There are two other components: (1) the phonological loop, which is involved in the rehearsal of verbal material; and (2) the visuo-spatial sketchpad, which is involved in the processing and transient storage of visual and spatial information.

The key prediction following from the above assumptions was that most of the adverse effects of anxiety on cognitive processing involve the central executive component of the working memory system. Baddeley (1986) assumed that the central executive was a unitary system, and so it was assumed within processing efficiency theory that anxiety impaired the functioning of this unitary system. However, it is important to distinguish between *performance effectiveness* (the quality of performance as assessed by conventional behavioural measures) and *processing efficiency* (the relationship between performance effectiveness and use of resources or effort). In essence, anxious individuals often exert more effort than nonanxious ones. As a consequence, there are generally greater adverse effects of anxiety on processing efficiency than on performance effectiveness.

There is considerable empirical support for processing efficiency theory (see Eysenck & Calvo, 1992, and Eysenck et al., 2007, for reviews). Some of the strongest supporting evidence was reported by Eysenck, Payne, and Derakshan (2005). Participants low and high in trait anxiety performed a complex visuo-spatial task (the Corsi task) as their main or primary task. At the same time, they performed a less important secondary task that required the use of the central executive, the phonological loop, or the visuo-spatial sketchpad. The key finding was that performance on the Corsi task was only significantly worse in the high-anxious group than in the low-anxious group when the secondary task required use of the central executive. This pattern of findings suggests that anxiety utilises some of the resources of the central executive (presumably through task-irrelevant thoughts) but has little or no effect on processing within the phonological loop or the visuo-spatial sketchpad.

Executive Functions of Attentional Control

Processing efficiency theory represented a clear advance on cognitive interference theory. It pinpointed the working memory system as being importantly implicated in the effects of anxiety on the cognitive system, it drew a fundamental distinction between processing efficiency and performance effectiveness, and it established a more precise framework within which to study the cognitive processes affected and unaffected by anxiety. However, processing efficiency theory was limited because it did not specify in any detail how anxiety affects the various functions of the central executive. An important reason for this was that in the early 1990s little was known about the number or nature of the main attentional or other functions involving the central executive. Indeed, it remains the case that there is uncertainty and controversy on this issue.

One of the most influential attempts to identify the major functions of the central executive system was that of Smith and Jonides (1999). They produced a list of five functions. First, there is switching between tasks. Second, there is planning sub-tasks in order to reach some pre-determined goal. Third, there is selective attention combined with inhibition. Fourth, there is updating and checking the information that is contained within working memory. Fifth, there is a function concerned with coding representations in working memory based on information about when and where the stimuli relating to the representations were encountered.

The most obvious limitation of the approach taken by Smith and Jonides (1999) is that it was not based directly on empirical evidence. Instead, it represented a reasonable attempt to make sense of a diverse set of findings. In contrast, Miyake et al. (2000) and Friedman and Miyake (2004) did not make any a priori assumptions about the number or nature of executive functions. Instead, they administered many tasks that are generally assumed to involve the central executive, and then submitted the resultant data to latent variable analysis. This empirically based approach led to the identification of three major functions: the *inhibition function*; the *shifting function*; and the *updating function*. These functions are largely independent. However, there are positive inter-correlations among them, which suggests that they may depend at least in part on some common processing resources.

Inhibition

The inhibition function is basically involved to resist performance disruption from task-irrelevant stimuli or responses. According to Miyake et al. (2000, p. 57), inhibition can be defined as, "one's ability to deliberately inhibit dominant, automatic, or prepotent responses when necessary". Friedman and Miyake (2004) extended the scope of the inhibition function to include inhibiting attention to task-irrelevant stimuli. It is important to note that numerous kinds of inhibition have been identified. For example, Nigg (2000) argued that there are eight forms of inhibition including interference control, cognitive inhibition, behavioural inhibition, and automatic inhibition of attention.

Shifting

The shifting function is involved in permitting flexible shifting of attention either within or between tasks to preserve focus on the most task-relevant stimuli. According to Miyake et al. (2000, p. 55), the shifting function involves, "shifting back and forth between multiple tasks, operations, or mental sets".

Information Updating

The updating function is mostly concerned with the transient storage of information. According to Miyake et al. (2000, p. 56), the updating function involves "updating and monitoring of working memory representations". It can appropriately be regarded as a measure of basic attentional or short-term memory capacity. It is encouraging that there is a reasonable overlap between these three functions and those identified by Smith and Jonides (1999). The inhibition function resembles the third function (selective attention and inhibition) identified by Smith and Jonides (1999). The shifting function is similar to Smith and Jonides' first function (switching between tasks). The updating function is similar to Smith and Jonides' fourth function, namely, updating and checking.

Attentional Control Theory of Anxiety Effects on Performance

Eysenck et al.'s (2007) attentional control theory used the tripartite division of the central executive proposed by Miyake et al. (2000) as the basis for some of their main theoretical assumptions. According to the theory, anxiety impairs the efficiency of two rather separate kinds of attentional control. First, there is negative attentional control. This involves the inhibition function and is used to prevent task-irrelevant stimuli (whether internal or external) from distracting attention away from task-relevant stimuli (Friedman & Miyake, 2004). In addition, it is assumed that the inhibition function also includes inhibiting prepotent responses, and that anxiety also impairs the inhibition function under those circumstances.

Second, there is positive attentional control, which is used to ensure that attention is deployed flexibly in response to changing task demands or requirements. In other words, anxiety impairs the efficiency of the inhibition function (negative attentional control) and of the shifting function (positive attentional control).

What about the effects of anxiety on the updating function? According to attentional control theory, this function is not directly affected by anxiety. Friedman et al. (2006) argued that this function (which seems to involve some basic short-term memory capacity) differs in an important way from the inhibition and shifting functions. More specifically, they found that performance on tasks involving the updating function correlated highly with measures of fluid and of crystallised intelligence. In contrast, performance on tasks involving the inhibition or shifting function failed to correlate significantly with either fluid or crystallised intelligence. The implication is that the updating function assesses some basic cognitive capacity related to intelligence rather than to anxiety.

Attentional control theory focuses on the effects on efficiency and on performance of individual differences in anxiety. Individuals differ in both trait anxiety (anxiety as a personality dimension) and state anxiety (anxiety as the current experience of anxiety). The available evidence suggests that both trait anxiety and state anxiety contribute to impaired attentional control. However, their respective contributions remain elusive for three reasons. First, trait anxiety and state anxiety typically correlate moderately highly with each other, which makes it difficult to discriminate between effects due to trait anxiety and those due to state anxiety. Second, the great majority of studies have focused on trait anxiety (or test anxiety) and have produced equivocal findings in which it is unclear whether the group differences reflect trait anxiety, state anxiety, or some combination of both. Third, there are remarkably few studies in which state anxiety has been experimentally manipulated, but this is perhaps the only method of disentangling properly the effects of trait and state anxiety on performance.

Research Findings

Eysenck et al. (2007) provide a review of the evidence relating to attentional control theory. Most of this research provides reasonable support for the theory. We will start by considering research focusing on the crucial distinction between processing efficiency and performance effectiveness, which is as important within attentional control theory as within processing efficiency theory. After that, we will consider recent unpublished research on the inhibition and shifting functions. It is worth pointing out that there is a very large discrepancy in the amount of anxiety research focusing on the inhibition function and on the shifting function. There have been approximately 30 studies on anxiety and the inhibition function, but practically none on anxiety and the shifting function. Accordingly, we will focus mainly on recent research on the shifting function.

One of the major predictions of attentional control theory is that anxiety impairs processing efficiency to a greater extent than performance effectiveness. Much of the evidence discussed by Eysenck et al. (2007) is consistent with that prediction. However, one of the issues that has proved difficult to address adequately is that of assessing processing efficiency with precision. Performance effectiveness can be assessed by conventional behavioural measures of performance, but efficiency also involves some assessment of the use of resources or effort during task processing. Recent research by Santos, Wall, and Eysenck (submitted) used functional magnetic resonance imaging (fMRI) to provide a more direct assessment of processing efficiency than any used hitherto in relation to the shifting function identified within attentional control theory. However, promising findings had been obtained previously, and will be discussed here.

One appropriate way of assessing processing efficiency is based on the *probe technique* (e.g. Johnston, 1972). In essence, use of this technique involves participants performing a main or primary task under two conditions. In one condition, this task is performed on its own. In the second condition, there is also a secondary task that needs to be performed occasionally and at unpredictable times. This secondary task is typically very easy (e.g. responding as fast as possible to an auditory probe). Of importance, participants are instructed in this latter condition to perform the main or primary task as well as possible and only to use spare processing capacity to perform the secondary task. The key assumption is that performance on the secondary or probe task provides an estimate of processing efficiency: individuals who are inefficient will allocate nearly all their processing resources to the primary task, and so will perform slowly on the secondary task.

Eysenck and Payne (in preparation) used the probe technique in two experiments. In the first experiment, the primary task involved letter transformation. Four letters were presented, and participants had to transform all four letters by working through the alphabet the requisite distance before responding. For example, "CHFR + 4" would have "GLJV" as the correct answer. This task becomes progressively harder as participants work through it, and the auditory probe could be presented at any point. There were two main findings. One was that the high-anxious participants responded more slowly to the auditory probe on average than the low-anxious ones. The other main finding was that the adverse effects of anxiety on speed of responding to the probe were greater as the demands of the main task increased.

In their second experiment, Eysenck and Payne (in preparation) used a different main or primary task. This time, participants had to perform four simple mathematical operations before producing the answer. The findings from this experiment replicated those of the first experiment. That is, high-anxious participants responded more slowly than low-anxious ones to the auditory probe, and this was especially the case when the demands of the primary task were great.

Research by other investigators using the probe technique has produced similar findings. For example, Williams, Vickers, and Rodrigues (2002) compared the performance of low-anxious and high-anxious individuals on their main task (involving table tennis). The high-anxious individuals also had significantly slower probe reaction times using auditory probe stimuli than the low-anxious ones, indicating that they had poor processing efficiency. Murray and Janelle (2003) had low-anxious and high-anxious participants perform a simulated driving task as their primary task. The key finding was that high-anxious participants had slower probe reaction times also using auditory probe stimuli than low-anxious ones, and this effect was greatest under competitive conditions.

We turn now to studies concerned with the effects of anxiety on the inhibition function. Published research in this area has predominantly reported that anxious individuals are more susceptible to distraction, thus supporting the notion that anxiety impairs the inhibition function (see Eysenck et al., 2007, for a review). However, there is an important limitation that applies to most of this research. The typical paradigm has involved comparing performance in distraction and no-distraction conditions or in high- and low-distraction conditions. What has usually been found is that the performance of high-anxious individuals is more adversely affected by distractors than is that of low-anxious ones. This is entirely consistent with the notion that anxiety impairs negative attentional control. However, the failure to assess attentional processes means that their role in mediating the behavioural findings has not been established.

In recent research, Derakshan, Ansari, Hansard, Shoker and Eysenck (2009) used the *antisaccade task* as a way of testing the notion that anxiety impairs the efficiency of the inhibition function more directly than has been achieved hitherto. Participants performing the antisaccade task are presented with a peripheral cue to one side of a central fixation point. They are explicitly instructed to avoid looking at the cue but are instead to direct their gaze as rapidly as possible to the other side of the fixation point. The main dependent variable is the latency of the first correct saccade (i.e. an eye movement towards the side opposite to the side on which the cue is presented). As Hutton and Ettinger (2006) argued in their review, it is reasonable to assume that part of what is involved on the antisaccade task is use of the inhibition function to prevent reflexive saccades to the cue. That justifies use of the antisaccade task as a way to assess the inhibition function. Its use is also justified by Miyake et al.'s (2000) finding that the antisaccade task loaded more highly than any other task on the inhibition function. We also used a control condition (the prosaccade task), in which participants were instructed to gaze at the cue when it appeared. In this condition, the inhibition function is not required.

In their first experiment, Derakshan et al. (2009) obtained the predicted significant interaction between anxiety and task (antisaccade task vs. prosaccade task). There was no effect of anxiety on the prosaccade task, which did not involve the inhibition function. However, as predicted, the high-anxious participants took significantly longer than the low-anxious ones to make the first correct saccade on the antisaccade task. While it is accepted that eye movements do not provide a direct assessment of attentional processes, it nevertheless seems reasonable to regard them as less indirect than most behavioural measures (e.g. percentage correct).

In their second experiment, Derakshan et al. (2009) also used the antisaccade and prosaccade tasks. The main difference between this experiment and the first one was that three different cues were used. More specifically, angry, happy, and neutral facial expressions were presented as cues on different trials. The rationale for this was the common finding that the increased susceptibility of high-anxious individuals to distracting stimuli is greater for threat-related stimuli than for non-threat-related ones (see Eysenck et al., 2007, for a review). There was a highly significant three-way interaction on latency of the first correct saccade based on the factors of task (antisaccade vs. prosaccade), valence (angry, happy, or neutral), and group (high-anxious vs. low-anxious). The pattern of this interaction was as predicted by attentional control theory. The adverse effects of anxiety on latency were found on the antisaccade task but not on the prosaccade task, and within the antisaccade task the effects of anxiety were greatest when the cue was threat-related.

The findings obtained by Derakshan et al. (2009) indicated clearly that there were significant adverse effects of anxiety when the inhibition is required but no effects at all when the inhibition function was not required. That means that the costs of inhibition are greater for high-anxious than for low-anxious individuals, although the data have not specifically been analysed in terms of inhibition costs.

We turn now to research on anxiety and the shifting function. Derakshan, Smyth, and Eysenck (in preparation) carried out the most thorough study to date. The optimal method for studying the shifting function is to make use of task-switching paradigms (see Monsell, 2003, for a review). What is of fundamental importance in task-switching paradigms is to have two conditions in which all participants in both conditions perform exactly the same two tasks. The only consequential difference between the two conditions concerns the pattern of trials on the two tasks. In the switching condition, participants alternate rapidly between the two tasks either in a predictable (e.g. task A on odd-numbered trials, task B on even-numbered trials) or unpredictable fashion (e.g. there is a 30% chance of task alternation on each trial). In contrast, in the non-switching condition, there is a solid block of trials all of which involve the same task, followed by another solid block of trials all of which involve the other task. Since the tasks are the same in both conditions, the crucial difference is that the shifting function is needed repeatedly in the switching condition but not in the non-switching condition. Thus, the prediction is that anxiety will impair processing efficiency (and perhaps also performance effectiveness) more in the switching condition than in the non-switching condition.

Derakshan et al. (in preparation) used several conditions. In one pair of conditions, the two tasks were multiplication and division problems. In the other pair of conditions, the two tasks were addition and subtraction problems. The switching condition involved alternation of tasks on every single trial. What happened was that two numbers were presented on each trial. A cue specifying the arithmetical process to be performed was either present or absent.

What did Derakshan et al. (in preparation) find? The most important finding theoretically was that there was a highly significant interaction between anxiety and task switching, and the pattern of the interaction was precisely as predicted. More specifically, high-anxious participants performed much more slowly under task-switching conditions requiring use of the shifting function than under non-switching conditions. In contrast, low-anxious participants performed comparably in the task-switching and non-switching conditions. In addition, the high-anxious group only performed significantly worse than the low-anxious group under task-switching conditions. These findings indicate that anxiety increases shifting costs although no direct measure of such costs was taken.

In the study by Derakshan et al. (in preparation), there was another important finding relating to the comparison between cueing and non-cueing conditions. Theoretically, it was assumed that the presence of a cue specifying the arithmetical process required on that trial would reduce the demands on attentional control compared to the condition in which there was no cue. As a result of that, it was predicted that the adverse effects of anxiety on performance should be greater in the cue-absent condition than in the cue-present condition. As predicted, there was a significant interaction between anxiety and cueing. The slower performance of the high-anxious participants than of the low-anxious participants was much more pronounced in the cue-absent condition than in the cue-present condition.

Santos et al. (submitted) also considered the effects of anxiety on the shifting function. In their study, participants were exposed to three conditions varying in the amount of task switching that was involved. The high-switching condition involved a task change three times in six trials, the low-switching condition involved a task change once in six trials, and the no-switching condition involved solid blocks of one task. There were three tasks altogether, all of which had to be performed on single digits presented on a computer screen. All of the tasks were simple, which explains why there were no effects of anxiety on task performance. However, an important aspect of the study was that fMRI was used to assess patterns of brain activation in all three conditions.

What predictions concerning the fMRI findings follow from attentional control theory? In essence, it was assumed that the increase in brain activation in the high-switching and low-switching conditions compared to the no-switching condition reflected the increase in use of cognitive processing resources when the shifting function was required. As a consequence, inefficient use of the shifting function by anxious individuals compared to non-anxious ones should be associated with a greater increase in brain activation for the former group.

There is another prediction that can be made. Wager, Jonides, and Reading (2004) reviewed studies that have focused on identifying those areas of the brain activated when individuals are engaged on tasks that involve the shifting function. Several different brain areas are involved, but various areas within the prefrontal cortex and associated areas seem to be of particular importance. If anxious individuals exhibit inefficient use of the shifting function, then it can be predicted that switching conditions should produce a greater increase in brain activation within those areas (especially BA9/46 and the anterior cingulated) for high-anxious than for low-anxious individuals.

What did Santos et al. (submitted) find? In essence, both of the major theoretical predictions were supported. First, high-anxious individuals showed a greater increase in brain activation than low-anxious ones when dealing with task switching (low-switching or high-switching). This finding coupled with the lack of effect of anxiety on task performance indicates that anxiety impaired processing efficiency when the shifting function was used. Second, a part of the prefrontal cortex (BA9/46) involved in the shifting function and attentional control showed a greater increase in the high-switch condition than the no-switch condition in high-anxious individuals. In addition, the anterior cingulate showed a greater increase in the low-switch condition than in the no-switch condition in high-anxious individuals. However, there were differential effects of anxiety on various other brain areas, so more research is needed to clarify the precise effects of anxiety on the shifting function.

Conclusions and Future Research

Evidence relating to three of the major assumptions of attentional control theory has been discussed. The focus of much recent research has been to test these assumptions more directly than has been done previously. Thus, for example, the probe technique and fMRI have been applied to the assessment of processing efficiency, and attentional processes under distraction conditions have been assessed by using an eye tracker. It is encouraging that the theoretically predicted findings continue to be obtained under these more stringent conditions. In addition, the novel prediction that anxiety should impair the efficient usage of the shifting function is starting to receive strong empirical research. In ongoing research, the finding that anxiety slows the latency of the first correct saccade on the antisaccade task has been replicated twice more (Derakshan et al., in preparation). Thus, it appears that attentional control theory provides a valuable theoretical framework within which to study the effects of anxiety on performance.

Implications for the Cognitive System Theory

In this section, I briefly speculate on the possible implications of the theoretical and empirical approach taken here for theories of attention and executive function. The starting point is the assumption that no single line of evidence is likely to provide decisive support for any theory within cognitive psychology. Instead, what is needed is converging evidence for any given theory based on different kinds of research (e.g. behavioural; neuroimaging). Consider, for example, Miyake et al.'s (2000) theory (developed by Friedman & Miyake, 2004), according to which there are three major executive functions, namely, the inhibition, shifting, and updating functions. They provided support for their theory via the use of latent-variable analyses based on the data from many executive tasks. However, while these analyses were consistent with the notion of three executive functions, they provided only limited support. First, there were positive inter-correlations among the three functions, so there is some doubt about their discriminability. Second, patterns of inter-correlations are intrinsically limited in terms of what they can tell us about executive functions.

Miyake et al.'s (2000) empirical approach was based upon assessing individual differences in performance on several executive tasks. However, they did not identify the key dimensions of individual differences responsible for differing levels of performance on each function. Real progress would be made if it were possible to find dimensions of individual differences relating in different ways to different functions. Precisely this was done by Friedman et al. (2006). As we have seen, they found that individual differences in intelligence predicted performance on tasks requiring the updating function but not on those requiring the inhibition or shifting function. That is important evidence, because it strengthens the argument that the updating function is separate from the other two functions in its demands on the cognitive system. Note, however, that Nęcka (1999) found that intelligence was significantly related to strength of attentional inhibition.

We have found evidence that individual differences in anxiety predict performance on tasks involving the inhibition or shifting functions but not on those involving the updating function. Such evidence provides additional support for Miyake et al.'s (2000) assumption that the updating function is distinctively different from the other two functions.

In sum, individual-difference approaches offer the prospect of assisting in the task of specifying more clearly the number and nature of executive functions. It is encouraging that such approaches are becoming much more common, as is shown by several other chapters in this volume.

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