Faculty of Health Science
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Using Attentional Control Theory to Account for Anxiety-Related Errors on Musical Performance Tasks

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Declaration

"To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university."

Matthew E Ruggiero
Date: 03/09/2012

Abstract

Attentional Control Theory (ACT) has emerged as a strong explanatory model of anxiety-related performance outcomes. The present research evaluated ACT hypotheses in an applied behavioural context. Comparatively few experimental studies of musician performance anxiety (MPA) have been conducted and no study has yet evaluated ACT hypotheses in a musical performance context. The present research represents the first attempt at manipulating task difficulty to produce valid experimental tasks for musical performance research. It is also the first contribution to evaluate the explanatory power of ACT for musical performance.

Study 1 adopted a qualitative methodology to determine the nature of task difficulty experienced by tertiary pianists (studying a university performance major) who regularly engaged in learning performance pieces by a variety of classical composers as part of their music studies. These musicians identified two types of factors that co-create task difficulty: intra-personal and extra-personal factors. The former included individual performer characteristics such as familiarity with components of the piece, technical ability through practice, personality, physical attributes, musical aptitude, emotional maturity, and motivation. The latter included characteristics of the performance piece such as technical complexity, the interaction between speed and density of notes, stylistic complexity, emotional complexity, and pattern repetition.

The second phase of Study 1 required the same sample of piano players to provide qualitative estimates of face validity for three musical tasks that had been rank ordered according to task difficulty (easy, intermediate, difficult). These musicians suggested changes to the intermediate piece that were consistent with well-established experimental design procedures. Variations to the intermediate piece also had acceptable content validity, as evidenced by strong similarities between actual structural variations and emergent task difficulty themes.

Study 2 used the performance pieces from Study 1 to evaluate eight ACT hypotheses. Specifically, it was predicted that primary task load and distraction would independently produce impairments in shifting and inhibition working memory functions and that these impairments would increase for those with higher trait anxiety. The study was comprised of two linked experiments. Study 2A was a pilot study, in which the researcher: (i) standardised experimental administration, and (ii) developed an objective set of criteria for grading the effectiveness (quality) of musician performances. In Study 2B, the musical tasks, grading criteria, and experimental modifications were used to conduct a carefully controlled, full-scale evaluation of ACT hypotheses. Participants sight read each piece (easy, intermediate, difficult) three times, once each under no distraction, neutral distraction, or social threat distraction conditions. The nine conditions were randomly presented to distribute order effects. During the neutral and social-threat conditions, participants were required to complete a secondary target-response task concurrently to sight reading the relevant piece. Piece completion time (primary task) and reaction time (secondary task) provided two measures of processing efficiency. Three indices of performance effectiveness were calculated. These were highly correlated and therefore combined into a single composite measure of effectiveness. Working memory capacity limits were estimated by tallying the number of location errors on the secondary task.

Mixed effects linear regression was used to estimate the main effects and interactions of trait anxiety, distraction, and musical task difficulty on efficiency and effectiveness outcomes. Of the eight hypotheses, two were supported and three were partially supported. Increases in musical task difficulty produced slower completion times and poorer quality musical performances. Performers with moderate to high trait anxiety demonstrated a narrowing of attentional flexibility when exposed to distraction. This created impairments in the shifting function that favoured the musical pieces over the secondary task. Prioritisation of the musical piece masked the observation of inhibition effects. The reduced flexibility demonstrated by moderate to high trait anxiety performers implicated a shift to stimulus-driven attentional allocation. These findings provide preliminary support for an ACT account of anxiety-related performance outcomes for musical tasks.

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Despite being a little unorthodox, I would like to finish by thanking myself. I have experienced some wonderful highs and some inexplicable lows, yet somehow I continued putting one foot in front of the other – an intimidating task that every person who has completed a doctorate can empathise with. Throughout this project I have managed to retain my passion, my faith, my enjoyment of music, and even developed a taste for research! I am proud of myself for evolving, adapting, growing, and making it “there and back again”.

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Acronyms and Abbreviations

ABRSM – Associated Board of the Royal Schools of Music

ACT – Attentional Control Theory

AMEB – Australian Music Examinations Board

ANOVA – Analysis of Variance

A-State – State Anxiety

A-Trait – Trait Anxiety

CSAI-2 – Competitive State Anxiety Inventory – Second Edition

DSM-IV-TR – Diagnostic and Statistical Manual of Mental Disorders: Fourth Edition: Text Revision

DSM-V – Diagnostic and Statistical Manual of Mental Disorders: Fifth Edition

GLMM – Generalised Linear Mixed Modelling

LSD – Least Significant Difference

MIDI – Musical Instrument Digital Interface

MPA – Musician Performance Anxiety

OCD – Obsessive Compulsive Disorder

PCA - Principal Components Analysis

RT – Reaction Time

SAD – Social Anxiety Disorder

STAI – State-Trait Anxiety Inventory

Chapter 1. Overview

Musician performance anxiety (MPA) is a widely experienced, debilitating condition (Fishbein, Middlestadt, Attati, Strauss, & Ellis, 1988). Despite this, there is little agreement regarding the causes of anxiety-related performance impairments (Kenny, 2011). Research in MPA literature has predominantly focussed on observable/experiential effects of anxiety on performance (and related correlates) rather than the processes underlying this relationship (Kenny, 2011). This has resulted in a fragmented literature. Not surprisingly, conflicting approaches to clinical assessment and treatment have emerged (McGinnis & Milling, 2005).

Through well developed and controlled studies, Attentional Control Theory (ACT) has been used to accurately model the relationship between anxiety and cognitive performance (Eysenck, Derakshan, Santos, & Calvo, 2007). Perceptuomotor researchers have started to develop experimental procedures to evaluate the usefulness of ACT for explaining impairment in highly applied behavioural contexts (e.g., Causer, Holmes, Smith, & Williams, 2011; Smith Bellamy, Collins, & Newell, 2001; Wilson, 2008; Wilson, Smith, & Holmes, 2007; Wilson, Vine, & Wood, 2009; Wilson, Wood, & Vine, 2009). No research has yet tested ACT predictions in the musical performance arena. In fact, no available model of MPA incorporates working memory research to predict performance outcomes.

The series of studies reported in the present doctoral dissertation utilised a novel research design to clarify the relationship between anxiety, attentional control, and performance quality in musical settings. Additionally, this research process was developed to supplement the dearth of well-designed perceptuomotor experiments evaluating ACT hypotheses. The intersection of cognitive and motor processes in musical performance is not unique to this domain. Many highly competitive performance fields impose simultaneous working memory and motor performance demands (Eysenck et al., 2007). The present thesis experimentally evaluates the extent to which ACT predicts variation in musician cognitive processes and subsequent musical performance quality. This line of inquiry can provide valuable insight into the mechanisms underlying anxiety-related perceptuomotor performance impairment. Such insight can be used to guide the performance optimisation strategies employed by trainers, performers, parents, coaches, therapists, academics, and many other stakeholders with a vested interest in performance outcomes.

Structure of the Dissertation

Chapter 2 begins by introducing the reader to the nature of anxiety and the ways in which anxiety can manifest in the performance arena. The difference between anxious states and anxious traits is explained. This is a particularly critical delineation and is drawn upon throughout the dissertation. The second half of Chapter 2 then evaluates the most important theoretical contributions in performance anxiety literature. Here, specific emphasis is placed on the capacity of each theory to predict and explain the breadth of findings regarding anxiety-related performance outcomes. This chapter ends with a discussion of Attentional Control Theory. It is argued that ACT provides the most testable, theoretically insightful set of hypotheses for predicting performance outcomes.

Chapter 3 focusses solely on the musical performance domain. The chapter begins by drawing together information to define musician performance anxiety in a manner that optimises cross-domain theoretical comparison. Three MPA-specific models of performance anxiety are presented, each of which predicts a set of variable relationships that transform internal anxiety into external performance outcomes. The limited cognitive research in MPA literature seems to support a non-domain-specific attentional model of performance anxiety; one that does not arbitrarily propose that musicians are somehow distinct from other perceptuomotor performers. This chapter ends by cataloguing the design and measurement limitations that have plagued musical performance experimentation.

Chapter 4 outlines the rationale for decisions made at each phase of the research process. Experiment conditions and outcomes are operationally defined. The rationale for each study is followed by a summary of relevant aims and predictions.

Two studies were conducted as part of this doctoral dissertation. Study 1 was a qualitative investigation of musical task difficulty. The methodology, results, and discussion for this are presented in Chapter 5. Since musical tasks are unquantifiable, the opinions and perceptions of a sample of experienced musical task performers (tertiary pianists studying a university performance major) were collated and thematically analysed to define musical task difficulty and then to maximise the face and content validity of three experimental musical pieces. These pieces formed three levels of the primary task in the experimental design implemented in Study 2, which systematically evaluated eight ACT predictions.

Chapter 6 reports a two-part experimental study. The chapter begins by detailing the dual task methodology that was used to test ACT hypotheses in the present research. Next, the results and discussion of a pilot of the experiment (Study 2A) and the full-scale experiment (Study 2B) are presented. Study 2A outlines the process through which administration of the experiment was standardised. It also reports the procedure used to develop a set of musical performance grading criteria. Study 2B outlines the methodology and statistical analyses through which ACT hypotheses were tested. Results for each of the hypothesis tests are presented and evaluated in light of previous findings. The chapter ends by interpreting the extent to which each of the eight hypotheses was supported.

Chapter 7 is a general discussion of the research, providing an integration of the findings and contributions of both studies. It begins by discussing each of the unique contributions made by the present research. An examination of the strengths and weaknesses of the research is then provided. Finally, practical implications and future directions of inquiry are discussed. The chapter ends with a summary of the contributions that the present research has made to both MPA and ACT literature.

Chapter 2. Theories of Performance Anxiety

On the right side-panel of the verbose and somewhat tautological box of Cheerios, it is written:

> If you are not satisfied with the quality and/or performance of the Cheerios in this box, send name, address, and reason for dissatisfaction—along with entire boxtop and price paid—to: General Mills, Inc., Box 200-A, Minneapolis, Minn., 55460. Your purchase price will be returned.

It isn't enough that there is a defensive tone to those words, a slant of doubt, an unappetizing broach of the subject of money, but they leave the reader puzzling over exactly what might be meant by the "performance" of the Cheerios.

Could the Cheerios be in bad voice? Might not they handle well on curves? Do they ejaculate too quickly? Has age affected their timing or are they merely in a mid-season slump? Afflicted with nervous exhaustion or broken hearts, are the Cheerios smiling bravely, insisting that the show must go on?

(Excerpt taken from Tim Robbin's *Fierce invalids home from hot climates*)

The Nature of Anxiety

Anxiety is a negative affective state in which a future-directed sense of unpredictability impacts upon one's cognitions, physiology, and behaviour (Barlow, 2000). These effects primarily manifest as increased autonomic arousal, negative and distressing cognitions, and avoidant/escapist behaviour (Barlow, 2004). Whilst anxiety can be a normal experience that may, to an extent, boost productivity and performance quality (as defined by appropriate behavioural indices), a significant proportion of people experience excessive anxiety, which detracts from the quality of performance (Eysenck, 1992; Eysenck et al., 2007; McGinnis & Milling, 2005). Such negative experiences are reported by many performers across domains as broad as music, sport, sexuality, public speaking, and virtually any other perceived performance setting (Davis & Sime, 2005; Hopko, Hunt, & Armento, 2005; McCabe, 2005).

Anxiety is typically understood as a sensation or awareness that danger is imminent in one's environment (Gross & Hen, 2004). Biologically, this activates an autonomic nervous system response, mobilising the body via: increased heart rate and blood pressure to maximise circulation of oxygen and glucose to muscles and limbs; pupil dilation to enlarge the peripheral visual field (at the cost of acuity); inhibition of insulin to increase blood sugar levels; increased fluid retention and fluid storage in kidneys; and increased adrenaline to facilitate changes to heart rate and blood pressure (Ganong, 2001; Kreibig, 2010). These processes are regulated by the hypothalamic-pituitary-adrenocortical axis, which secretes cortisol to assist in converting norepinephrine to epinephrine, resulting in the above system changes (Porges, 2001). The increased heart rate circulation, pupil dilation, and heightened awareness that accompany a state of anxious arousal allows the anxious organism to both detect and behaviourally respond to environmental threats as rapidly and efficiently as is biologically possible (Porges, 2001). Historically, this threat-response system has ensured survival by means of defence against, or evasion of, predators (Porges, 2001). In modern times, our anxiety response system has continued to inform us of potential predators and threats to self, however these threats can also exist internally since we have the capacity to form internal representations of threatening objects and outcomes (Barlow, 2004).

Performance Anxiety

Performance anxiety, also referred to as stage fright or competitive state anxiety, is an experience of anxiety that leads to a perceived detriment in one's performance, often despite sufficient skill, preparation, and practice (Kenny, 2006; Martens, Vealey, & Burton, 1990; Salmon, 1990). Whilst normal levels of anxiety can result in symptoms that are typically perceived as adverse (like shaking or sweating), these do not always significantly impact on performance outcomes (Edwards & Hardy, 1996; Kerr, 1999; MacPherson, Stewart, & McWilliams, 2001). As a normal physiological state, anxiety heightens awareness and sensitivity, which can be beneficial to a performance since it increases responsiveness and perceptual acuity (Baddeley, 1972; Staal, 2004).

Differential Diagnoses

Psychiatric diagnosis of clinical anxiety (i.e., higher than normal) cannot be made unless the anxiety is chronic and excessive in proportion to the perceived threat, resulting in a significant impediment to the functioning of the individual and/or those connected to the individual (American Psychiatric Association, 2000). There are a number of manifestations that this can take, typically distinguished by the object or provocateur of the anxious response. These manifestations are often understood by applying diagnostic categories of 'best-fit' such as Generalised Anxiety Disorder, Obsessive-Compulsive Disorder (OCD), or Social Anxiety Disorder (SAD).

Only two of the diagnostic categories are specifically performance related – OCD and SAD. Of these, the performance component of an OCD presentation is typically the wrong way around to be considered a performance anxiety domain. That is, the anxious individual characteristically uses a particular behavioural compulsion to *alleviate* anxious arousal. This outcome is a negative reinforcer that increases the frequency of the compulsive behaviour (Cavedini, Gorini, & Bellodi, 2006). Conversely, a socially anxious individual fears the outcomes that may *result* from a particular public behaviour (e.g., social disgrace). Therefore, this diagnostic category most closely parallels the popular conception of 'performance anxiety'. Performance anxiety can, when sufficiently severe, meet the criteria for Social Anxiety Disorder. This does not mean that SAD is a useful diagnostic category for this phenomenon. Hays (2009, p. 105) expresses this point effectively in the following observation:

> It is one thing to avoid cocktail parties (or funerals) because you feel uncomfortable in the presence of others. It is quite another, however, to diagnose a tenor as having a social phobia as a result of the following: He functions quite well in most social situations but feels at least momentarily daunted anticipating the thousand pairs of eyes and ears watching and listening as he opens his mouth to sing "Comfort Ye, My People," the initial vocal moment in Handel's Messiah.

This quote demonstrates that for real-world performers, social anxiety is often an inadequate lens for conceptualising performance anxiety. The key difference between these two constructs is that performance anxiety is experienced before or during a performance that is held as the centre of attention by an observing audience. An elite athlete who “chokes” under pressure does so to the disappointment of paying viewers, punters placing bets, team supporters, advertising contractors, team-mates, and the team’s corporate executive. In this example, the term “audience” refers to all of these vested parties, not just those physically watching the game. To this end the audience has a vested interest in the quality of the performance and a performer’s awareness of this is occupationally appropriate. Although an attentive audience can also be involved in social anxiety, it is not a diagnostic necessity (this criterion is not specified in the DSM-IV-TR diagnostic system). It would be remiss to ignore performance anxiety that does not meet currently recognised diagnostic criteria since many performers across a variety of domains suffer debilitating and performance-detracting anxiety nonetheless. Furthermore, it is in the interests of all vested parties indicated above to minimise the effect such anxiety can have on future performances.

Some considerations are being made for the inclusion of a ‘predominantly performance’ SAD specifier in the DSM-V (Bögels et al., 2010). This is consistent with cross-domain evidence for the qualitative separation of performance anxiety from other SAD subtypes (Blöte, Kint, Miers, & Westenberg, 2009). Unlike other forms of SAD, there is no relationship between performance anxiety and personality factors or behavioural inhibition (Hofmann, Heinrichs, & Moscovitch, 2004; Hook

& Valentiner, 2002). Furthermore, beta-blockers have been found to reduce the symptoms of performance anxiety, despite having no effect on the symptoms of generalised SAD (Hofmann et al., 2004; Hook & Valentiner, 2002). For these reasons, inclusion of performance anxiety as a SAD specifier seems questionable.

Stress, Workload, and Task Load

Stress is one of the most diversely defined constructs in psychological research (Staal, 2004). The evolution of stress research is beyond the scope of this thesis. Nevertheless, it is important to be aware of the currently recognised transactional model of stress, which distinguishes between stress-related performance effects and workload-related performance effects. Within this model, stress is determined by the interaction between internal and external factors, including: an individual’s perception of task demands, their concurrent perception of available coping resources, and the context-specific importance of coping (Stokes & Kite, 2001). Historically, stress researchers supposed that psychological stressors exert equivalent effects across individuals and can therefore be experimentally manipulated toward a generalisable prediction of psychological cost and performance detriment (Staal, 2004). Although increased task demands may exact a psychological cost (e.g., anxiety, attentional bias, reductions in working memory capacity) and result in a performance deficit, there is evidence that suggests this is not always the case (Hockey, 1970; Matthews, Sparkes, & Bygraves, 1996).

Since task load does not necessarily predict psychological cost, it is critical to further distinguish between workload and task load. Task load is generally viewed as the entirely exogenous load that a task imposes on an individual (Hilburn & Jorna, 2001; Parasuraman & Hancock, 2001). Researchers have manipulated task load experimentally by increasing the demand characteristics of the task itself (Keppel & Wickens, 2004). Hilburn and Jorna’s (2001) model of workload suggests that workload is determined by the interaction between task load and intra-performer factors (such as skill, strategy, experience, and so on). Essentially, workload encompasses an individual’s perception of the demands of a task. This definition is in line with current transactional models of stress, which hold that an experiment cannot accurately model the uniform effects of a stressor on performance of a given task, since a range of intra-performer factors influence the workload and consequent stress of the task for every individual (Grange, 2005; Jones & Hardy, 1995; Stokes & Kite, 2001). An understanding of these definitional differences is assumed throughout the remainder of the present discussion on performance anxiety. This becomes especially important in Chapter 3 of this dissertation, since contamination of workload and task load factors is largely overlooked in experimental musician performance anxiety research.

State and Trait Components of Performance Anxiety

Anxiety may be conceptualised as a multiple outcome latent construct, comprising both trait- and state-related facets (Martens et al. 1990). Trait anxiety (A-Trait) is innate and denotes a biological proneness/sensitivity to experiencing state anxiety (Spielberger, 1972). Alternatively, state anxiety (A-State) is that which is derived from the specific environment that the anxiety is experienced within (Spielberger, 1972). A-State is therefore circumstantial and variable, whilst A-Trait is a relatively stable personality trait (Hainaut & Bolmont, 2006). Spielberger's (1966) Trait-State Anxiety model formally differentiates between these concepts, proposing that A-Trait is a positive, linear predictor of A-State (Figure 1). Within this framework, Spielberger (1966) likened trait and state anxiety to potential and kinetic energy respectively, indicating that specific 'kinetic' experiences of anxiety are determined largely by one's cognitive appraisal of external stimuli, which itself is affected by an underlying tendency or 'potential' to become anxious.

Although situation-specific threats can produce elevated arousal of the autonomic nervous system in all people, high A-Trait individuals have been consistently demonstrated to have a chronically hyper-aroused autonomic nervous system as indicated by a variety of physiological measures (Barlow, 2004). Moreover, the resting electroencephalogram of high A-Trait individuals contains a higher proportion of beta waves, typically coupled with stronger anterior right hemisphere electroencephalogram activation and asymmetrical parieto-temporal cortical activity (Aftanas & Pavlov, 2005; Davidson & Tomarken, 1989). Beta waves are usually distributed symmetrically in the brain and associated with frontal and prefrontal cortical regions. An increased ratio of beta to alpha waves signifies an increase in alertness (Thompson, 1967; Valle & DeGood, 1977). High A-Trait individuals have a higher baseline level of cortical arousal, and habitually demonstrate an asymmetrical pattern of cortical activation when faced with anxiety-provoking situations (Aftanas, Pavlov, Reva, & Varlamov, 2003; Wilt, Oehlberg, & Revelle, 2011). Such individuals are 'over-prepared' for threatening situations. They have learnt that potential threats must be anticipated and prepared for.

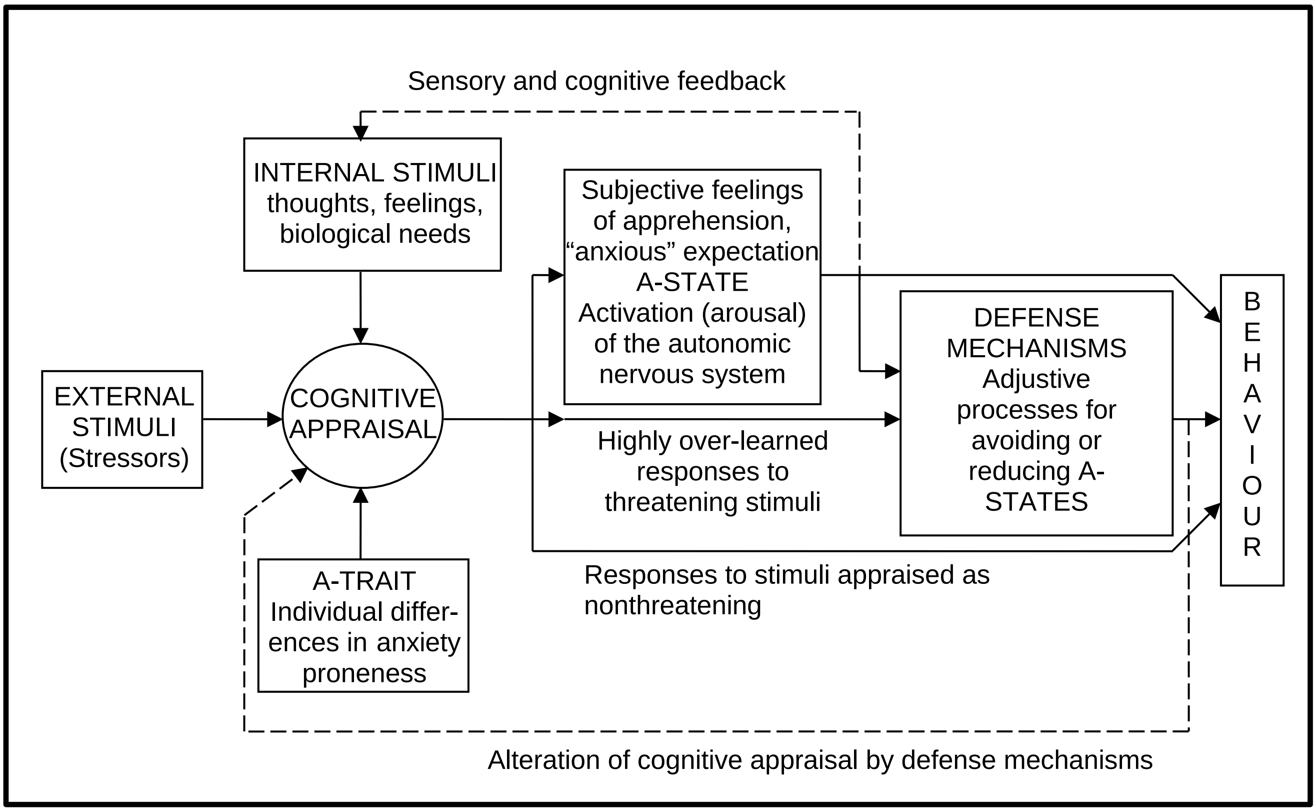

Figure 1. Spielberger's (1966) model of State-Trait Anxiety.

In classical anxiety theory, A-Trait is regarded as a predictor of A-State. Recent findings suggest that A-Trait may be represented more accurately as a positive linear moderator on the relationship between A-State and behaviour (Spielberger, Ritterband, Sydeman, Reheiser, & Unger, 1995; Wilt et al., 2011). Hardy, Jones, and Gould (1996) observed that in performance settings, having low A-Trait with high A-State largely facilitated peak performance in their sample of professional athletes, whereas high A-Trait with high A-State was stifling. Similarly, Hainaut and Bolmont (2006) tested the effect of moderate A-State on response time in low and normal A-Trait participants. A-State was assessed using the A-State subscale of the State Trait Anxiety Inventory (STAI), and heart rate was monitored throughout each task to ensure a moderate level of arousal was maintained. In their cohort, A-Trait moderated the effect of moderate A-State on participant reaction times in visual and auditory performance tasks. A possible explanation of this observation is that enduring personality constructs such as A-Trait modulate the allocation of attentional resources to environmental factors during such performance tasks, and can therefore explain performance deficits. That is, performance problems can be predicted via the interaction between A-State and A-Trait.

To assess the extent to which A-Trait can predict behavioural outcomes in performance settings, Ruggiero (2006) administered a revision of Osborne and Kenny’s (2005) Musician Performance Anxiety Inventory for Adolescents (MPAI-A), together with a number of personality measures to 81 regularly performing musicians. Hierarchical regression analysis revealed that A-Trait was the only significant predictor of self-reported performance difficulties (p = .003) once gender was included as a control variable. Moreover, this study avoided the effects of attenuating influences that have plagued similar studies by including literature-driven covariates and predictors in the analysis. Taken together, Hainaut and Bolmont (2006) and Ruggiero provide strong evidence that A-Trait moderates the relationship between A-State and behavioural outcomes, rather than simply predicting A-State as Spielberger (1966) originally supposed.

Another important element in Spielberger’s (1966) model is the assumption that A-State is transient, whereas A-Trait remains relatively constant across time. Whilst the conceptualisation of A-State as a transitory state is still widely accepted, some contention currently remains over whether A-Trait is a stable personality trait as Spielberger originally supposed. Lau, Eley, and Stevenson (2006) attempted to measure the unique influences that genetic vulnerability and environmental stress contribute to developing A-State and A-Trait. The researchers administered Spielberger’s (1983) State-Trait Anxiety Inventory for Children to 529 twin pairs, and grouped participants on the basis of zygosity. Bivariate genetic analyses were conducted using structural equation modelling and simple comparisons. Structural equation modelling is an intuitively appealing analysis for genetic modelling since a model of best fit for the observed data can be equated using fewer analyses and providing higher accuracy (i.e., error variance estimated and removed) than many other correlational approaches (Tomarken & Waller, 2005; Ullman, 2010). The model of best fit in this study predicted A-State on the basis of non-shared environmental influences (64-84% variance predicted), as should be expected within a Spielbergerian framework. Genetic vulnerability predicted 31% of the variability in A-Trait and non-shared environment still accounted for a greater portion (54%). This is not entirely in line with Spielberger's (1966) model, since Spielberger suggested that environmental influences are largely inconsequential in determining A-Trait. Consideration of Lau et al.'s findings in conjunction with the age range of their sample (8-16) seems to indicate that non-shared experiences during critical neurodevelopmental periods may shape one's genetic vulnerability to anxiety. Moreover, this process may not be 'complete' until myelination of neural regions implicated in the A-Trait/A-State relationship is complete. This is a critical consideration for studies evaluating A-Trait in child and adolescent samples.

Distinguishing independent contributions of A-State and A-Trait to performance anxiety outcomes is critically important. A-Trait is particularly important, since it appears to act as a positive linear moderator on the relationship between A-State and performance (Hardy, Jones, & Gould, 1996; Spielberger et al., 1995; Wilken, Smith, Tola, & Mann, 2000). It is therefore necessary to conceptualise anxiety as a multifaceted construct when researching its effect on performance. This can be achieved in experimental research by using fixed repeated measures A-State conditions that qualitatively differ (e.g., anxiety-provoking versus neutral conditions).

The Performance Anxiety Puzzle

Researchers, therapists, and performers have grappled with the same central question in their pursuit to understand and effectively deal with performance anxiety: what specific mechanism or set of mechanisms directly impacts on observed performance? A variety of performance anxiety theories have sought to answer this question in a way that captures the breadth of real-world performer experiences. For structural clarity, the major contributions discussed in this chapter are evaluated systematically, based on historic significance and explanatory value. Arousal theory is presented first, followed by the multi-dimensional theory of anxiety, Hardy's (1990) cusp catastrophe theory, Hanin's (1980) individual zones of optimal functioning model, processing efficiency theory (Eysenck & Calvo, 1992), and finally Attentional Control Theory (Eysenck et al., 2007). It is argued that Attentional Control Theory is the best explanatory model of performance anxiety since it explains the cognitive mechanisms underlying observed performance outcomes in a comprehensive and testable fashion.

Arousal Theory

Arousal theory developed out of animal studies and behaviourist research in the early 1900s. The inverted-U hypothesis is the most influential theory within this tradition (Landers & Boutcher, 1986) and is therefore accorded the most detailed analysis in this section. Reversal theory is argued to provide an improvement on early arousal theory assumptions by accounting for both positive and negative perceptual experiences of extremes in autonomic arousal.

The Inverted-U Hypothesis

In 1908, Yerkes and Dodson developed a theory concerning the relationship between arousal and performance that has been influential in the development of many current theories of anxiety – the inverted-U hypothesis. Their study on habit strength formation in mice under different punishment conditions led them to suggest that moderate levels of arousal in the mice resulted in much better performance than either a very low or very high level of arousal. Groups of mice performed 10 trials of a brightness discrimination task every day with the groups receiving electric shocks of varying magnitudes to trigger arousal of the stress response system. The criterion for learning in Yerkes and Dodson’s experiments required that no errors be committed for a period of three consecutive days (30 trials). The task was tested at three levels of difficulty, each defined by the difference in brightness between forced choices. In the easy task a large difference in brightness was presented, in the difficult task a very small difference in brightness was presented, and in the medium task a brightness contrast halfway between the other two conditions was presented. Yerkes and Dodson observed that task difficulty and shock magnitude covaried inversely, such that for the most difficult tasks acquisition occurred fastest in the low shock groups and vice versa. Interestingly, arousal itself was not tested by the researchers; rather, it was assumed that electric shocks activated a stress response in the mice. More recent studies indicate that mild to moderate electric shocks can be habituated to by some species under laboratory conditions (Hancock & Ganey, 2002), making it difficult to accurately draw conclusions about the arousal-performance relationship based on this study alone. The original Inverted-U Hypothesis is depicted in Figure 2.

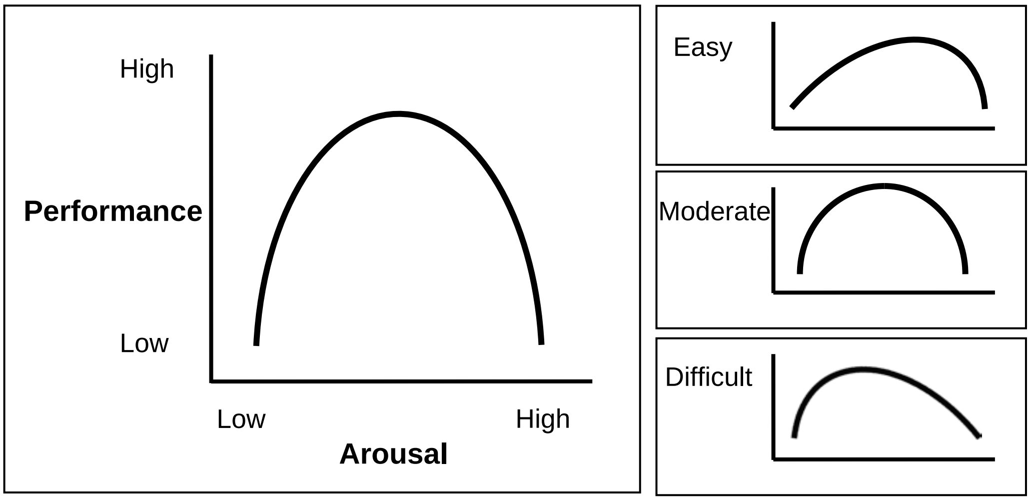

Figure 2. Yerkes & Dodson's (1908) original inverted-U hypothesis. Separate graphs illustrate the predicted relationship between arousal and performance on easy, intermediate, and difficult tasks.

After publication, Yerkes and Dodson’s (1908) findings were criticised openly because many of their rodent groups contained only 2-4 subjects. Moreover, the experiments lacked design precision in crucial ways, such as ensuring uniformity of conditions across tests, which severely damaged internal validity. In response, Cole (1911) and Dodson (1915) repeated these experiments with chickens and kittens respectively. Neither study adequately improved the methodological imprecisions of the original experiments (Brown, 1965). Thus, the theory was largely neglected by the scientific community for 40 years. During this intervening period, researchers reported inverted-U observations in separate theoretical domains, including: activation theory derived from early electroencephalographic research (Fuster, 1958; Lindsley, 1951, 1957; Lorente de No, 1939), behavioural energetics (Cannon, 1915; Duffy 1951, 1957), and drive (motivation) theory (Falk & Bindra, 1954; Hebb, 1955; Hull, 1943; Spence, 1958). Although an exhaustive review of these is outside the scope of the present thesis, awareness of this period is important, since it sparked a revival of interest in Yerkes and Dodson's original research that has persisted in performance anxiety theory and intervention right up to the present. Malmo's (1959) review provides an integration of some of the key optimal arousal research up to that point.

Broadhurst's (1959) study of rat performance in tasks across three difficulty levels and four motivation levels (3 x 4 factorial design) was ground breaking because his re-creation of the original Yerkes-Dodson findings contained none of the previously identified design flaws. Broadhurst is attributed by some as primarily responsible for the broad popularisation of the inverted-U hypothesis and its elevation to law status amongst many researchers and performers (Staal, 2004). His conclusions allowed that performance deficits could be represented graphically, explained simply, and therefore predicted and minimised in human tasks. The notion that a unitary construct might explain the complete range of human performance probabilities across any kind of task proved attractive. Duffy (1962), Easterbrook (1959), Fiske and Maddi (1961), Leavitt (1979), Oxendine (1970), and Cratty (1973) published seminal contributions on diverse human applications of arousal theory, each making two core assumptions: that arousal (measured physiologically) is central to human motivation and action; and that arousal (or factors directly influenced by arousal) affects task performance according to an inverted-U, with moderate arousal tending to be optimal across most tasks.

Putting aside the enduring question of ecological validity when generalising rodent performance within a laboratory setting to human performance in real-world tasks, there were some critical and overlooked flaws in Broadhurst's (1959) methodology and analysis (omnibus ANOVA) that severely detract from the validity of his conclusions and those of subsequent researchers. Brown (1965) observed that few optimal arousal studies have conducted a data check at each level of task difficulty, to ensure an 'optimal arousal point' exists that is in line with Yerkes and Dodson's (1908) proposition (i.e., optimal points exist such that: difficult < intermediate < easy). Broadhurst's research, for example, was hallmarked as a fresh proof of the Inverted-U hypothesis despite the fact that only the 'difficult' condition produced a statistically significant difference in acquisition speed across arousal conditions. That is, the easy and moderate conditions showed no difference between two or more activation points, meaning no 'optimal arousal point' could be produced. A significant *F* ratio cannot be used to propose incremental effects across all levels of an independent variable, since significance merely indicates that *at least one* level of the independent variable interacts significantly with the dependent variable (Rosnow & Rosenthal, 2005). When contrasting performance anxiety effects across multiple task difficulty levels, a researcher therefore needs to ensure that each difficulty level contains an ‘optimal point’ *before* analysing the impact of task difficulty on performance. Without this, a significant ANOVA can at best be understood as an illusory artefact, and cannot be used to suppose that the data recreates the inverted-U relationship. If the hypothesised relationship only exists in difficult tasks, it is misleading to report the omnibus ANOVA and extrapolate the relationship to apply across all tasks.

As the inverted-U relationship became an increasingly popular focus of experimentation, researchers began testing its applicability to the human performance experience. Oxendine (1970, 1984) notably proposed a framework for predicting sport performance as a function of arousal and task difficulty. He listed sports that required each of five levels of arousal (ranging from slight arousal to extreme excitation) for optimal performance. Although appealing in its simplicity, Oxendine’s (1984) model was criticised for its reductionistic assumptions regarding task load in sports performance (Neiss, 1988). Furthermore, his division of sports tasks was entirely based on the complexity of body movements involved, linking greater complexity with lower optimum arousal requirements. This largely ignores the variations in workload attributable to cognitive processes and intra-performer factors.

Not all performance researchers have commended the usefulness of the inverted-U hypothesis. Broadbent (1963) reviewed a number of experiments that aimed to determine the impact of environmental stressors on human nervous system arousal and consequent performance and behaviour. Noise, heat, and lack of sleep are stressors with directly demonstrable effects on autonomic arousal (Hockey, 1970; Johnson, Slye, & Dement, 1965; Provins, Glencross, & Cooper, 1973). The most common experimental task used to test these effects in the studies Broadbent reviewed was the serial reaction test. This presents a random series of single activations in five separate light bulbs, requiring a participant to touch a stylus to the contact point connected to each light that is activated. This continues for 30 minutes, during which participants tended to perform with consistent speed and high accuracy under normal conditions (Broadbent, 1953; Pepler, 1959; Wilkinson, 1959). Unique performance effects were shown to accompany increases in each of these stressors. Specifically, participants tended to make more errors as heat and noise each increased, with no reduction in performance speed, and perform lower when sleep deprived, with no reduction in accuracy (Broadbent, 1953, 1954; Pepler, 1959; Wilkinson, 1959). For heat, this effect was observed throughout the performance, whilst for noise and lack of sleep, these effects were only observed towards the end of the 30 minute performance period. These results necessitate that, at the very least, arousal cannot be expected to enact the same effect on performance across all scenarios.

There are three other possible explanations for these results, all of which allow for the existence of an inverted-U relationship, albeit in a modified form. The first is that certain *types* of arousal may impact *some* tasks according to the expected inverted-U, but only when arousal affects body systems directly related to the task. It stands to reason that fewer mistakes would be predicted in a noise condition than a heat condition for a visuomotor task, since heat directly impacts the physiology of the relevant sensory organ (eye) and the appendage undergoing movement (via sweating and accelerated fatigue) whereas noise affects neither. The accuracy reduction seen towards the end of the task in noise conditions may also have nothing to do with noise, but rather be an artefact of the duration of the task. From this perspective, an inverted-U relationship might still exist. The performance task and the arousal manipulation need to be adequately matched in order to increase the probability that such a result will be experimentally captured.

A second explanation is that the noise and heat conditions affected information processing but not the speed of the perceptuomotor system (i.e., time taken to send the processed response to the acting body organ), whilst sleep deprivation had the opposite effect. Hick’s Law is a very accurate function of processing speed (typically $r > .95$) such that: Reaction Time = Movement Time + $\log_2(n)$ / Processing Speed, where n is the number of binary digits (BITS) of information to be processed (Fitts, 1954; Hick, 1952). A Fitts Task is any repeated measures experimental manipulation that assesses this relationship by quantifying average movement time and processing speed (BITS/second). In Fitts Task literature, reaction time (y-axis) is then graphed as a function of processing speed (BITS numerically represented on x-axis). If the slope of the graph changes after manipulation, the task is said to have impacted the speed of processing, whereas a y-intercept shift reflects a change in the overall speed of the perceptuomotor system. In the studies discussed above, the discrete differences between heat, noise, and sleep deprivation conditions may simply indicate that *different systems* were fatigued in the high arousal conditions, resulting in *different* performance detriments. As with the previous explanation, this does not preclude the existence of an inverted-U relationship between arousal and performance, but does necessitate that arousal be viewed as a multi-dimensional construct. Early critics and proponents of the inverted-U made the same measurement error, adopting conditions based on the assumption that observed physiological changes were triggered by a unitary arousal construct.

Finally, the discrete performance differences between the heat, noise, and sleep deprivation conditions might be indicative that a third, untested variable moderates the relationship between arousal and performance. Grillon, Duncko, Covington, Kopperman, and Kling (2007) proposed that the relationship between anxiety, arousal, and performance is such that anxiety is potentiated by stress and leads to activation of the autonomic nervous system and consequent physiological arousal. This stress hypothesis appears supported by historic arousal research. For example, Martens and Landers (1970) conducted an experiment in which 90 junior high school males were required to track a ring along an electrical wire that it encircled, without allowing it to make contact. There were 30 males in high, moderate, and low stress conditions respectively. Performance was measured by recording the number of times the ring made contact with the wire (thereby completing an electrical circuit), and level of arousal was measured by heart rate (measured five times throughout the procedure) and palmar sweat print (obtained from the third finger on the left hand). Martens and Landers found that arousal and performance quality formed a statistically significant inverted-U shape, which was moderated by stress level. The depth of the inverted-U changed significantly across stress conditions, suggesting that stress may potentiate anxiety and consequent arousal. Grillon et al.’s appraisal of these results is that when an individual is placed in a performance situation in which uncertainty and apprehension are triggered, the autonomic nervous system is activated, and this level of activation directly impacts the quality of performance. They propose that stress moderates the height of the U-shape graph.

Transactional models of stress (discussed previously) suppose that independently manipulating heat, noise, and sleep deprivation would qualitatively change the workload (and therefore the stress) imposed by an experimental task (Staal, 2004). Serial reaction test results cannot be compared after these manipulations are applied. Comparisons between studies that have tested these disparate manipulation effects therefore lack validity. This does not disallow an inverted-U relationship between arousal and performance. Nonetheless, a two variable relationship is too simplistic to adequately account for real-world environmental variation.

Reversal Theory

There is no shortage of researchers who have criticised the inverted-U hypothesis on the grounds of methodological flaws, post-hoc trend generation, and acceptance of findings that were likely artefactual (Baddeley, 1972; Martens, 1974; Naatanen, 1973; Welford, 1976). One further flaw is that the model cannot account for possible pleasant experiences at either extreme of the arousal continuum. Smith and Apter (1975) developed a theory of reversals between motivational states after noticing that the inverted-U hypothesis did not account for the effects that different emotional experiences of arousal can have on performance. According to Apter (1981), behaviour is driven by motivational drives, which are determined by mood state. For example, high arousal might produce feelings of extreme anxiety in some situations and excitement or exhilaration in others, with dissimilar resultant effects on behaviour. Similarly, low arousal can produce feelings of relaxation through to boredom, also resulting in a range of possible behaviours. Importantly, reversal theory rejects cognition-based explanations of behaviour, prioritising the evaluation of emotion and consequent motivation to account for real-world human action (Grange, 2005). Apter rejected a predominantly physiological definition of arousal, espousing the centrality of emotional arousal in behavioural motivation.

Apter (1982) proposed four meta-motivational states (frames of mind). Telic and paratelic states are bipolar opposites of the meta-motivational state most often studied in sports performance literature. A telic state is a goal-oriented state characterised by seriousness, intentionality, and a preference for low arousal experiences (Svebak & Stoyva, 1980). A paratelic state is a sensation-oriented state characterised by playfulness, spontaneity, and a preference for high arousal experiences. Although switching between these states is common, an individual can be measured for dominance in one or the other (Kerr, 1987). Svebak and Stoyva (1980) have suggested that behaviour will be determined by the hedonic tone experienced within each state (extent to which an emotion state is perceived as pleasant/unpleasant, depicted in Table 1), such that in a telic state an individual will seek to lower arousal and in a paratelic state an individual will seek to raise arousal. A reversal is said to occur when a sudden switch is made from one meta-motivational state to another (Smith & Apter, 1975).

Table 1

Categorisation of Hedonic Tone Associated With Each of Four State Experiences

	Meta-motivational state	
	Telic state	Paratelic state
High arousal	Unpleasant (anxiety)	Pleasant (excitement)
Low arousal	Pleasant (relaxation)	Unpleasant (boredom)

Interestingly, a graphical representation of Apter’s (1982) reversal theory creates an X-shape, the lower half of which resembles Yerkes and Dodson’s (1908) inverted-U. Kerr (1985) suggested that a major limitation of the inverted-U hypothesis is that very low and very high arousal can result in only one performance outcome (performance impairment). Since much supporting research has been interested in performance deficits, researchers have understandably manipulated and measured tasks in which this occurs. Thus, alternative feeling states associated with very high and very low arousal (those that engender pleasant feelings) have been overlooked. A complete overview of the four reversal theory meta-motivational states is provided by Kerr, Murgatroyd, and Apter (1993).

Despite the increasing popularity of reversal theory in performance anxiety literature, there is limited evidence that behaviour, and specifically performance, is markedly different between such emotional states. Thatcher, Kuroda, Legrand, and

Thatcher (2011) hypothesised that congruence between meta-motivational dominance and state would lead to enhanced performance outcomes in their sample of cyclists. That is, telic dominant cyclists would perform best in a telic state and paratelic dominant cyclists in a paratelic state. Using a repeated measures design, the researchers assessed meta-motivational state at five minute intervals throughout the 30 minute performance. This approach was used to ensure that reversals to alternate states did not occur, since this would constrain interpretability and has been a design limitation in previous pre/post-test studies (Kerr & Cox; 1988, 1990; Kerr & Pos, 1994; Males & Kerr, 1996; Wilson & Kerr, 1999). Surprisingly, dominance and state measures were unrelated to performance. This may have been due to measurement limitations since there is no available method of assessing meta-motivational state changes as they occur across a performance, and the researchers hoped that five minute intervals would capture significant changes. Results were therefore inconclusive as testing methods may not yet be precise enough to adequately measure reversal effects *during* performances.

Reversal theory has practical appeal because of its consideration of individual-specific factors and affordance for intervention. However the ability of reversal theory to account for pleasant experiences during extreme arousal states might not be of significant importance in performance anxiety literature, as researchers have typically been more interested in capturing when performance *is* impaired, rather than recognising that it *is not always* impaired. Although reversal theorists claim that assisting performers to switch meta-motivational states is the best intervention for improving performance (Kerr, 1987; 1997; 2001), studies have not yet adequately demonstrated that meta-motivational states are a strong predictor of performance impairment.

Evaluation of Arousal Theories

The inverted-U hypothesis has all but fallen from grace in contemporary performance literature. Multi-dimensional and catastrophe models dominate sport performance literature whereas attentional models dominate cognitive performance literature (Eysenck et al., 2007; Hassmen, Raglin, & Lundqvist, 2004). Autonomic arousal is still often observed to form a negative quadratic relationship with performance (e.g., Arent & Landers, 2003), however the variability in performance indices that arousal explains is consistently insufficient to account for ecologically-gathered variations in inter-task and inter-participant performances.

An underlying assumption of arousal theories, including reversal theory, is that arousal must form a unitary construct encapsulating both psychological and physiological response systems; that is, that ‘arousal’, however it is operationally defined, adequately captures the full set of internal events that lead to observed behavioural outcomes. Physiological measures have been by far the dominant data source for gauging arousal in performance anxiety literature (Neiss, 1988; Staal, 2004; Stokes & Kite, 2001). The problem with this is that physiological markers have at times been observed to vary as a function of task workload, rather than emotional stress, A-state, or perception of threat (Roscoe, 1978). The requirements and complexity of a task can be a stronger predictor of physiological arousal than any internal emotion state.

Trait factors have also been shown to better account for performance detriments than physiological arousal in some studies. For example, Shostak and Peterson (1990) measured the physiological arousal and cognitive anxiety of 132 participants whilst they performed mental arithmetic. They found no correlation between anxiety ratings and physiological arousal during task performance, even in high anxiety participants. Individual differences in anxiety sensitivity (a trait factor) provided the only significant link to task anxiety, which would be expected according to Spielberger’s (1966) model. These results oppose an arousal-only model of performance. To assume that anxiety can be adequately encapsulated via physiological measures ignores the multi-dimensionality of anxiety and the varying systemic effects that A-State can have on a person’s observed behaviour. Moreover, arousal theory largely ignores task specific stress responses and associated performance detriments that are seen across a range of performance tasks (Lazarus, 1991).

Leaving the Past Where it Lies

Despite its continued face validity amongst performers, there is sufficient evidence to suggest that the two-dimensional Inverted-U hypothesis is too simple a depiction of the anxiety-performance relationship (Hays, 2009; Staal, 2004). One operational limitation of this theory has been the obscurity surrounding the basic constructs (Gould, Greenleaf, & Krane, 2002). In an attempt to more reliably capture the inverted-U relationship, researchers have independently proposed that the x-axis depicts anxiety, motivation, activation, and stress (Easterbrook, 1959; Eysenck, 1982; Jones, 1990; Jones & Hardy, 1989; Martens et al., 1990). These are entirely different constructs, none of which are adequately justified by Yerkes and Dodson's (1908) original research. More practically, there is no consistent evidence that any of these alternatives adequately predicts performance in every task and circumstance. Critics of the inverted-U hypothesis do not seem to be saying that it does not exist, but rather that the hypothesis itself is merely an inverted-U *observation*, rather than a predictive model (Baddeley, 1972). Task type and complexity can cause large variations in the skewness of the quadratic curve, and it seems far more important that the underlying mechanisms that create this U be documented and tested, rather than simply observed.

Nevertheless, some valuable lessons can be drawn from this historical literature. The interest and enthusiasm that arousal theory has provoked, coupled with an apparent eagerness to prioritise face validity over internal validity, attests to the strong desire that researchers and performers have to understand anxiety-related performance deficits. Although an attractive solution, it is unlikely that a single latent factor can be shown to reliably and validly predict performance across all possible tasks and task complexities. Two-dimensional depictions of performance anxiety are now, at least in research circles, largely historical. This chapter will now present and evaluate the most important alternative theories that have emerged in performance anxiety literature up to the present.

Multi-Dimensional Anxiety Theory

Arousal theorists assumed that performance could be predicted based on changes in one unitary construct. This proved too narrow to account for real world performance variability. After summarising the limitations of uni-dimensional arousal theory, Lacey (1967) postulated that arousal can manifest in three independent ways: physiological events, psychological processes, and behavioural responses. Subsequent theorists chose to re-interpret this arousal factor as anxiety (Davidson & Schwartz, 1976), since the physiological connotations historically associated with arousal confound any broader use of the term. Multi-dimensional anxiety theory differentiates between somatic and cognitive anxiety, proposing that each impacts behavioural outcomes independently and according to a unique time-course (Liebert & Morris, 1967). Formal organisation of research and measurement construction within this approach can be attributed to Martens et al.'s (1990) exhaustive review of multi-dimensional anxiety research, offered alongside the publication of the Competitive State Anxiety Inventory – Second Edition (CSAI-2). In this section, the central tenets are briefly defined prior to an evaluation of the strengths and limitations of the theory.

Central Tenets

Somatic anxiety embodies many of the elements that 'arousal' did in the Inverted-U hypothesis – namely physiological and affective events elicited by autonomic arousal (Martens et al., 1990). In fact, Martens et al. (1990) maintained that somatic anxiety and performance form a stable, inverted-U relationship. Burton (1988) suggested that somatic anxiety reactions are often classically conditioned responses to cues in the performance arena that are predictably brief since they become decreasingly relevant once attention is directed toward the performance. That is, somatic anxiety is predicted to increase leading up to a performance, peak as the performance begins, and then reduce after that.

Cognitive anxiety encapsulates the appraisals that a performer makes regarding the probability of success and the predicted consequences of failure (Martens et al., 1990). Imagery content, internal dialogue, and self-confidence are all considered sub-components of this construct (Burton, 1988). Martens et al. (1990) proposed that there is a negative linear correlation between cognitive anxiety and performance. Cognitive anxiety has been offered as the dominant explanatory factor for observed deficits during the course of a performance, since it continually covaries alongside one's expectation of success (Parfitt & Pates, 1999).

Independent sub-components of anxiety have been observed, often by other names, in earlier literature. Hamilton (1959) conducted open-ended interviews with clinically anxious psychiatric inpatients, clustering symptoms and rating severity on a five point Likert scale. Factor analysis produced a bipolar factor, dividing anxiety symptoms into two groups that Hamilton labelled psychic symptoms (fears, cognitive changes, and so on) and somatic symptoms. These factors very closely resemble Martens et al.'s (1990) descriptions of cognitive and somatic anxiety. Buss (1962) replicated Hamilton's study amongst a non-specific group of psychiatric inpatients and two factors similarly emerged. Buss's interview questions were shaped by his expectation of a two factor model; he reports asking increasingly closed questions to make sure "the same areas were explored in each subject" (p. 426). This source of experimenter bias largely restricts the validity of conclusions that were drawn from the study. Despite these limitations, a two factor solution has continued to emerge in anxiety studies using varied methodologies (Gorsuch, 1966; Sassenrath, 1964; Sassenrath, Kight, & Kaiser, 1965).

During factor analysis of the CSAI-2, Martens et al. (1990) noticed "the serendipitous emergence of [a] state self-confidence factor" (p. 90). In reality, this third factor emerged unexpectedly and led the researchers to a *post hoc* evaluation of Bandura's (1977) self-efficacy research. Since self-confidence and expectations of success had been previously shown to positively correlate (Morris & Fulmer, 1976), and expectancy biases had been observed to impact performance bi-directionally (Feltz, 1982; Weinberg, Gould, & Jackson, 1980), they argued that their emergent variable would be positively correlated with performance. Although current clinical perspectives on anxiety acknowledge the independent contributions of somatic and cognitive anxiety components (Barlow, 2004), self-confidence is typically not allotted a central role in broader anxiety literature.

Theoretical Shortcomings

Adoption of a multi-dimensional approach to understanding anxiety is arguably one of the most important developments within performance anxiety research literature. Prior to this, arousal theories were still being relied upon to inform intervention and performance coaching despite substantial acknowledgement of the role of cognition within clinical and experimental anxiety literature (Staal, 2004). Since publication of Martens et al.'s (1990) review, integration of cross-domain research in the performance anxiety literature has markedly increased. Nevertheless, there are a number of limitations in multi-dimensional anxiety theory that warrant evaluation.

Multi-dimensional anxiety theory is not (contrary to the assertion of some proponents) a three dimensional model of performance anxiety; rather, it is a theory that proposes independent two-dimensional relationships (Hardy, 1996). Martens et al. (1990) distinguished distinct antecedent pathways. For example, they proposed that classical conditioning leads to somatic anxiety and perceived probability of success/failure to cognitive anxiety. In their defence, they did indicate that evidence for independence was somewhat ambiguous, and that devising experimental manipulations that only affect either somatic or cognitive anxiety is difficult. Even so, they maintained that independence exists between these constructs. Other researchers have identified a correlation between somatic and cognitive anxiety that opposes the hypothesis of independence (Caruso, Dzewaltowski, Gill, & McElroy, 1990; Jones & Cale, 1989; Jones, Cale, & Kerwin, 1988; McNally, 2002; Parfitt & Hardy, 1987). In fact Parfitt, Jones, and Hardy (1995) argue that the temporal design of Martens et al.'s experiments is unacceptably vulnerable to detecting false positive somatic anxiety effects. It seems probable that the impact these dimensions of anxiety have on performance is not as straightforward as Martens et al. originally conceived. At the very least, insufficient evidence has been provided to justify construct independence. A three-dimensional model of anxiety seems more probable and needs to be intentionally evaluated.

Despite emerging unexpectedly in Martens et al.'s (1990) initial investigation, self-confidence has demonstrated the strongest, most consistent effect on performance of all three theoretical constructs (Craft, Magyar, Becker, & Feltz, 2003). Qualitative exploration has shown that elite athletes perceive a very strong causal relationship between self-confidence and consequent physiological symptoms and debilitating thoughts and fears (Hanton, Mellalieu, & Hall, 2004). This seems to line up with quantitative research. Using a well-designed repeated measures experiment, Hatzigeorgiadis, Zourbanos, Mpoumpaki, and Theodorakis (2009) captured a strong self-confidence effect on performance ($\eta^2 = .24$, $p < .001$). Woodman and Hardy's (2003) meta-analysis of 48 ecologically valid sport performance experiments yielded a similarly large mean effect size for the relationship between self-confidence and performance ($r = .24$, $p < .001$). This was moderated by sex and standard of competition such that the largest effect sizes were produced for men and those engaging in elite competition. In contrast, cognitive anxiety has produced inconsistent small effects on performance (Craft et al., 2003: $\eta^2 = .13$; Hatzigeorgiadis et al., 2009: $\eta^2 = .08$; Woodman & Hardy, 2003: $r = -.10$), and somatic anxiety has produced small effects (Craft et al.: η^2 = .09; Hatzigeorgiadis et al.: η^2 = .07). It appears that cognitive anxiety and somatic anxiety are at best inconsistent predictors of performance (Landers & Arent, 2006). This may be a measurement issue, since the CSAI-2, which is most often used in this area, has not reliably outperformed more general measures of anxiety in predicting performance (Landers & Arent, 2006).

The Problem of Validity in Perceptuomotor Research

Autonomic arousal cannot be permanently maintained (Pfaff, 2006), however a body of evidence shows that: (a) for many performers the magnitude of somatic symptoms fluctuates throughout a performance, and (b) these symptoms are often the eventual cause of performance detriment (Baddeley & Idzikowski, 1985; Cox, Hallam, O'Connor, & Rachman, 1983; Idzikowski & Baddeley, 1983, 1985). Although none of these studies have tied the related somatic events to anxiety specifically, the connection is implied via their repeated contextual presence and covariation with other facets of the anxiety response. Real world examples of this might include sweaty palms impeding a free-throw shot in basketball, or a vocal tremor causing a singer's voice to break momentarily mid-performance. A question of underlying mechanisms is raised here: why do these somatic events and subsequent impairments occur during *some* performances for *some* performers?

Multi-dimensional anxiety theory cannot account for this observation. One possible explanation for this is that task load (duration and component complexity) and workload (time pressure and participant perceptual changes) have not been sufficiently differentiated. Parfitt and Pates (1999) advise that global performance measures are unacceptable, since stressors have been demonstrated to impact very specific components of a performance task. For example, Parfitt and Hardy (1987) assessed athletes (various sports) on a range of task-relevant motor and cognitive performance measures at three times: two days and one hour prior to a competitive match, and two days after the match. Somatic anxiety had mixed improvement and decrement effects on different measures, and cognitive anxiety was associated with improvements on a range of measures. Aside from failing to support previous negative-only cognitive anxiety effects, this study demonstrated the importance of dividing complex tasks into separate components for more accurate assessment of anxiety effects. Increased ecological validity in all performance anxiety domains might be obtained by developing a method for measuring segregated components of the specific anxiety-provoking task.

There is an added layer of necessary inquiry to this issue. Many sport performance experiments have used a ‘time to event’ paradigm, gauging performance on component tasks at specified intervals leading up to and following competitive performance (e.g., Parfitt & Hardy, 1993; Parfitt, Hardy, & Pates, 1995). Although this has allowed pseudo-longitudinal assessment of anxiety and performance in a domain that is notoriously difficult to assess experimentally and ecologically, it is likely that state changes in anxiety during untested periods may not be captured. This measurement strategy resembles a time series analysis, which can only be used to draw conclusions about transitory variables when outcome variable data is collected *simultaneously* with predictor variables *at every point* in the time series (Yanovitzky & VanLear, 2008).

There does not appear to be an easy solution to this problem. Parfitt and Pates (1999) used a frame-by-frame video-capture system to measure performance in basketball players throughout a competitive game. Specific task components were therefore able to be discretely analysed and operationally measured. To minimise the time between anxiety assessment and performance, the researchers trained participants in a single-response anxiety rating system that had previously demonstrated comparable reliability in A-state measurement to the CSAI-2 (Hardy & Upton, 1992). Yet measurement consistency does not guarantee validity, which is notoriously dubious for single item measures (Bergkvist & Rossiter, 2007). Due to measurement limitations there is no way to continually measure state changes in anxiety throughout a performance. In the absence of continuous measurement of both anxiety and performance causal explanations remain inaccessible. If possible, future performance anxiety studies should utilise manipulations that have *already* been shown to reliably trigger particular anxiety responses within the population of interest in previous studies. Measurement of multi-dimensional indices of A-state would then be unnecessary since reliable and valid manipulations could be assumed to exact the same effect they have previously. This is the only foreseeable way for researchers to draw causal links about performance anxiety effects in perceptuomotor domains.

Individual Zones of Optimal Functioning

Through his observation of elite athletes, Hanin (1980, 1986) developed an alternative framework for understanding performance anxiety. He proposed that every individual has a task-specific zone of optimal functioning, sometimes referred to as a range or “bandwidth” of preferred pre-competitive A-State (Gould & Tuffey, 1996). This represents the range of A-State that optimises performance of a specific task for a specific person. Hanin’s (1980) evaluation of rower performance produced non-significant group data, however individual data was highly predictive of future performance. Consequently, he proposed that it is only useful to consider the individual when evaluating performance anxiety effects. It is important to note that Hanin’s early research treated anxiety as a uni-dimensional construct.

Zones of optimal functioning are assessed by collecting A-State scores immediately before performance. By matching performance indices with this rating over time, a performer’s preferred level of pre-competitive A-State can be observed. Hanin (1980) formally operationalised a zone of optimal functioning as this observed score ± 4 points on Spielberger, Goruch, and Lushene’s (1970) State-Trait Anxiety Inventory (STAI). Hanin also proposed a retrospective rating approach, which has since been criticised as highly variable depending on a number of extraneous time-related factors (Brewer, Linder, van Raalte, & van Raalte, 1991).

Hanin (2000) later adapted the initial scope of his theory to incorporate the influence of a constellation of emotions (individual zones of optimal functioning). He proposed that athletes develop patterns of emotional experience over repeated performances that are person- and task-specific and that manifest (and are therefore evaluated) in five dimensions. The *form* of an athlete’s pre-competitive state incorporates specific emotions, cognitions, motivations, physiology, body sensations, effort, communication, and volition (Hanin, 2010). An athlete then appraises the *content* of these formative factors in line with reversal theory conceptions of hedonic tone (Hanin, 2000; Robazza & Bortoli, 2003). These appraisals are qualitatively collected by a coach or researcher. Each form is then quantitatively measured for *intensity* by eliciting subjective ratings from the performer. Finally, these three dimensions are placed in an *environmental* and *temporal context*, with an exhaustive range of influential factors requiring consideration (Ruiz & Hanin, 2011).

Many sports psychologists have since agreed that emotions broader than anxiety can impact performance (Woodcock, 2011), however agreed relevance does not equate to statistical relevance. Studies that have identified the centrality of broader emotion states have relied heavily on subjective ratings of performance (Jones, 2003; Mellalieu, Hanton, & Fletcher, 2006; Mellalieu, Hanton, & Jones, 2003; Mellalieu, Hanton, & Shearer, 2008). Performers are required to list their pre-competition feelings, perform, and then complete a single Likert-scale item to express the extent to which each feeling facilitated or debilitated performance. Researchers have then assumed that such ratings are statistically comparable to the measured influence of psychometrically valid anxiety scales. In addition, the single items are often summed to obtain an overall affect direction score. It is no surprise that such studies identify numerous emotion states as influential to performance since they are relying on performers *in* those emotion states to rate the *effect* of those emotion states. Not only do these researchers assume that performers have the vocabulary and psychological mindedness to accurately label their emotion states, they may also be indirectly influencing the performer's retrospective memory of performance to accord greater import to these affect states than was actually relevant.

The fundamental problem with individual zones of optimal functioning is that this form of assessment is costly and impractical. The conceptual depth of the theory has evolved beyond useful proportions. Although it may provide a practical performance optimisation strategy for elite and financially-endorsed performers (assuming sufficient psychological mindedness in the observer), the theory has almost no utility for performance optimisation outside of elite settings. Furthermore, trend data cannot be validly estimated because the theory prioritises an intra-performer focus.

Finally, an analysis of one's individual zones of optimal functioning provides observations rather than explanations for anxiety-related performance deficits. There is no evidence within this paradigm to show that anxiety directly impacts performance. Without directional evidence, a mediation hypothesis is equally viable, with some third factor either eliciting anxiety or resulting from it prior to observation of performance deficits. As a result, Hanin's (2000) model is an effective (albeit costly) performance optimisation tool, not an explanatory model of performance anxiety.

Catastrophe Models

When evaluating hypothesised inverted-U relationships, performance anxiety researchers have observed that over-arousal results in performance impairment that cannot be easily retracted, even by subsequently reducing arousal (Hardy, 1990). Any semblance of an inverted-U relationship between physiological arousal and performance is observed to become uni-directional once a high arousal threshold has been crossed. There is no available explanation for this observation in either arousal theory or multi-dimensional anxiety theory. Both of these theories provide graphical representations of continuous models that should (theoretically) allow multi-directional movement.

Catastrophe theory was developed in geometric mathematics (Thom, 1975) and later applied to natural and behavioural science phenomena. A ‘catastrophe’ is said to occur when the proverbial straw breaks the camel’s back. Academically, this refers to any discrete, non-continuous change in the behaviour of a dynamic system under observation (Gilmore, 1992). For example, a gas will suddenly convert to liquid or solid form at a specific temperature with massive resultant changes to its volume (Zeeman, 1977). Dynamic systems comprise a set of organic, typically stable variables that spontaneously organise at a relevant point in temporal space in response to environmental pressures (Thelen & Smith, 2006). Weather systems, chemical reactions, population growth, familial relationships, and behavioural reactions to emotional states can all be understood within a dynamic systems framework. Changes in any single element within a dynamic system can be observed to effect changes in many other elements of the system (Thelen & Smith, 2006). Future changes in a system are unable to be accurately foreseen, since future influences cannot be predicted, however the magnitude of a catastrophe or discrete change in the behaviour of a system can be (in many cases) perfectly represented using a set of mathematical functions (Thelen & Smith, 2006).

Hardy (1990) used one of Thom’s catastrophe models (the cusp catastrophe) to create an explanatory alternative for performance anxiety that incorporated the complex discontinuous observations described above. Hardy’s model (Figure 3) is a true three-dimensional representation of the impact that cognitive anxiety and physiological arousal effects and interactions have on performance. In this model, physiological arousal is referred to as an asymmetry factor since its influence is observably asymmetrical at different levels of cognitive anxiety (splitting factor). Four proposed relationships emerge:

1. A positive linear relationship between cognitive anxiety and performance when physiological arousal is low
2. A negative linear relationship between cognitive anxiety and performance when physiological arousal is high
3. An inverted-U relationship between physiological arousal and performance when cognitive anxiety is low
4. A catastrophic drop in performance as physiological arousal increases when cognitive anxiety is high, with a large reduction in physiological arousal required before performance improvements are visible

During a performance, physiological events can be observed to fluidly change over time. For example, heart rate may initially be very high, gradually reduce as the performance continues, and then spike suddenly as a difficult section approaches, or a thought about failure enters one's mind. Performance quality is not a static occurrence, but rather an additive, subjective evaluation of the standard compared against observer expectation at every experienced point of the performance. Therefore, if physiological arousal impacts performance quality, a calculation of mean heart rate across the performance would effectively reduce the interaction of dynamic variables across time to a single (largely meaningless) number. The same can be said of cognitive anxiety, which has historically been measured at a static point in time – usually immediately prior to performance. Presumably, one's perception of the likelihood of success and failure also fluctuates during a performance. Predictors as diverse as audience behaviours, complexity of a task, and negative thoughts about oneself have all been linked with increases in autonomic arousal during performance (Bargh & Cohen, 1978; Gellatly & Meyer, 1992; LeBlanc, Jin, Obert, & Siivola, 1997). Although these links are correlational, they consistently emerge and do so in the same temporal configuration (i.e., predictor occurs immediately prior to the observed change in arousal). Since it is unlikely that some third factor is responsible for producing changes in, for instance, audience behaviour *and* autonomic arousal, it seems reasonable to assume causation.

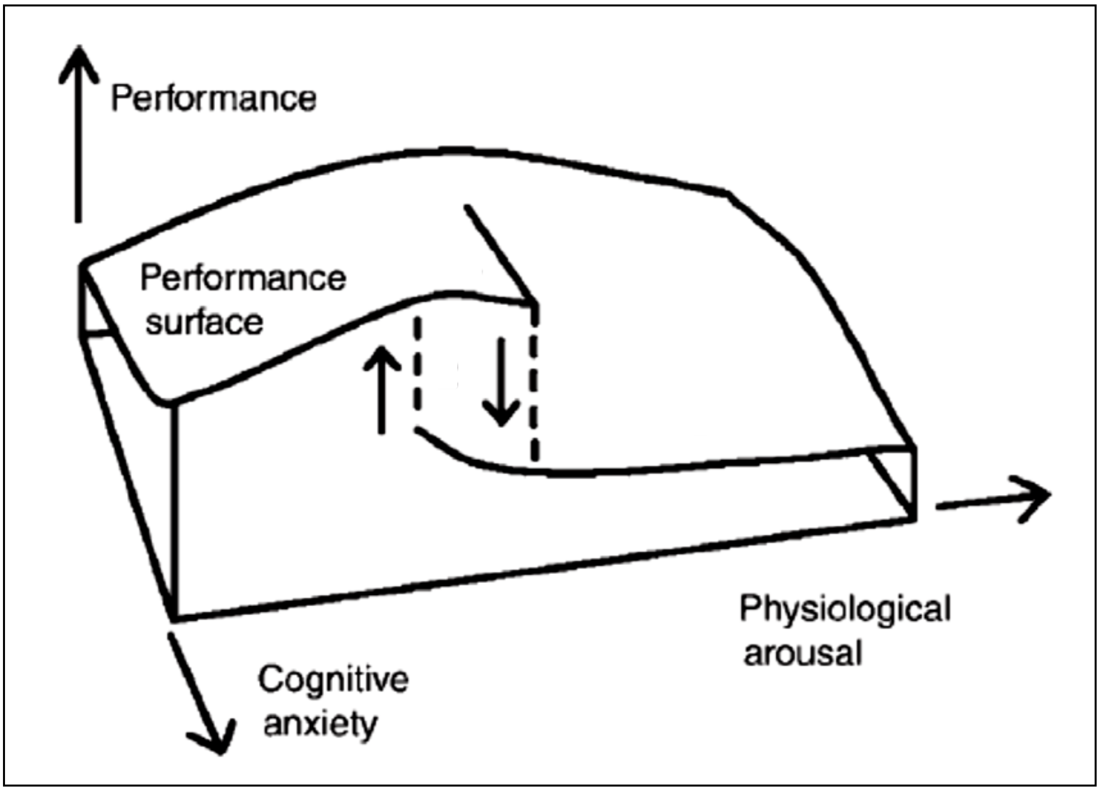

Figure 3. Graphical depiction of Hardy's (1990) cusp catastrophe model of performance anxiety; taken from Hardy, Beattie, and Woodman (2007).

The intuitive strength of a catastrophe model of performance anxiety resides in the potential for consideration and analysis of the whole performance event, rather than the final outcome. The magnitude of the moderation effect is modelled in three dimensions using behaviour surfaces, which recognises the variability of possible behaviours within the relevant ranges of the asymmetric and splitting variables. Moreover, this approach can explain sudden changes in performance at high levels of arousal that were previously viewed as anecdotal anomalies (Hardy, 1990). Consideration of separate variable relationships within this framework is irrelevant, because performance quality is shaped by the complex interaction of cognitive anxiety and physiological arousal over time.

Physiological indicators of anxiety have been commonly measured. However no research to date has employed a continuous measurement strategy to test cognitive anxiety outcomes. Cognitive anxiety ratings have generally been collected pre- and post-performance using a questionnaire (Hardy et al., 2007; Hardy & Parfitt, 1991; Hardy, Parfitt, & Pates, 1994). It is understandably difficult to devise a valid, efficient, and continuous strategy for measuring cognitive anxiety. However cognitive anxiety is hypothesised to vary during a performance and sudden deficits or changes in performance are conceptually linked to this variation. Thus, the utility of this paradigm for explaining performance anxiety effects cannot be confirmed at this stage. It should also be noted that personality factors (such as A-Trait) have not been adequately integrated into the model.

Processing Efficiency Theory

Selective attention is an important cognitive function that allows one to prioritise task-relevant information rather than existing in a perpetual state of distraction (Tong & Melara, 2007). Since humans have limited attentional resources, the quantity of resources required to perform a task is referred to as the ‘efficiency’ of the task (Eysenck & Calvo, 1992). Furthermore, the quality to which the task is performed is termed the ‘effectiveness’ of the performance (Eysenck & Calvo). For instance, two musicians might perform the same musical piece with comparable effectiveness (judges deem the quality of the performances as equivalent), but if one musician was able to complete the performance with less difficulty and distraction, that musician would be the more efficient of the two.

Processing efficiency theory (Eysenck & Calvo, 1992) proposes that worry directly influences efficiency, which can under certain circumstances result in performance deficits. Borkovec (1994) defined worry as a component of anxiety comprised of evaluation fears and prediction of aversive consequences. Worry is akin to Martens et al.’s (1990) definition of cognitive anxiety and both constructs have been consistently linked to performance detriments, albeit in separate literature domains (e.g., Burton, 1988; Morris, Davis, & Hutchings, 1981). Processing efficiency theory emerged as an extension of Eysenck’s (1979) early work on attentional processes, and relied heavily on Baddeley and Hitch’s (1974) tripartite model of working memory (which has since been modified into a four-component model: Baddeley, 2001).

Baddeley and Hitch (1974) partitioned working memory into three components: a central executive responsible for planning and monitoring performance, a phonological loop used to temporarily store and rehearse verbal input, and a visuospatial sketchpad for temporary storage and processing of visual and spatial information. Processing efficiency theory predicts that worry impacts the central executive directly, since attending to and inhibiting such thoughts consumes attentional resources, leaving fewer available to spend on the working memory costs of the primary performance task (Eysenck & Calvo, 1992). Predicting aversive consequences (a cognitive feature of worry) is hypothesised to enhance effort and motivation, resulting in a mobilisation of auxiliary resources, which can prevent a decrease in effectiveness. Eysenck and Calvo (1992) argued that reduced effectiveness is only likely to occur when insufficient auxiliary resources can be mobilised to compensate the resource cost of the primary task.

Increases in components of the anxiety response have been commonly shown to restrict attentional processes. Easterbrook's (1959) seminal review established that increases in physiological arousal and emotion directly correspond to reductions in the breadth of the perceptual field. He said that restrictions in the availability of peripheral environmental cues can, to a point, boost performance on some tasks by allowing focussed attention on cues of highest perceived salience. However, excessive arousal can lead to restriction of task-relevant peripheral cues, resulting in performance deficits. This observation has been coined the 'tunnelling hypothesis' and is reminiscent of the inverted-U hypothesis. It remains one of the strongest observed effects in literature regarding stress effects on attentional processes (Baddeley, 1972; Murata, 2004; Salas, Driskell, & Hughes, 1996; Staal, 2004). Processing efficiency theory researchers have argued that the internal mechanisms underlying this observation are more complex than Easterbrook thought (Eysenck, 1992; Eysenck & Calvo, 1992).

Historic models of performance anxiety in the cognitive domain supposed that anxiety always affects tasks with a high attentional demand (Humphreys & Revelle, 1984; Sarason, 1988). Specifically, these researchers have equated worry with avoidance motivation, which leads to decrements in resource allocation to a primary task. Participants with high A-Trait and A-State should therefore consistently underperform on high demand tasks compared to those low in either or both anxiety factor. However a number of studies have reported no performance differences between high and low A-Trait groups or high and low A-State groups

(Blankstein, Flett, Boase, & Toner, 1990; Blankstein, Toner, & Flett, 1989; Calvo & Ramos, 1989). For instance, Calvo, Alamo, and Ramos (1990) conducted an experiment into test anxiety in which participants were required to complete two tests: one with as much time as required, and one with insufficient time to complete the full test. Surprisingly, participants performed equally on both tests regardless of their A-Trait, A-State, or test instructions. Such a result cannot be reconciled using the performance anxiety theories described previously, since either the individual differences (A-Trait) or the experimental conditions (impacting A-State) would typically be expected to create a disparity between the two performances. Calvo et al. suggested that performance quality (effectiveness) is only affected by anxiety as a function of attentional interference (efficiency). These results have been replicated within the cognitive domain, suggesting that high- and low-anxious participants only differ in performance when the task requires more attentional resources than are available (Blankstein et al., 1990; Byrne & Eysenck, 1995). A reduction in processing efficiency therefore need not impair performance effectiveness. This does not eliminate the necessity for A-Trait testing in such experiments; rather, it provides evidence that attentional load is a critical consideration when studying performance anxiety. In fact, the sizeable effect of A-Trait on specific working memory processes will be discussed within the context of Attentional Control Theory (p. 40).

Eysenck and Calvo (1992) argue that instead of activating task avoidance motivation, anxiety increases motivation to avoid aversive consequences, except in circumstances where continuation of the task is predicted to result in more aversive outcomes than discontinuation. According to Eysenck and Calvo, the presence of additional motivation in high A-Trait/A-State participants can subsidise the working memory deficiency, resulting in equivalent performance. This supposition is central to processing efficiency theory and accounts for findings that have been otherwise unexplainable from earlier theoretical perspectives. Moreover, processing efficiency theory is an active paradigm of human perception and action, rather than one in which a performer’s behaviour is passively and mechanistically determined by task load.

Studies assessing the explanatory power of processing efficiency theory for cognitive tasks have reported consistent support for the theory. For example, Hadwin, Brogan, and Stevenson (2005) separated 30 normally developing children (aged 9-10) into high and low A-Trait groups and assessed them on three working memory tasks: forward and backward digit span and a spatial working memory task. The researchers were primarily interested in gauging the effects of A-State on task accuracy (effectiveness) and completion speed and effort (both indices of efficiency). A-State had no impact on effectiveness for any of the tasks, however high A-Trait children self-reported increased effort in the forward digit span task and were slower at completing the backward digit span task. All participants self-reported increased effort for the backward digit span task. These results are consistent with processing efficiency theory assumptions. The main limitation of this study was that effort was subjectively rated and therefore subject to response biases. Schniering, Hudson, and Rapee (2000) found that children tend to under-report their experience of task difficulty. The directionality of this effect means that Hadwin et al.'s (2005) findings are likely to have under-represented the strength of attentional influences in their target population.

Recent sport performance studies have also reported findings in accordance with processing efficiency theory predictions, although methodological limitations have persistently contaminated internal validity in these studies. For example, Smith, et al. (2001) recorded video footage of specific volleyball skills in experienced players during 31 competitive sets. A-Trait was measured prior to performance and A-State and mental effort were assessed throughout the competition. Set criticality was determined by the point separation of the two teams at the end of each set (7+ = low; 3-6 = moderate; 2 = high). High A-Trait participants rated themselves as significantly more anxious than low A-Trait counterparts, and mental effort increased alongside set criticality when performance outcomes were equivalent for high and low A-Trait players. Tukey *post hoc* analyses were used, requiring an alpha level correction (not performed by the researchers), however the probability statistics were all sufficiently significant that this would not have altered the results. Smith et al. (2001) suggested that these findings confirm processing efficiency theory hypotheses. A major hindrance to the accuracy of this conclusion was that processing efficiency theory hypotheses were not evaluated in a theory-driven fashion. To be consistent with processing efficiency theory, performance should be predicted by the interaction of processing efficiency with motivational factors (Eysenck & Calvo, 1992). Smith et al. merely confirmed the presence of increased (self-reported) effort in highly motivating conditions when performance was already equivalent across participants (an atheoretical temporal ordering of variables). In order to be a true assessment of processing efficiency theory predictions, efficiency and effectiveness need to be treated as a dependent variable and measured as outcomes of anxiety.

Wilson et al. (2007) contrasted processing efficiency theory with an alternative paradigm of sport performance deficits. Medium handicap golfers (n = 18) were videotaped for a number of target putts and asked to complete the same measures as employed by Smith et al. (2001). All participants performed in two conditions (counterbalanced order) – one containing low pressure instructions and the other high pressure instructions. A median split separated golfers into high and low A-Trait groups. High A-Trait participants consistently scored higher on the A-State measure, increased their effort to a greater extent, looked at the target more often, and took longer to initiate backswing, than low A-Trait participants. The researchers suggested that their results supported processing efficiency theory hypotheses since high A-Trait individuals demonstrated increased effort and a delayed speed in action (they argued that these were indicators of reduced processing efficiency). This is a dubious interpretation; a variety of alternative explanations might also predict variance in time delay prior to backswing (e.g., perfectionism, neuroticism, pre-swing routine). Although the design certainly improved on Smith et al.'s study, multiple *t*-tests and Tukey *post hoc* analyses were employed for part of the analysis without applying an alpha level restriction, which in this case would have shifted performance probability statistics into the non-significant range. Despite their limitations, the results of these perceptuomotor studies warrant further investigation.

Eysenck et al. (2007) asserted that processing efficiency theory is fundamentally limited by a number of theoretical gaps. Eysenck and Calvo (1992) claimed that anxiety consumes attentional resources allocated by the central executive (a component processing system in the pre-frontal cortex). They did not specify *which* central executive functions are impaired by anxiety. This is largely because the key contributions regarding the structure of the central executive had not been published at the time processing efficiency theory was introduced. Miyake et al. (2000) used college student data across a number of cognitive tasks to conduct a latent factor analysis aimed at identifying the basic control functions of the central executive. Cognitive tasks loaded on three independent latent variables: inhibition, shifting, and updating. Inhibition and shifting are the most important factors in this review, and will be covered in detail in the next section of this chapter. Processing efficiency theory provides limited utility for subsequent investigation, since being able to differentiate central executive effects is critical and necessary to accurately model the mechanisms underlying anxiety related performance deficits (Eysenck et al., 2007).

Most activities in life are performed in complex stimulatory settings in which shifting attention to unrelated distractors would be detrimental to the quality of the outcome. A distractor is any non-task related stimulus in the immediate environment (internal or external) that does not form a necessary part of a current task or goal (Eysenck et al., 2007). Processing efficiency theory does not model the effects that such distractors might provoke, such as reduced processing efficiency or performance effectiveness. This is a considerable gap in the theory and has meant that related studies have tended not to consider the possible extraneous influences that non-task related cues might impose. For example, Smith et al.'s (2001) volleyball study had considerable ecological validity, however there was no estimation or discussion of task-irrelevant events, interruptions, or interactions that might have impacted performer efficiency and effectiveness. Neither should this have been expected of the researchers since they employed a processing efficiency theory paradigm, which does not promote the evaluation of distractors. These factors are nonetheless likely to be present (Calvo & Eysenck, 1996; Eysenck & Graydon, 1989; Hopko, Ashcraft, Gute, Ruggiero, & Lewis, 1998). Future researchers in perceptuomotor performance domains need to weigh up the importance of experimental control versus ecology, since there are advantages and disadvantages to prioritising each.

Threat-related task content imposes a greater influence on performance outcomes than neutral content (Egloff & Hock, 2001; Eysenck & Byrne, 1992; Keogh & French, 2001; Mathews & MacLeod, 1985; Mogg, Mathews, Bird, & MacGregor-Morris, 1990). This effect is most apparent in tasks involving social threat cues (Amir et al., 1996; Mansell, Ehlers, Clark, & Chen, 2002). Processing efficiency theory was developed using research on neutral task performance (such as letter-number sequencing). This poses restrictions on the explanatory power that processing efficiency theory can provide for performance on tasks containing threatening cues and tasks presented simultaneously with threatening distractors.

Finally, no explanation is available for instances in which high A-Trait individuals outperform their low A-Trait counterparts (Byrne & Eysenck, 1995; Spence, Farber, & McFann, 1956; Spence, Taylor, & Ketchel, 1956; Standish & Champion, 1960). Rather, processing efficiency theory only predicts that high A-Trait participants can underperform or (using additional motivational resources) equally perform to those with low or moderate A-Trait.

Eysenck et al. (2007) have developed an updated model (Attentional Control Theory) that improves upon each of the above models. The next section of this chapter will explain and evaluate this theory. It is argued that ACT has increased testability and is a theoretically stronger alternative to the historic performance anxiety models reviewed in this chapter.

Attentional Control Theory

Attentional Control Theory (ACT) is a relatively new approach to anxiety and cognition that seeks to explain the processes of efficiency and effectiveness underlying the relationship between anxiety and performance (Eysenck et al., 2007). According to this theory, humans have two attentional systems – the stimulus-driven system, which seeks to integrate moment-by-moment information from one’s internal and external environment in a bottom-up fashion, and the goal-directed system, which maintains the overall plan and is influenced by expectation and current goals in a top-down fashion (Corbetta & Shulman, 2002). Essentially, ACT maintains that anxiety upsets the balance between these two attentional systems so that threatening stimuli (worrisome thoughts and task-irrelevant distractors) are more readily prioritised (Fox, Russo, & Giorgiou, 2005). In accordance with this, recent studies have found that distractors, particularly threatening ones, impact the performance of high A-Trait performers to a greater extent than low A-Trait performers (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Eldar, Yankelevitch, Lamy, & Bar-Haim, 2010; Hopko et al., 1998). Some researchers have also found this effect regardless of A-State activation (Byrne & Eysenck, 1995). This is not surprising, since broad allocation of attention facilitates the detection of immediate threat or danger to oneself and one's current goals (Mogg et al., 1990).

Neurobiological studies reinforce the idea that anxiety increases prioritisation of bottom-up perceptual processes. Threatening cues (regardless of task-relevance) are consistently linked to amygdala activation (Bishop, Duncan, Brett, & Lawrence, 2004). Anxiety appears to increase amygdala activation simultaneously with reducing dorsolateral prefrontal cortex and ventrolateral prefrontal cortex activation (Bishop, 2007). These regions are critically involved in top-down allocation of attention in tasks with a strong attentional load (Miller & Cohen, 2001). Anxiety therefore creates a neural bias for locating salient stimuli within one's present internal and external environment and concurrently reduces attentional focus on overarching task goals. It is the power of anxiety to control the directional flow of attention between the stimulus-driven and goal-directed systems that is of central importance in Attentional Control Theory.

Specific Effects of Anxiety on the Central Executive

Miyake et al.'s (2000) latent factor analysis has provided the strongest empirical foundation for division of central executive functions. These authors identified three functions, two of which directly relate to anxiety effects in attentional control (i.e., inhibition and shifting). The third function, updating, provides active monitoring of task-relevant information, which is coded for temporal relevance and transiently stored until newer relevant information is perceived (Jonides & Smith, 1997). Updating is a reliable indicator of attentional capacity but does not directly control attentional allocation (Eysenck et al., 2007) and is therefore not discussed further in this review.

Inhibition utilises attentional resources to resist disruption and interference from stimuli that are irrelevant to the goals of a current task. Friedman and Miyake (2004) postulated that the central executive inhibits attention to irrelevant stimuli *and* irrelevant (prepotent) responses. Inhibition restrains attentional allocation so that efficiency of a performance is not unnecessarily undermined. This function entails negative attentional control. Several taxonomies of inhibition have segregated this function into separate independent processes (e.g., Harnishfeger, 1995; Nigg, 2000).

Nevertheless, Friedman and Miyake's unitary model of inhibition proved a better statistical fit of their participant data.

Shifting allows a performer to flexibly modify the distribution of attention as task goals change (Friedman & Miyake, 2004). Complex tasks often require separate sets of information to be attended to at different points in time throughout the task duration. Shifting actively allocates attention to information sets as required for the attainment of overarching task goals. Additionally, shifting involves the suppression of priming effects created by processing of previous information sets (Allport & Wylie, 2000). This function entails positive attentional control.

Distractors appear to impact on performance proportionate to the working memory demands of a task (Graydon & Eysenck, 1989; Lavie, Hirst, de Fockert, & Viding, 2004). The central executive acts to maintain attentional control by inhibiting task-irrelevant stimuli from entering attentional focus and shifting attention toward relevant information sets. When task demands are high on the central executive, ACT hypothesises that the inhibition function will be impaired, resulting in: (a) a greater susceptibility to (internal and external) distraction, and (b) reduced prepotent response inhibition (Eysenck et al., 2007). Moreover, these effects are assumed to be stronger in high A-Trait individuals. Although there is no perceptuomotor research that has directly evaluated these hypotheses, there appears to be a strong predictive link between specific central executive functions and motor performance (Rigoli, Piek, Kane, & Oosterlaan, 2012).

Traditional dot probe tasks present participants with two stimuli (one threatening and the other neutral) on either side of a monitor. After a brief delay, these are followed by a target in the position of one of the stimuli. Participants are required to indicate whether a target stimulus was presented to the left or right by pressing the respective button. Eldar et al. (2010) observed an attentional bias (faster reaction times) when dot probes were presented in the visual space previously occupied by an angry face (threatening distractor). They argued that high A-Trait moderated this effect. Specifically, high A-Trait participants had attentional bias scores significantly greater than zero, whereas low A-Trait participants did not. This interaction was replicated in a similar study by Helfinstein, White, Bar-Haim, and Fox (2008), who demonstrated that for highly anxious participants attentional bias disappears when a transient threatening prime precedes the threatening stimulus and instead emerges when a threatening prime precedes a neutral stimulus.

Eldar et al. (2010) and Helfinstein et al. (2008) both failed to justify the use of multiple *t*-tests to evaluate anxiety moderation effects. In reality, their 2 x 2 ANOVA produced no significant interaction. Post hoc comparisons should have been conducted in the context of the ANOVA rather than multiple *t*-tests, since the latter increases the risk of Type I error and underestimates error variance (Keppel & Wickens, 2004). Unfortunately post hoc comparisons would have been redundant because both studies failed to capture an interaction in the overall *F*-test. Taken together, these findings provide only tentative support for Eysenck et al.'s (2007) supposition that anxiety increases the salience of distractors by prioritising stimulus-driven distribution of attentional resources for those with a highly anxious personality. For these people, the salience of threatening cues is predicted to reduce processing efficiency when such cues are peripheral to the primary task or goal. The evidence for this prediction is mixed and requires further evaluation for clarity to emerge.

Evidence for Inhibition Effects

The emotional Stroop task has been the most commonly employed experimental strategy for testing inhibition hypotheses. Participants are presented a series of coloured words, one at a time, and are required to name the colour of the word as quickly as possible. Wordlist content differs between studies, however all contain a mixture of neutral and threat-related words. Reaction time (RT) is measured so that neutral RT means can be contrasted with threat RT means between high and low A-Trait participants. In most of these studies, there is a significantly slower reaction time for threat-related words, and this effect is pronounced in high A-Trait participants, implying impaired inhibition (Egloff & Hock, 2003; Mogg & Marden, 1990; Mogg et al., 1990; Richards & French, 1990; van den Hout, Tenney, Huygens, Merckelbach, & Kindt, 1995). A number of alternative interpretations can also be made of emotional Stroop task findings. Eysenck et al. (2007) provide a brief review of emotional Stroop findings that support the impairment of inhibition by anxiety.

Antisaccade tasks have provided even stronger evidence that inhibition functions are impaired by anxiety. In these tasks a brief peripheral stimulus is presented to one side of a central fixation point. Prior to experimentation participants are instructed to ignore the stimulus and fixate on the other side of the fixation point (Hallet, 1978). Participants are then presented with a number of trials and eye movement accuracy and latency are measured. This task indisputably requires top-down inhibition to perform, since orienting to a novel stimulus is a natural response (Miyake et al. 2000; Rohrbaugh, 1984). Using an antisaccade task, Ettinger et al. (2007) conducted a neuroimaging study and found that dorsolateral prefrontal cortex and ventrolateral prefrontal cortex activation were the best predictors of correct responses on the task. Derakshan, Ansari, Hansard, Shoker, and Eysenck (2009) extended this by comparing results for a prosaccade control condition (instruction to look at, rather than ignore, the peripheral cue) and an antisaccade condition between high and low A-Trait participants. Although both groups performed equally on both tasks, latencies were significantly longer for high A-Trait participants. This study provides robust evidence for two hypotheses of ACT: that the inhibition function is directly related to processing efficiency; and that reductions in efficiency need not impact effectiveness. These studies have improved on emotional Stroop task research because the nature of the antisaccade task disallows the alternative explanations that have plagued Stroop research (Derakshan & Eysenck, 2009).

Evidence for Shifting Effects

Task switching and prospective memory tasks are both used to distinguish shifting effects. Task switching typically involves completion of two or more simple tasks, which are alternated by the experimenter (Eysenck et al., 2007). For example, a participant may be asked to complete as many maths sums as possible in a time limit. Initially the participant is only presented with addition sums. After a switch, only subtraction sums are presented. Continued switching can occur throughout the duration of the task. Processing efficiency and performance effectiveness are then compared with two control conditions (non-switching, each involving only one of the two types of task). Task switching has been observed to slow participant performance and increase error-proneness, however this effect is minimised if preparation time is provided (Monsell, 2003). Although task accuracy improves quickly after the initial post-switch performance deficit, there appears to be a long term cost such that performance remains poorer than it does on a single (non-switching) task (Monsell, Sumner, & Waters, 2003). Furthermore, there seems to be a strong interaction between A-Trait and switching performance, such that high A-Trait participants significantly underperform compared to low A-Trait participants (Derakshan, Smyth, & Eysenck, 2009).

The strongest task switching study to date was conducted by Ansari, Derakshan, and Richards (2008). These researchers created an antisaccade experiment in which participants performed traditional prosaccade and antisaccade trial sets as well as a mixed set involving randomly alternating presentation of both trial types. In the mixed set, presentation of a diamond prior to a peripheral cue signalled that a prosaccade response was required, whereas a circle signalled that an antisaccade response was required. As predicted, latencies were longer and error rates higher on all antisaccade trials (single and mixed). An interesting effect emerged between high and low A-Trait participants. Low A-Trait corresponded with a paradoxical improvement of antisaccade latency times in the mixed task compared to the single task, which is consistent with previous studies (Barton et al., 2002; Hodgson, Golding, Molyva, Rosenthal, & Kennard, 2004). This paradox fits an integrated model of ACT hypotheses and switching task preparation effects. The researchers proposed that precuing of the task (via a diamond or circle) instigated attention allocation earlier than a non-cued (single) task so that despite the apparent simplicity of the latter, the mixed task resulted in greater efficiency. Thus, in a single experiment all ACT hypotheses regarding switching efficiency were able to be tested and supported. Unfortunately, such clear distinction and measurement of separation effects is harder to achieve in complex, high ecology behavioural tasks (such as sport or musical performance).

Prospective memory tasks are an alternative method of testing switching hypotheses with increased utility in broader performance domains. They are a variation on classical dual-task methodology, requiring a primary task to be performed continuously and a sporadically presented secondary cue to be responded to when relevant (Graf & Uttl, 2001). Failure to shift attention to the secondary cue is rated as an incorrect response, and latencies for correct responses denote processing efficiency. Primary and secondary tasks need to be presented to different sensory modalities because sensory modalities are controlled by independent attentional processes (McLeod, 1977) and presentation of similar modality dual tasks generates an extraneous restriction of attentional capacity (Duncan, Martens, & Ward, 1997). It is also important to exclude incorrect responses from correct response latency means so that alternative explanations for latency variation can be rejected.

Results from prospective memory tasks have supported performance impairment in high A-Trait participants (Cockburn & Smith, 1994; Harris & Cumming, 2003; Harris & Menzies, 1999). Efficiency effects have been inferred from these results. This should not be mistaken for ACT evidence, as there was no direct evaluation of efficiency in any of the above studies. What they show is that anxiety impacts on performance in dual tasks that have a considerable working memory load. In order to capture changes in attentional allocation, future studies would need to measure comparative mental effort between the two tasks. Additionally, the secondary task should be as simple as possible, since the consistent pattern of performance deficits in relevant studies indicates that task load is too demanding to capture sensitive attentional effects. Manipulating primary task difficulty in a fashion that produces linear variations in processing efficiency would allow A-Trait comparisons to be made on both tasks across varying levels of task load.

Limitations of Attentional Control Theory Evidence

A number of researchers have evaluated sports performance in ways that draw upon components of ACT (Wilson, 2008; Wilson, Vine, & Wood, 2009; Wilson, Wood, & Vine, 2009). Nevertheless, only one perceptuomotor study has tested ACT predictions. Causer, Holmes, Smith, and Williams (2011) evaluated the efficiency of gun motion and shot accuracy in 16 elite shotgun shooters who performed within both practice and competition conditions (counterbalanced). As predicted, performers were less efficient and demonstrated significantly lower accuracy during competitive conditions. Causer et al. concluded that anxiety impaired goal-directed attentional allocation. They also suggested that shifting and inhibition functions were impacted, although no justification was provided for this conclusion. Causer et al. did not measure A-Trait, which is a significant limitation since ACT predicts that high A-Trait individuals demonstrate much stronger anxiety-related attentional impairment than low A-Trait individuals (Berggren & Derakshan, 2012; Eysenck et al., 2007). Causer et al. have therefore provided inconclusive evidence that the link between anxiety and attentional processes outlined in ACT can predict efficiency and effectiveness outcomes in perceptuomotor tasks. Future studies need to evaluate outcome differences across levels of A-Trait.

Eysenck et al. (2007) admit that many of the studies supporting ACT hypotheses separate participants into high and low anxiety groups using a median split on anxiety questionnaire scores. Test anxiety and A-Trait are the two most common grouping variables in these studies. Many statisticians advise against the arbitrary dichotomisation of continuous variables since it falsely increases statistical power and increases the Type I error rate (MacCallum, Zhang, Preacher, & Rucker, 2002; Streiner, 2002). Median splits in particular can create differences where none actually exist (Streiner). This means that there is an increased probability that relationships and interactions that do not exist in the target population will emerge (Maxwell & Delaney, 1993). Since A-Trait is theoretically continuous, it does not make sense to arbitrarily create groups on the basis of central tendency.

Creating categories implies experimental design (and therefore causation) rather than correlational design (Striener, 2002). True experimental designs require that either: (a) groups are exposed to different levels of a particular independent variable, or (b) participants are all exposed to all of the levels of a particular independent variable across time (Keppel & Wickens, 2004). Neither occurs when a dependent variable is treated as an independent variable (as occurs when test anxiety measures are used to predict processing efficiency variation). Aside from unacceptably increasing the probability of incorrectly rejecting the null hypothesis, dichotomisation also presumes temporal ordering of variables, in this case that anxiety states precede attentional and performance outcomes. This might be a reasonable assumption for A-Trait, but is not when using a state or context-specific measure of anxiety.

Future attentional studies need to: (a) evaluate whether A-Trait produces significant variation in processing efficiency indicators when it is treated as a continuous independent variable, and/or (b) use experimental conditions that have already been reliably demonstrated to manipulate A-State in a predictable fashion in the target population (such as frequently replicated Stroop or probe task conditions). This will allow stronger evidence to be compiled when examining the utility of ACT and other competing models of anxiety-related performance impairment.

Chapter Summary

In this chapter I have outlined the nature of performance anxiety and the key theoretical models that have been used to explain anxiety-related performance deficits. Performance anxiety was argued to be conceptually distinct from currently recognised diagnoses of clinical anxiety; the chief distinguishing factor being that holding an observing audience in mind is contextually appropriate in most performance arenas. To some extent the attentional cost that related distractions incur is a necessary element of a successful performance encounter (a workload component). Therefore the unique goal of performance anxiety intervention is not to extinguish this attentional focus, but to minimise the impact that anxiety-related processes can inflict on the performance itself. In order for this to occur, an empirically-driven explanatory model of mechanisms underlying this impact is needed.

A variety of models have emerged in performance anxiety literature, many of which have been exclusively tested in sport or cognition domains until recently. In sport literature, models emphasising the direct effects of anxiety-related phenomena have been preferred. The inverted-U hypothesis is the most well-known of these, explaining performance as a direct result of physiological arousal. This model evolved in a variety of directions. Reversal theorists changed the meaning of ‘arousal’ to accommodate the full spectrum of emotional experience. This has led to progressively complicated measurement strategies and difficulty calculating group trends. Similarly, Hanin’s individual zones of optimal functioning theory prioritised the intra-performer experience of performance anxiety to such an extent that patterning of underlying mechanisms is a nearly unachievable task. Both of these alternatives have proved practically useful (when implementation cost is not an issue), however neither offers testable theoretical predictions regarding the effect of anxiety on consequent performance outcomes.

A multi-dimensional conception of anxiety developed within clinical and cognitive literature and was eventually applied (albeit somewhat delayed) in motor performance research. Out of this emerged catastrophe theory – a theoretically effective way of accounting for fluid changes in A-State and performance indicators. Unfortunately, it is difficult to examine the predictions of this theory because no direct and efficient method of measuring cognitive anxiety as a continuous variable has been developed. Herein lies the appeal of processing efficiency models of performance anxiety. Surges in technology and innovation over the past 20 years have led to an increasingly complex, yet still somewhat conflicted, understanding of working memory. Experimental designs thought to allow direct assessment of specific central executive functions have revealed similarities in the attentional processes underlying performance deficits in anxious individuals across a variety of tasks. Attentional Control Theory is the most recent and progressive contribution in this field and has consistently modelled performance deficits in cognitive tasks. Few attempts have been made to apply ACT to perceptuomotor research. It is much harder to validly segregate the working memory requirements of such complex, high ecology tasks. Developing performance tasks that are ecologically valid *and* allow discrete separation of efficiency and effectiveness is a formidable undertaking. If done well, it may provide a triangulated source of evidence for the cross-domain utility of Attentional Control Theory. The present study is a step towards this.

Chapter 3. Musician Performance Anxiety

The performance was exotic. It was short. And it wasn't much more dreadful than the Chinese opera that had been performed last year.

"Bravo!" Ned called. He applauded madly. Thankfully, everyone joined in.

Blakely bowed, rather stiffly, and picked his way through the rows toward his seat. He didn't even make eye contact with Ned, didn't acknowledge that Ned had just saved him.

Ha, just because Blakely had no humility didn't mean Ned couldn't try to humiliate him further.

"Encore!" Ned shouted.

Blakely fixed Ned with a look that promised eventual dismemberment. Luckily for the future attachment of Ned's limbs, nobody else took up the cry.

(Excerpt taken from Courtney Milan’s *Proof by seduction*)

The Scope of the Problem

Musician performance anxiety (MPA) is a debilitating psychological experience for a high proportion of musicians, but it does not *necessarily* impede performance (Kenny, 2010; LeBlanc et al., 1990). Traditionally, clinicians and music teachers have assumed that practice, preparation, and correct technique are the most effective strategies for maximising performance quality (Salmon, 1990), however performance errors can occur despite a high level of experience, practice, and preparation (Butler & Baumeister, 1998; van Kemenade, van Son, & van Heesch, 1995). In elite performance arenas, very small performance margins typically separate top performers, so although errors may be smaller in magnitude, the effect on outcomes can still be practically significant (Hopkins, Hawley, & Burke, 1999). Performance quality is a significant predictor of audience enjoyment in musical performances (Thompson, 2006) and is strongly related to anxiety conditioning in musicians, which can interfere with future performances (Kenny, 2010). Identifying mid-performance causal factors that result in errors would allow musicians to target these factors in their performance preparation endeavours.

This chapter begins by discussing the nature and definition of MPA. It is important to operationally define this phenomenon before reviewing any proposed relationship between anxiety and musical performance quality. Next, three models for predicting musician performance impairments are discussed. Of these, none have been tested beyond the single studies or discussion papers in which they were presented. It is argued that Attentional Control Theory can account for the full range of anxiety-related performance outcomes without restricting performance ratings to categorical investigation. Finally, experimental MPA research has characteristically violated internal validity; conclusions based on such research are dubious at best. The chapter ends by evaluating the methodological limitations of these previous studies. Subsequent improvements are suggested for future experimental studies in the domain.

The Nature of Musician Performance Anxiety

The musician anxiety experience is observably similar to that of other performer populations (Kenny, 2006; Taborsky, 2007). Many musicians report a combination of negative cognitions, physiological symptoms (e.g., trembling, sweating, dizziness, and nausea), and avoidance behaviours (Fehm & Schmidt, 2006; Osborne & Kenny, 2005; Salmon, 1990). Despite this, the impact of these factors is highly domain-specific (Steptoe, 1982). Physiological symptoms such as a dry mouth pose a realistic threat to a singer or flautist, as do sweaty hands to a string or percussion player. These symptoms have the potential to directly impair the physical actions and practiced movements of the performer, particularly when excess body tension is applied (Goode, 2004). Over an extended duration, the postural and tension related outcomes of these physiological events can cause acute and sometimes permanent damage, which can shorten a musical career (James, 1994). The cognitive features of MPA also have the potential to impair the quality of a performance, and can shorten a career indirectly through conditioned fear associations with the performance arena and subsequent avoidance (Kenny, 2010).

Prevalence Rates of Clinical Anxiety in Musicians

Simon and Martens (1979) unexpectedly identified the significance of A-State in musicians when they compared child anxiety in sport performance (across seven different sports), general school participation (including test performance), and musical performance (including band and solo participation). Band solos generated more anxiety than all other activities ($p < .01$), followed by wrestling and gymnastics (both solo sports), and band group performance respectively. Simon and Martens noticed that the potential for, and importance of, evaluation co-varied with A-State in a positive linear fashion. This study was the first to draw researcher attention to the comparatively high magnitude of anxiety experienced by musicians and has been consistently replicated (Hamilton & Kella, 1992; Marchant-Haycox & Wilson, 1992; Sternbach, 1995).

One of the diagnostic necessities of clinical anxiety is that the anxiety is perceived to significantly detract from the sufferer’s lifestyle, career, and/or relationships (American Psychiatric Association, 2000). Fishbein et al. (1988) undertook the largest frequency assessment in the field, compiling data for 2212 orchestral musicians across 48 orchestras. Of these, 25% of the sample suffered clinical levels of anxiety in performance contexts and 16% indicated that their anxiety seriously impacted their performance capacity. These estimates were based on a single interview question, and are conservative compared to those of smaller studies that have used more comprehensive measurement strategies (e.g., 47% in Marchant-Haycox & Wilson, 1992; 32% in Steptoe & Fidler, 1987; 58.7% in van Kemenade et al., 1995). Studies assessing the frequency of MPA in secondary and tertiary student samples have produced somewhat lower clinical estimates (33.8% in Fehm & Schmidt, 2006; 22.8% in Schröder & Liebelt, 1999; 21% in Wesner, Noyes, & Davis, 1990).

The seriousness of MPA becomes apparent when the prevalence rate of problematic anxiety in musicians is compared to rates of anxiety disorders in the broader population. In their US population study, Kessler et al. (2005) observed a 12.1% prevalence of social phobia and a combined 28.8% prevalence of all anxiety disorder diagnoses. Despite considerable variation between studies in the percentage of musicians who report clinical anxiety and associated performance deficits, all professional musician statistics exceed rates of social phobia in the wider population and also approach or exceed combined estimates of anxiety disorders. Regardless of whether the high prevalence of anxiety in musicians is an artefact of the musical domain, types of people that engage in musical pursuits, or an interaction between the two, MPA affects a substantial proportion of musicians and so is not a minor concern.

Competing Definitions of Musician Performance Anxiety

Historically, MPA research has been strongly influenced by inverted-U theory. Early researchers agreed that when the psychological distress of a public performance causes performance catastrophes, despite sufficient preparation, it should be distinguished as maladaptive performance anxiety (Appel, 1976; Kendrick, Craig, Lawson, & Davidson, 1982; Steptoe & Fidler, 1987). In contrast, adaptive performance anxiety referred to facilitative levels of autonomic activation that were observed to enhance performance (Steptoe & Fidler; Wolfe, 1989). This dichotomy has a clear inverted-U flavour, attributing performance facilitation/debilitation to a single factor (Currie, 2001). Autonomic measures were the primary outcomes collected in these early studies (Salmon, 1990). The uni-dimensionality of this approach renders it susceptible to the same criticisms as early arousal theories (pp. 21-23).

Two dominant conceptual positions have emerged in the field. In 1990, Salmon defined MPA as “the experience of persisting, distressful apprehensions about and/or actual impairment of, performance skills in a public context, to a degree unwarranted given the individual’s aptitude, training, and level of preparation” (p. 3). Performance impairment was recognised as a potential (albeit non-essential) component of the MPA experience. This departed from the traditional facilitation/debilitation dichotomy, and instead prioritised cognition and “generalised psychological distress” (p. 3) as the core features of MPA. Salmon did not include physiological variables in his definition, but suggested that they be included in an assessment of MPA nonetheless. This recommendation was in accordance with multi-dimensional anxiety theory, which at the time was an innovative theoretical development in the sport performance literature. Salmon’s definition has since dominated English (language) MPA research.

Möller (1999) proposed a competing conceptualisation of MPA, which has been widely used in German literature. He recommended that moderate levels of anxiety that enhance performance (stage fright) be differentiated from those levels that detract from performance (performance anxiety). Sybille (2008) referred to stage fright as “an internal voltage” (p. 5) that rouses the body to perform optimally, whereas performance anxiety occurs when cognitions containing failure-related content provoke sufficient inner tension to undermine the performance. Möller’s dichotomy is therefore defined by the magnitude of felt anxiety *and* the quality of performance outcomes. This proposition that performance deficits are a necessary diagnostic feature of musician performance anxiety departs significantly from Salmon’s (1990) definition. Moreover, it is difficult to determine the precise operational location of an arbitrary cut-off between stage fright and performance anxiety, since this cut-off might reasonably be expected to change depending on the method researchers use to gauge performance deficits (e.g., pre-performance, mid-performance, or retrospective ratings provided by an audience, examiner/s, or performer).

Möller’s (1999) definition represents a return to an inverted-U conception of performance anxiety (Fehm & Schmidt, 2006). Chapter 2 (pp. 21-23) presented evidence that *any* model seeking to predict performance outcomes using a single predictor necessarily oversimplifies the relationship between anxiety and performance. Decades of research have shown that categorical separation is not concordant with a valid explanatory theory of performance anxiety.

Finally, a number of researchers have proposed that extreme MPA is sufficiently similar to Social Anxiety Disorder (SAD) to warrant inclusion in this diagnostic category (Clark & Agras, 1991; Cox & Kenardy, 1993; Gorges, Alpers, & Pauli, 2007). This position was discussed in detail in Chapter 2 (pp. 6-8) and is subject to the same criticism as early distinctions between adaptive and maladaptive performance anxiety; an arbitrary cut-off is needed to differentiate facilitative and debilitative levels of performance anxiety. Huston (2001) conducted one of the only comparison studies between SAD and MPA. She found that they were moderately correlated (r = .35), shared very few developmental similarities, and were predicted by unrelated regression equations when calculating the variance contributed to each by age, gender, and task experience. This is not surprising, since the task demands of musical performances are significantly more complex, multi-determined, and specialised than the tasks typically feared in SAD (Kenny, 2010).

Current Status of the Research

Kenny (2010, p. 435) has offered the most recent and comprehensive definition of MPA, suggesting that:

> Music performance anxiety is the experience of marked and persistent anxious apprehension related to musical performance that has arisen through specific anxiety-conditioning experiences. It is manifested through combinations of affective, cognitive, somatic and behavioural symptoms and may occur in a range of performance settings, but is usually more severe in settings involving high ego investment and evaluative threat. It may be focal (i.e., focussed only on music performance), or occur comorbidly with other anxiety disorders, in particular social phobia. It affects musicians across the lifespan and is at least partially independent of years of training, practice, and

> level of musical accomplishment. It may or may not impair the quality of the music performance.

This definition integrates a wealth of MPA research with broader anxiety literature, thus providing a useful starting point for future targeted research in the domain. Performance anxiety is recognised as being significant regardless of the presence/absence of comorbid DSM-IV-TR diagnoses. Kenny also allows that MPA does not always result in performance deficits, however there is no indication of when or why performance impairment can accompany the anxiety experience. A number of MPA-specific causal models have been proposed to explain anxiety-related performance deficits. This chapter will now outline and evaluate each of these models.

When Do Errors Occur?

Three MPA-specific explanatory models have been put forward in an attempt to predict performance errors and distinguish the musician experience from other performance domains. Zinn, McCain, and Zinn (2000) argued that MPA is the result of somatic manifestations of repressed anxiety. It follows that performance deficits (mistakes) are mere artefacts of a hyper-reactive nervous system (such as sweaty fingers slipping on a key). Kirchner (2003) constructed a musician-specific model that closely resembles multi-dimensional anxiety theory. Within this model impairment results from the combined influence of high cognitive and somatic distraction and low self-confidence. Finally, Papageorgi, Hallam, and Welch (2007) revised the inverted-U hypothesis for predicting musician performance quality. Since none of these theories have been rigorously tested, the merits and central tenets have been evaluated on the basis of the individual studies they were derived from and broader psychological literature. At the end of this section it is proposed that a non-domain-specific predictive model of performance impairment is a more elegant solution to performance anxiety research.

A Psychophysiological Model of Musician Performance Anxiety

Zinn et al. (2000) conceptualised musician performance anxiety as a psychophysiological disorder akin to somatisation. They applied Wickramasekera's (1994) high-risk model of threat perception to MPA, suggesting that the explanatory factors contributing to a somatoform disorder diagnosis would also explain a majority of the variance in MPA symptomatology. Zinn et al. argued that MPA events consist of autonomic nervous system dysregulation and sympathetic nervous system hyper-reactivity. Perceived threats therefore interact with negative affect and catastrophic thinking to trigger somatic complaints (such as sweaty palms), which increase the probability of performance errors. These errors promote further catastrophic thinking and negative affect, which manifest as increased autonomic nervous system dysregulation and sympathetic nervous system hyper-reactivity.

To test this theory, Zinn et al. (2000) recruited 16 college music majors (aged 18-25) six weeks prior to a performance exam, and asked them to complete measures of hypnotisability, neuroticism, social desirability, and catastrophic thinking, and peripheral vasoconstriction (peripheral temperature). After performance, the students measured their peripheral temperature again and completed an A-State questionnaire. A regression analysis was run, using all of the measures as predictors of A-State. The authors reported that 47% of the variance in A-State was accounted for by the predictors. Hypnotisability was excluded from this analysis because it did not significantly predict A-State. No separate data were provided to show the unique variance contributed by each predictor. Neither were the partial correlations for individual variables significantly correlated with A-State. The authors proposed that interactions between the variables were necessary for the observable changes in A-State to occur, however no data were provided to support this.

Zinn et al. (2000) interpreted their results as evidence that MPA is a form of somatisation disorder in which physiological symptoms occur as a result of repressed anxiety and distress. There are a number of dangers in adopting this model of MPA. Even when only considering cases involving actual performance impairment, the *most* conservative estimates indicates that 16-25% of musicians are affected (Fishbein et al., 1988). In contrast, De Waal, Arnold, Eekhof, and Van Hemert (2004) estimated that *up to* 16% of their 1046 patient sample presenting for general practitioner care met the diagnostic criteria of a somatoform disorder. If Zinn et al.'s model of MPA provides a reliable fit for explaining MPA symptoms, then there must be something about musicians as a sub-population that increases their vulnerability to somatoform disorders; that is, a third variable that predicts musical pursuit and somatoform diagnosis. This seems highly unlikely, and at the very least has not yet been explored.

A second (larger) problem with this theory is that MPA is symptomatically similar to the experience of anxious sports performers (Marchant-Haycox & Wilson, 1992; Simon & Martens, 1979; Sternbach, 1995). Unless a unique psychological difference can be identified to distinguish musicians from athletes (and performers from other domains), it seems unnecessary to adopt an explanatory model that separates musicians from these other groups. There may be differences inherent in various performance *tasks*, however as yet no psychological trait differences have been identified between those involved in different performance domains.

A Multidimensional Model of Musician Performance Anxiety

An alternative MPA-specific model was devised by Kirchner (2003) via qualitative exploration of the musician experience. Six solo pianists participated in semi-structured interviews, and transcripts were coded so that data could be thematically categorised. The experience of MPA was sufficiently similar between the participants that no new data emerged in the sixth interview (i.e., saturation was attained). Kirchner noted that threat perception was the distinct starting point of performance anxiety for all of the participants; that is, all symptomatic manifestations were triggered by a threatening cue. Three sets of symptom responses were categorised: physiological reactions (body temperature, muscle tension, heart rate changes), cognitive processes, and negative feelings. There was no clear hierarchy or order of symptoms across performance experiences; rather, anxiety seemed to trigger a combined response incorporating all three. These symptoms impacted each pianist's identity (comprised of one's sense of self as a performer, self-confidence, and perceived public image), which then further exacerbated the symptoms. There was also a recognised temporal component to the pianists' experiences since identity influenced the anxiety response in subsequent performances.

Quantitative analysis of the data (counting similarly coded data) indicated that cognitive processes were the most common resultant symptom. These cognitions were perceived as invasive distractions, the content of which included uncertainty and self-doubt. Primary feelings included apprehension (fear), despondency, despair, and poor self-esteem. The last of these seems inappropriately categorised, since the data in this ‘self-esteem’ sub-category was largely cognitive (e.g., “I feel that when I bow I’m apologising”, p. 80). The key methodological flaw of Kirchner’s (2003) study is that there is no indication that the pianists structured the data themselves. Instead, it seems that the researcher grouped themes based on the two interview questions (not provided). Kirchner writes that “the researcher…looked for key words or phrases to emerge in response to [each] specific question” (p. 79). This is not an iterative process (Constas, 1992); rather, it is vulnerable to confirmation bias (Onwuegbuzie & Daniel, 2003). Consequently, the data is more likely to reflect the researcher’s perceptions of MPA than the combined experience of the pianists themselves. Researcher expectancy effects cannot be ruled out (Lee, 2000).

Kirchner’s (2003) MPA model is similar to multi-dimensional anxiety theory (discussed in Chapter 2, pp. 23-28). In both theories environmental threats trigger cognitive and somatic responses. Kirchner’s model also implies a moderation effect of self-confidence (termed identity) on symptom magnitude. Kirchner selected pianists with the highest self-reported performance anxiety, so this moderation effect can only be interpreted for highly anxious musicians. Nevertheless, these data implicate a similar set of variable relationships to those proposed in multidimensional anxiety theory. The origin of this similarity cannot be adequately determined. There is insufficient discussion of the research process or researcher expectations and biases to distinguish an emergent similarity from an expected or tailored similarity.

A Temporal Model of Musician Performance Anxiety

Papageorgi et al. (2007) devised a framework for modelling the magnitude of felt anxiety, and the subsequent impact of this on task performance. Their model was divided into pre-, during-, and post- performance factors. Intra-performer factors (personality, demographics, and cognition) were said to create a susceptibility to anxiety. These then interact with task efficacy and environmental characteristics to produce situation-specific evaluations and consequent autonomic nervous system arousal. Papageorgi et al. argued that autonomic arousal was the sole predictor of performance quality. Specifically, they modified the inverted-U hypothesis so that low and high levels of autonomic activity produce maladaptive outcomes and moderate autonomic activity produces adaptive outcomes. Operational differences between the three ordinal autonomic arousal categories and two quality outcomes were not further clarified. Papageorgi et al. also predicted that post-performance self-evaluations of quality impact self-esteem and performance motivation, which then influence pre-performance susceptibility in the future.

Many inappropriate generalisations were made at each structural point in this model. It was largely constructed without reference to broader anxiety and performance anxiety literature. Kenny (2010) has provided an alternative temporal model for the psychological experience and perpetuation of musician anxiety that is consistent with current, cross-domain anxiety research. Evaluation here will focus on the during-performance components, since these are central to the prediction of performance errors and have not been modelled effectively in any other source.

The main evidence that Papageorgi et al. (2007) cited to support their adaptation of the inverted-U hypothesis was a widely used performance psychology textbook by Wilson (2002). Wilson claimed that A-Trait, task difficulty, and situational stress predict autonomic arousal, which then generates an inverted-U relationship with performance quality. This is similar to Oxendine’s (1984) thesis, which has been widely criticised for its oversimplicity in performance anxiety research (see Chapter 2, p. 16). There is no currently accepted evidence that autonomic arousal predicts performance outcomes. Papageorgi et al. are correct in suggesting that MPA research has lacked a framework for comparison between studies, however their model does not fill this gap in the literature.

Within MPA literature, there has been a persistent tendency to dichotomise performance anxiety outcomes into adaptive and maladaptive categories (Currie, 2001; Gabrielsson, 1999, 2003; Steptoe, 2001). There is no validity or practical relevance in retaining this distinction. Future studies need to treat performance quality as a continuous outcome (or set of continuous outcomes) in order to model the nuances that are observed across performers and performance contexts. Uni-dimensional arousal-based models of performance outcomes provide too simplistic an account of variable relationships to retain explanatory value.

Summary of Domain-Specific Models

None of the above theories provides an adequate account of anxiety-related performance outcomes. Zinn et al.'s (2000) model appeared to fit the experience of their specific sample, however it is difficult to reconcile the implication that musicians have trait differences compared to other performers. Kirchner's (2003) model closely resembled multidimensional anxiety theory, albeit without a comparable empirical foundation. Papageorgi et al.'s (2007) model was based on an out-of-date theory and is consequently invalid. In Chapter 2 (pp. 40-48), attentional processes involving working memory functions were argued to explain the complex set of findings that emerge in broader performance anxiety literature (Eysenck et al., 2007). The possibility that a single explanatory model might account for all outcome variations across performance domains is a more elegant solution for modelling the anxiety-performance relationship. This would eliminate the need for domain-specific models.

Attentional Processes in Musician Performance

There are very clear workload differences between the perceptuomotor demands of a musical performance and, say, a competitive game of chess. It is much harder to distinguish differences in workload between solo musical performance and competitive tennis, which also involves solo (identifiable) performance of complex time-based sequential behaviours simultaneous to cognitive processing and goal-oriented action monitoring, the failure of which might reasonably be perceived as catastrophic (Pfordresher & Palmer, 2006).

The goal-monitoring and motor-adjustment mechanisms underlying musician tasks appear to be similar to those observed across other performance domains. Specifically, the posterior frontomedial cortex is consistently related to performance monitoring and error correction when salience of errors is high (Ganushchak & Schiller, 2008). Ruiz, Strübing, Jabusch, and Altenmüller (2011) measured pre-error event-related potentials (neural firing reliably linked to specific thoughts, perceptions, or behaviours) in 14 professional pianists. Of these, eight participants were healthy controls and six were diagnosed with Musician's Dystonia, a neurological condition in which fused representation of muscle groups in the sensorimotor cortex causes spontaneous muscle contractions and can impede performance in fine motor tasks. These participants played with their affected and unaffected hands on separate trials. Performance accuracy was measured by computing the disparity between notes played (recorded using a MIDI program) and metronomic beats (120 beats per minute = 1 beat every 125ms). No difference was observed between the groups, however participants with Musician's Dystonia showed greater timing accuracy with a probability statistic approaching significance ($p = .06$). The loudness (note velocity) differences between correct notes and errors were significant for all participants ($p = .001$), regardless of group membership.

Ruiz et al.'s (2011) findings strongly support the conclusion that a corrective neurobiological response is initiated prior to actual performance of errors. Healthy participants showed bursts of beta and theta waves at posterior frontomedial cortex electrodes up to 120ms prior to the actual performance of errors. These findings implicate predictive sensorimotor control processes for errors in the goal-monitoring behaviour of healthy pianists. Ruiz et al. therefore confirmed that the goal monitoring mechanisms used by musicians are similar to those used in other complex tasks requiring the organisation of complex time-based, sequential behaviours (Ganushchak & Schiller, 2008; Ullsperger & von Cramon, 2004). This evidence supports a non-specific model for predicting performance deficits in perceptuomotor tasks. Once such a model has been constructed, its predictive utility can be evaluated across a variety of perceptuomotor tasks, so as to gauge the influence of specific workload factors.

The central role of attention in musical performance is not a new concept. Chapter 2 of this dissertation (p. 35) outlined evidence for the tunnelling of attention (reduction of cue utilisation) during periods of anxious arousal. Reduced saliency of peripheral cues is facilitative in musical performance since this allows greater attentional allocation to elements of the task (Keller, 2001). Flow experiences – periods of peak attunement to, and involvement in, a task – have been observed to result in optimal performance in music and other performance domains (Kenny, 2011). Many of the symptoms of MPA may compete for attentional resources, depending on their saliency during a performance. By extension, increases in distractor saliency and attendance should reduce the capacity for flow (peak) performance. This necessitates a more thorough examination of the role of attention and working memory functions in predicting performance quality.

Forced attentional prioritisation of internal events can be detrimental to musical performance quality, particularly as task difficulty increases. Cheng, Heiß, Großbach, and Altenmüller (2011) measured timing accuracy in 25 professional pianists as they played two (fingering) variations of a C major scale at 80 beats per minute, under different feedback conditions (normal, silent, and 200ms delay). Participants performed the scales using conventional fingering and a novel scale fingering variation under all three feedback conditions. They were instructed to coordinate the sound, not the key depression, with the metronome during the delay condition. Delayed feedback impacted timing of the scales but fingering changes had no effect. This seems to indicate that professional pianists can adapt to motor coordination changes effectively, however a forced internal focus of attention reduces the quality of skills despite familiarity and practice. Interestingly, when the researchers deprived participants of auditory feedback (silent condition) performance did not deteriorate. They interpreted this as confirmation that task complexity moderates the impact of attentional focus; that is, an internal focus of attention only results in impairment on difficult tasks. Although this conclusion is an extrapolation of the results of the study, it is congruent with findings in sport performance literature (Wulf, Töllner, & Shea, 2007), lending further external validity to attentional modelling in these domains.

Attentional factors may in fact mediate the relationship between anxiety and performance impairment in musicians. This seems particularly plausible since treatments targeting (and effectively reducing) physiological arousal are often employed by sport and music psychologists (McGinnis & Milling, 2005; Zaichkowsky & Takenaka, 1993), yet these strategies have mixed effectiveness in improving motor performance itself (Kageyama, 2007; Neiss, 1988). This is not surprising given the uni-dimensional focus of such treatments. Kageyama (2007) predicted that attentional control training would result in greater perceived concentration by expert musicians, and fewer consequent errors, than either traditional arousal control strategies or no-treatment. Participants (n = 18) performed the same excerpt of music at two times (separated by a treatment condition to which they were randomly assigned). Treatment involved either two workshops teaching breathing and muscle relaxation (arousal control group), a single arousal-based workshop followed by an attentional control training workshop (attentional control group), or no contact (control group). The attentional control group demonstrated the largest positive shift in attentional focus and A-State and the greatest increases in performance quality. However there were no statistically significant differences between the groups on pre- or post-test self-report measures of performance quality or A-State; therefore none of the group differences can be validly interpreted. Additionally, Kageyama introduced a novel performance quality rating approach that was not piloted or standardised and produced low inter-rater reliability. This is a possible extraneous source of error variance that might have limited the probability that genuine treatment effects could be captured. This study therefore does not provide direct evidence for attentional mediation between performance and anxiety, but implies value in further exploration of this possibility.

Only one other study to date has explicitly evaluated attentional processes involved in the impairment of musical performance. Wan and Huon (2005) compared the predictive capacity of two attentional models to account for performance errors in beginner keyboard players (participants who had completed a keyboard orientation). Distraction theory is the predecessor of processing efficiency theory, and explains errors as the effect of anxiety driven task-irrelevant shifts in attention. Beilock and Carr’s (2001) explicit monitoring theory alternatively suggests that task pressure and increased self-consciousness can increase attentional allocation to performance micro-skills, which then results in errors for performances that are reliant on implicit memory (often called muscle memory by musicians). Wan and Huon required their participants to practice 15 trials of a four bar keyboard task under three conditions: single task involving no manipulation; a pseudo-dual task requiring participants to simultaneously listen to a piece of music (no responses were required); and a video-monitoring condition, during which participants were videoed with the knowledge that experts would review the tapes at a later date to evaluate keyboard skill acquisition in beginners. After this, all participants were randomly assigned to a low- or high-pressure test. No reference to testing or evaluation was made for those in the low-pressure condition. Conversely, reward contingency and ego-threat instructions were given to those in the high-pressure group. High pressure resulted in increased errors for those in the single and dual task groups, however performance improved in the video-monitoring condition. The researchers interpreted these results as evidence that explicit monitoring theory accounts for performance errors since this was the only condition promoting active task-monitoring during skill acquisition. Random allocation to groups ensured strong internal validity in this study. As a result, attentional processes during skill acquisition appear relevant in the explanation of performance errors.

A major limitation of Wan and Huon’s (2005) study is that it tested the earliest and most basic level of musical performance. There is no indication that these results can be extrapolated to more advanced musicians, pieces, or performances. Moreover, the attentional theories tested do not represent current advancements in cognition and attentional literature. Attentional Control Theory subsumes the explanatory power of both of the models tested by Wan and Huon. Performance errors in single and dual task participants could alternatively be explained by task shifting and inhibition deficits, since these groups had to then adapt to evaluative conditions. In contrast, the video-monitoring group practiced under evaluative conditions and therefore had practice at inhibiting evaluation-related thoughts and mobilising effective compensatory strategies/resources. They also did not need to shift resources from the training to performance task, since an evaluative component was retained for both, whereas the other groups needed to adapt to the updated requirements of the experiment. Regardless of these interpretive differences, the centrality of attentional processes in governing the performance deficits that were observed remains clear.

The Mechanics of Musical Experiment Design

This chapter has considered evidence for currently available models of anxiety-related musician performance outcomes and argued that a general attentional model may be useful for predicting performance outcomes across a range of perceptuomotor tasks (including musical performance tasks). In order to test this, robust experimental research is required. There are very few examples of this to draw upon and adapt in current MPA literature. This section evaluates common shortfalls in experimental MPA research and proposes a number of considerations that proved useful when designing the experiment reported in phase two of the present dissertation. It is hoped that future contributions in the field will also benefit from these design considerations.

Limitations in Musician Performance Anxiety Research

Very few experimental MPA studies have been conducted. This is because of the difficulty researchers have encountered in: a) establishing valid procedures for measuring performance; b) operationalising task difficulty in a meaningful and consistent way so that comparisons can be made across levels of this factor; and c) designing robust experimental tasks. Researchers conducting experimental music psychology studies have preferred to assess anxiety across diverse scenarios and tasks, rather than many variations of one scenario or task (e.g., Abrams & Manstead, 1981; Brotons, 1994; Egner & Gruzelier, 2002; Hamann & Sobaje, 1983; LeBlanc et al., 1997; Yoshie, Kudo, Murakoshi, & Ohtsuki, 2009). Participants have been required to either perform the same task in a variety of performance conditions (within-subjects design), perform separate pieces that they individually prepared (between-subjects design), or a combination of the two. These varied methodologies, tasks, and experimental approaches cannot be reliably compared.

Designing experimental procedures requires an awareness of ethical practicalities. For example, Section E13 of the Australian Psychological Society (2003) Code of Ethics states that:

> …no research procedures likely to cause severe distress should be used under any circumstances. If unexpected stress reactions of significance occur, the member has the responsibility immediately to alleviate such reactions and to terminate the investigation. If a research procedure involves participants in high levels of emotional arousal, it is incumbent on the member to ensure that no psychologically vulnerable person participates.

Since between 15 and 25% of musicians experience anxiety that is detrimental to their performance (McGinnis & Milling, 2005), and factors such as increased stress and focussing on negative cognitions can also reduce performance quality (Grillon et al., 2007), it is difficult to conceptualise experimental methodologies that satisfy the standards of governing bodies whilst maintaining methodological precision.

Despite this literature void, many researchers have proposed treatment strategies specific to musician experiences. These conclusions should only be established via true experimental designs that are based on established models of the underlying causal processes occurring between physiological and psychological variables (McBurney & White, 2007). Research regarding cognitive components of anxiety and the effects of reticocortical arousal on performance in broader anxiety literature highlights a growing need for inter-domain research. No explanatory models from other psychological domains have been effectively evaluated within the MPA field.

MPA studies have assessed the efficacy of treatments as broad as cognitive-behavioural therapy, relaxation therapy, biofeedback, hypnotherapy, meditation, drug interventions, and music therapy (Kenny, 2005). McGinnis and Milling (2005) completed a comprehensive review of studies employing control/placebo comparisons within these treatment domains. They reported a scarcity of rigorous experimental designs compared to research within other performance anxiety domains. Indeed, very few justifiable conclusions arise from the review at all. Most of the available treatments demonstrated only marginal superiority over control/placebo conditions. McGinnis and Milling suggested that reasons for these relatively trivial findings include insufficient power (only four studies reviewed employed a sample size larger than 10) and an over-reliance on self-report outcome measures, single-therapist provision of treatment (usually the primary researcher), and a lack of long-term follow-up.

Another common problem in MPA research is the use of poorly defined constructs. Terms such as stage fright, arousal, activation, and performance anxiety have been used interchangeably by theorists who come from a wide variety of traditions (e.g., psychoanalytic, phenomenological, biological, cognitive, and behavioural). Researchers have defined and measured constructs differently (and sometimes disparately), which diminishes the ability of future researchers to make accurate inter-study comparisons (Fehm & Schmidt, 2006). With no valid explanatory model available from which to conceptualise the processes underlying the relationship between anxiety and performance, studies have been conducted on the basis of varied findings, personal opinions, worldviews, and anecdotal experience.

The Nature of Task Difficulty

The demand for standardised grading within formal musical training schools has provided an impetus for task difficulty research. Emergent pedagogical systems have adopted highly specific frameworks for deciding: (i) which technical skills should be associated with specific categorical ‘levels’ of task difficulty, and (ii) the relative weighting that specific skill requirements should be given when grading a piece (Winston, 2003). The subjectivity inherent in these decisions has resulted in significant disagreement between independent pedagogues (Ralston, 1999). For example, Bauer (as cited in Winston, 2003) selected four pieces that he thought typify early-intermediate, middle-intermediate, late-intermediate, and early-advanced grading levels. On the basis of this subjective decision, Bauer created a database of 1200 piano pieces that she levelled in comparison to these benchmarks. Similarly, Thompson (1976) categorised a number of pieces as elementary, intermediate, or advanced, but provided no details regarding these grading decisions. Non-empirical grading decisions have been made in a number of other publications (Butler, 1973; Hinson, 1987; Kern & Titus, 1964; Magrath, 1995; Maxwell, 1983; Newman, 1965). The subjectivity of task difficulty has resulted in large discrepancies between these grading systems (Winston, 2003). Importantly, each of the above systems was created for teaching, rather than experimentation, purposes and is therefore not useful for the present experimental research.

In an attempt to rectify the inconsistencies in past grading systems, some authors have proposed that pieces be graded using a strict set of technical criteria (Halbeck, 1992; Hu, 1991; Jones, 1988; Ralston, 1999; Scanlan, 1988). Scanlan’s (1988) criteria have been widely adopted in piano teaching books and dissertations. These criteria include a consideration of figuration (scale patterns and length), harmony and modulation, melody and rhythm, phrasing and articulation, and dynamics and ornamentation. Winston (2003), Halbeck (1992) and others have adapted these criteria in highly specific grading system configurations and designed piano indexes based on them. Despite this, no agreement has been reached regarding the relative importance of each technical component in determining the difficulty of a musical task. Neither may such specificity be practically useful for musical teachers. The subjectivity within this literature does however complicate task difficulty considerations in well-controlled experimental research.

There is value in considering broader (non-technical) factors that can contribute to a musician’s experience of task difficulty. There is a general consensus in the musical teaching community that pieces should be selected to match individual students (Winston, 2003). Factors worthy of consideration might include performer mood and skill (Halbeck, 1992), motivation (Winston, 2003), musicianship (Scanlan, 1988), and piece-relevant knowledge (Jarvis, 1987). Transactional models of performance stress could be extrapolated to predict that in any given performance the difficulty of a musical piece will be determined by the interaction between task-specific elements and performer-specific characteristics (Staal, 2004). No study has attempted to empirically model this interaction.

Confounding Effects of Task Difficulty

Task difficulty has been largely unconsidered in MPA research and has never been operationally defined and controlled in experimental studies. For example, LeBlanc et al. (1997) attempted to measure the effect that anxiety has on piano performances across different audience conditions: no audience; one researcher; all researchers plus a peer group. The measurement of audience moderation effects in this study provided strong ecological validity since some of the audience conditions strongly resembled those a musician might experience in real world performance arenas. Performance quality was rated via researcher assessment of the videotaped performances and performers prepared a piece of their choosing. The researchers did not impose restrictions on the subjective selection of performance pieces. Audience size and A-State covaried positively, and audience size and performance quality covaried negatively, both in a linear fashion. LeBlanc et al. concluded that A-State significantly impeded performance, however the validity of this conclusion is questionable. The researchers collected subjective performance quality ratings without reporting calculations of inter-rater reliability and failed to control for practice effects across the three testing conditions. Of more concern was the unoperationalised nature of key variables and the possibility that task differences might have affected performance quality. Since participants chose their own pieces, performance quality might be expected to vary depending upon performer skill, task difficulty, and a variety of other uncontrolled factors. Performance quality and anxiety may have each been affected by differences in task load relative to performer skill, and there is no reason to assume that these effects would vary in a linear fashion across the three audience conditions.

More recent studies have improved external validity by formally operationalising dependent variables. Egner and Gruzelier (2002) evaluated the extent to which attention and relaxation neurofeedback training can improve musical performance in two consecutive studies. In their first study, 22 tertiary level music students were trained in neurofeedback protocols, and their pre- and post-training performances compared to a ‘no training’ control group (n = 14). A significant improvement in performance was found for musicians with neurofeedback training. This study improved on the methodology adopted by LeBlanc et al. (1997) since examiners were blind to group membership and performance order, meaning that examiner bias was adequately minimised. Despite this strength, participants performed two separate pieces of their own choosing at pre- and post-test. No attempt was made to equate the various pieces in any way. Consequently, interpretation of results was still limited by the possible extraneous influences imposed by task differences at both testing times and between participants.

For within- and between-subject research designs, changes in anxiety indicators are measured and compared between conditions or participants respectively. In MPA research there is arguably no valid basis for quantitative comparison when using either methodology exclusively. Participants playing different pieces might differ in performance quality as a function of task difficulty; that is, differences in performance quality are mere artefacts of the differences in difficulty between pieces. Similarly, anxiety levels of participants playing the same piece across different scenarios might be influenced by unaccountable differences between qualitatively different situational factors. The performance arena is too complex to fully equate these factors experimentally without compromising ecological validity. Nevertheless, music experiments need to be designed with greater rigour than they have in the past.

Methodological limitations aside, the problem in current MPA literature has been an ignorance of the effect that the task itself might have on anxiety and/or performance quality (e.g., Salmon, Schrodt, & Wright, 1989). Anxiety arises in anticipation of future danger. This means that any potentially threatening future event can evoke an anxiety response. Musical task difficulty cannot be ruled out as an extraneous factor in these studies. Some researchers have indicated that they considered task difficulty during experimentation (LeBlanc et al., 1997), however choices regarding task difficulty and the possible effect this might have on research results have not been empirically driven. For example, LeBlanc et al. avoided standardisation of their musical tasks because “[they] thought it would be unattractive to [their] participants” (p. 484). Inter-study comparisons cannot be validly made since there is no set of operationalised criteria to guide the manipulation of musical tasks. Given this, it is necessary for future research to equate and control for variations in task difficulty. Before this can be attempted, musical task difficulty needs to first be explored and defined.

Cognitive load research (reviewed by Berggren & Derakshan, 2012) might offer some insight into the nature of musical task difficulty. Tasks with greater structural complexity (more notes, articulations, and dynamics) and played at faster speeds might be argued to impose a greater cognitive load. Attentional control required for successful performance would therefore increase concurrently with task load. Any restriction of attentional resources would then be likely to increase the probability of performance errors when cognitive load is highest. This probability may not increase in a linear fashion; rather, observable errors may only occur once a particular cognitive load is surpassed.

Establishing Validity for Tasks Used in Music Experimentation

There are no accurate methods available for quantifying musical tasks for testing purposes. This means that task difficulty cannot be treated as a continuous variable in experimental research. No study to date has rank ordered musical tasks in terms of task difficulty; rather, performers have typically been assessed for performance anxiety whilst performing a personally chosen piece. As previously discussed, the internal validity of such studies has likely been confounded by a complex interaction of task and performer differences. Ordinal ranking of specific musical tasks by task difficulty would allow researchers to equate and remove variance in performance ratings contributed by specific intra-performer factors (such as A-Trait) at each level of the experimental task, since the task itself would be varying uniformly for all participants. Ideally, only one component of the task should be manipulated at each level of difficulty, since differences in perceived difficulty could then be attributed to specific task factors. The sheer number of elements within a musical piece may mean that this is inefficient (requiring participants to potentially perform a very large number of piece variations). Nevertheless, it is desirable to minimise the number of elements varied between each level of the task, and this may mean that easier pieces with fewer manipulable elements are better suited for experimentation.

Accurate rank-ordering of musical tasks by task difficulty needs to be theory-driven since linearity of task variations cannot be quantified for musical tasks. An inductive approach might be used, allowing high level musicians to comment on the perceived linearity of variations. Although not mathematically driven, this approach draws upon the collated perceptions of experienced musicians to establish accurate task ordering, which is perhaps the best that can be achieved in musical research until a quantification process is established. To date no study has identified the factors that contribute to a difficult musical task, much less utilised these factors to design experimental variations of musical tasks that satisfy both face and content validity.

Individual Differences

Musician performance anxiety is observed across all ages and ability levels (van Kemenade et al., 1995), however researchers have typically limited the scope of their assessment to child (<12), adolescent (12-19), or adult (18+) samples (e.g., Fishbein et al., 1988; Osborne, Kenny, & Holsomback, 2005; Ryan, 1998). Gender differences also emerge within these studies, with prevalence rates consistently higher in female musicians (Abel & Larkin, 1990; Rae & McCambridge, 2004; Schröder & Liebelt, 1999). Although correlated with anxiety magnitude, these factors do not necessarily correlate with performance outcomes (LeBlanc et al., 1997). Theoretically, an elegant attentional model for predicting performance outcomes should demonstrate good fit across gender and age categorical groupings.

Some researchers have argued that personality factors (i.e., extraversion, A-Trait, and perfectionism) can influence MPA (Buttsworth & Smith, 1995; Mor, Day, Flett, & Hewitt, 1995). Ruggiero (2006) noted that extraversion became a non-significant predictor once gender and A-Trait were added to his regression model. Similarly, Kenny, Davis, and Oates (2004) found that perfectionism did not predict a significant proportion of variance in MPA after A-Trait and A-State were entered into their regression model. A-Trait is the only personality factor that has consistently predicted MPA (Kokotsaki & Davidson, 2003; Ruggiero, 2006; Yoshie, Kudo, & Ohtsuki, 2008). This is to be expected, given the historic importance of A-

Trait across every performance domain. A-Trait is therefore a necessary factor to include in any study evaluating a model of musician performance.

Performance Quality Scoring Procedures

There is a division between those researchers, clinicians, and teachers who believe musical performance can be evaluated quantitatively and those that do not. This disagreement seems to be dependent on one's philosophy regarding the nature of music and the value and accuracy of such quantification (Wrigley, 2005). Proponents of qualitative (intuitive) evaluation have contended that examiner value judgements are consistent with the holistic nature of music, which cannot be segmented and quantified without compromising the global substance of a performance (Johnson, 1997; Mills, 1991). Nevertheless, Wrigley (2005) has proposed that quantification of musical ratings is possible via inter-subjective objectivity – an evaluation of the shared meaning that independent observers attribute to an event (Annett, 2002). This is important, because the traditional subjective-only approach to musical performance evaluation has produced an observable halo-effect on the basis of factors such as gender, instrument type, and attractiveness (Davidson & Coimbra, 2001; Elliott, 1995).

Davidson et al. (1998) designed the Music Performance Quality Rating Form. Performances on this scale are quantitatively scored in five domains (e.g., technical competency). Each domain is scored on a five point Likert scale that specifies a percentage range for each possible response (e.g., for technical competency, 1 = "seldom performs with right notes or with mistakes constantly [0–25%]"; 5 = "very secured strong fingers with perfect techniques in the difficult passages [95–100%]"). The mean of these five ratings provides an Average Performance Quality rating. A sixth item asks jurors to rate the Overall Performance. Davidson et al. argued that quantitative musical performance ratings are the only way to ensure inter-examiner consistency. Lin, Chang, Zemon, and Midlarsky (2008) conducted the only study to date that has used the Music Performance Quality Rating Form. They produced acceptable inter-rater reliability for both Average Performance Quality scores ($r = .77$) and Overall Performance scores ($r = .70$). Some statisticians advise against the use of single-items for measurement of ambiguous constructs (Youngblut & Casper, 1993). No study to date has determined the dimensionality of musical constructs such as technical competency. This scale is therefore of limited value in producing valid performance quality ratings.

Wrigley (2005) developed the Performance Examination Report using the previously described inter-subjective objectivity method. Tertiary performance examination reports were thematically analysed, and data reduced to a set of instrument-specific criteria. Structural equation modelling was then used to estimate the relationships between component factors within instrument-specific versions of the rubric. The piano version of the rubric demonstrated very high inter-rater reliability (r = .98) and was unaffected by performer gender. Consequently, the Performance Examination Report appears to be the most useful evaluation tool for complex performance assessment. Latimer, Bergee, and Cohen (2010) evaluated a similar rubric, however the construction and validation process was less comprehensive and produced lower reliability and validity ratings than Wrigley's contribution.

The Performance Examination Report was developed and validated on tertiary students performing their usual live assessments. This may mean that the measure is too complicated to be used in evaluations of less able groups of musicians. Indeed many of the component factors are irrelevant in basic and intermediate level performances (Kageyama, 2007). The relationship between anxiety and performance exists independent of performer skill (Salmon, 1990). In order to establish a model of anxiety-related performance outcomes, researchers therefore require a tool or method that is valid at *any* performance level. Additionally, models that explain performance outcomes using factors that vary throughout the performance (as is proposed in Attentional Control Theory) require an evaluation method that tracks discrete changes in outcomes across the performance. Error counts are one such method that has been previously recommended (Appel, 1976).

Kageyama (2007) opposed error counts and other component measures of performance quality, arguing that they lack ecological validity and focus solely on decreases in quality. He constructed a single global scale (1-90 divided into 10-point increments), which was completed for each participant performance by three highly accomplished musical figures. This examiner-driven rating system marked a return to intuition-based assessment and demonstrated acceptable inter-rater reliability (r =

.71) but inconsistent inter-rater correlations. Indeed, Kageyama chose to discard ratings from two judges to deal with these inconsistencies.

Intuition-based assessments are increasingly obsolete in performance evaluation contexts (Wrigley, 2005). Nevertheless, Kageyama (2007) raised some valid points regarding the use of negative-only discrete measures for performance quality evaluation. There are alternative methods that researchers might consider to counter the negative bias inherent in this approach. In reality, musicians treat errors in varying ways. Some continue forward in the piece while others repeat the incorrect musical chunk until mastered. The first approach results in a completion time more consistent with the requirements of the piece, the second a greater *percentage* of correct notes. Future researchers can adopt multiple indicators of performance quality, such as completing an error count *and* establishing the number of chunks repeated, percentage of correct notes played (despite errors), and length of the piece. This is one example of a multi-dimensional approach to measuring performance quality discretely across the duration of a piece that does not create a negative-bias in quality assessment. No research has attempted this form of evaluation, so there is no indication to date of the possible utility and effectiveness of such as approach.

Accurate quantification of performance quality is likely to require a rating strategy that is compatible with the inter-task differences in a given study. Whether a global scale is able to provide this is arguable. Before this problem can be addressed, researchers need to more thoroughly explore the nature of musical tasks (as experienced by musicians), to determine the component domains that quantitative ratings should measure. Doing so from the perspective of musicians recognises the subjective nature of musical tasks (a key point raised by those against quality quantification) and does not position the researcher as expert. Inconsistencies between subjective musical experience and subsequent rating methodologies would therefore be minimised, since it is commonalities between real-world musical experiences that would be driving quantitative weightings and ratings.

Chapter Summary

The experience of physiological, cognitive, and behavioural anxiety symptoms is common and often debilitating amongst musicians. In fact, rates of debilitating anxiety in musician samples are consistently higher than those observed in any other form of anxiety and in any other performer population. Performance effects inconsistently coincide with these symptoms. The causal mechanisms through which this anxiety-performance relationship occurs are currently unknown. Domain-specific models for predicting performance outcomes on the basis of anxiety factors have been empirically inadequate. Cross-domain similarities in error response and processing suggest that a non-specific attentional model might be a more elegant solution. Attentional Control Theory is a good starting point for this, since it already demonstrates utility in cognitive anxiety literature and, to a limited extent, perceptuomotor performance anxiety literature. In order to test the applicability of the theory to the musician experience, robust experimental designs are needed. Such studies should control task difficulty variations very carefully so that inter-piece variations do not contribute extraneous variability. Perhaps the most accurate approach available with current technology is to rank order by task difficulty with single elements being varied between each task. Finally, task variations need to be varied in a manner consistent with whichever quantification method is used to convert performances into quality outcomes.

Chapter 4. Rationale and Predictions

The aim of this doctoral contribution was to evaluate the extent to which Attentional Control Theory (ACT) hypotheses predict variation in efficiency and effectiveness in the musical performance arena. Importantly, this is the first contribution to do so without dichotomising A-Trait. To accomplish these goals, the experiment needed to be able to capture trait anxiety-related changes in: (i) attentional focus and flexibility, (ii) efficiency of specific working memory functions, and (iii) cognitive load (Berggren & Derakshan, 2012; Eysenck et al., 2007). Previous perceptuomotor studies have provided evidence that anxiety, attention, and performance outcomes are linked (Causer et al., 2011; Smith et al., 2001; Wilson et al., 2007). Preliminary evidence also suggests that anxiety can reduce the saliency of goal-directed processes in perceptuomotor tasks (Causer et al., 2011), although this has not been linked to A-Trait specifically. To date, no contribution has evaluated ACT hypotheses using a perceptuomotor dual task paradigm. There is therefore no evidence that the anxiety-related inhibition and shifting effects observed in cognition experiments would emerge similarly during complex perceptuomotor tasks. The possible utility of ACT for predicting musical performance anxiety (MPA) outcomes has been suggested (Kenny, 2011) but not yet tested.

A-State is inconsistently related to efficiency and effectiveness outcomes (see Eysenck et al., 2007 for an overview of relevant studies). However differences in A-Trait reliably impact attentional processes (Berggren & Derakshan, 2012). In the present study, A-State was not measured. Instead, this research was interested in determining the extent to which A-Trait predicts efficiency and effectiveness in a musical task when it is treated as a continuous variable. The two distraction condition wordlists (social threat, neutral) were taken from Helfinstein et al. (2008), who showed that the social threat words produce an attentional bias in those with anxious personalities. Employing these wordlists as high/low threat conditions meant that A-State did not need to be measured. Therefore, the present study was able to avoid the issues associated with continuous A-State measurement that have plagued previous perceptuomotor studies.

Two valid and reliable self-report MPA measures are available. The Kenny Music Performance Anxiety Inventory (K-MPAI: Kenny et al., 2004) is a self-report measure of MPA symptom severity. Osborne and Kenny's (2005) Musician Performance Anxiety Inventory for Adolescents (MPAI-A) is a similar measure, which is used to estimate symptom severity in adolescent musicians. The present research used Spielberger's (1983) STAI rather than either of these MPA questionnaires. This was because MPA diagnosis was not the focus of the research per se; rather, the researcher was interested in using musicians to test ACT hypotheses. The STAI has been frequently used to measure A-Trait in previous ACT studies. Using it here allows for direct comparisons to be made with these studies.

Piano players have often been used to study performance anxiety (e.g., Cheng et al., 2011; Wristen et al., 2006).The piano is a ubiquitous instrument; many children start on the piano and often musicians learning another instruments to a high level are required to become proficient on the piano. In addition, electronic pianos and MIDI notation software allow researchers to develop a level of experimental precision that may be more difficult to obtain using some other types of instruments. For these reasons, piano performance was chosen as the focus of the present research.

Study 1

The first goal of the present research was to create three musical tasks of increasing difficulty so that ACT hypotheses could be evaluated across discrete levels of task load. No researcher to date has equated or ranked the musical tasks that participants have been required to perform. Indeed, task difficulty itself has been overlooked in previous musical performance studies (e.g., Egner & Gruzelier, 2002; LeBlanc et al., 1997). Participants have typically self-selected performance pieces, which reduces experimental validity since there is no quantitative basis upon which to compare the tasks that each participant engages with. Attentional control research supports the importance of considering task load when designing an experiment. When working memory requirements are taxing, anxious individuals seem to be more likely to recruit auxiliary resources to neutralise task-irrelevant distractors (Ansari & Derakshan, 2011). Alternatively, easier tasks may impair efficiency outcomes precisely because they do not pose a high enough cognitive load to activate compensatory processes (Berggren & Derakshan, 2012). In order to test these sorts of task load effects in musical performance it was necessary to first establish a means of measuring musical task load. Study 1 was therefore a novel piece of research *and* a necessary preparation for Study 2.

Musical Task Selection

No template for experimental task design was available in music literature for this undertaking. Therefore a new type of experimental task was created. To do this, I (the researcher) located and sight read all of the piano examination pieces in the 1990-1995 AMEB curriculums for Grades one to three. I wanted to use a relatively easy piece so that a wide range of piano players at different skill levels would be able to perform the task. Similarly, I assumed that musicians would be less likely to encounter or remember a piece derived from a now unused curriculum. As I played each of the pieces, I held in mind my goal to create easier variations of the piece by manipulating the number of notes in both the treble and bass. I chose Telemann's *A Graceful Dance* because it has a simple harmonic structure that lends itself well to note deletion without compromising this structure. It is played at a moderate tempo and does not contain complicated articulations or dynamics.

In order to capture anxiety-related outcomes across different levels of task difficulty, three musical tasks were created. The unquantifiable nature of music means that this could not be done with the precision typically expected of a controlled experiment. Instead, the pieces were qualitatively rank ordered and manipulated so that they maximised face and content validity and were perceived by experienced musicians to vary in difficulty in as close to a linear fashion as possible.

Establishing the Criteria that Comprise 'Task Difficulty'

The first step in the research process was to compile an exhaustive archive of factors that require consideration when manipulating task difficulty in musical tasks. The difficulty of musical tasks cannot be directly quantified; rather, it is experienced by the musician engaging the task, whose perceptions can be collated and ranked using qualitative techniques. Interviews were therefore the most suitable data collection method for this phase of the research. Current tertiary level musicians were considered well-qualified for participation since they are required to engage with and perform a range of styles and composers each semester throughout their degree.

Establishing the Validity of Three Musical Tasks

There are no accurate methods available for quantifying the elements of a musical task. This means that task difficulty cannot be treated as a continuous variable in experimental research. No study to date has rank ordered musical tasks in terms of task difficulty for experimentation purposes; rather, performers have typically been assessed for performance anxiety whilst performing a personally chosen piece. The internal validity of such studies has likely been confounded by a complex interaction of task and performer differences. Ordinal ranking of specific musical tasks by task difficulty would allow researchers to estimate the variance in performance ratings contributed by specific intra-performer factors (such as anxiety) at each level of the experimental task, since the task itself would be varying uniformly for all participants.

Accurate rank-ordering of musical tasks by task difficulty needs to be theory-driven because linearity of task variations cannot be directly quantified for musical tasks. An inductive approach might be used, allowing high level musicians to comment on the perceived linearity of variations. Although this approach is not mathematical, it draws upon the collated perceptions of experienced musicians to establish accurate task ordering, which is perhaps the best that might be achieved in musical research at present. To date no study has identified the factors that contribute to a difficult musical task, much less utilised these factors to design experimental variations of musical tasks that satisfy both face and content validity.

Research Aims

A qualitative methodology was employed for this study. Specifically, thematic analysis was used to identify the relative importance of categorical data regarding the component structure of musical task difficulty. Inductive analysis (Constas, 1992) allowed participants to shape the emergent data to best replicate their collective experiences of task difficulty across their musical careers. No hypotheses were proposed for the study. To minimise researcher bias, the naming of categories was left to participants and any deviations from this were explicitly identified and reflectively discussed. It should be noted that the researcher only undertook to name categories when similar content was discussed by participants using inconsistent language. Within this framework, the goals of the study were to:

1. Identify the important criteria that contribute to the difficulty of a musical task (termed 'task difficulty').
2. Evaluate the extent to which three variations of Telemann's *A Graceful Dance* vary according to these criteria.
3. Make appropriate changes to the three variations of Telemann's *A Graceful Dance* so that increases in 'task difficulty' between the pieces resemble a linear progression.

Study 2A

Attentional control studies have primarily measured efficiency and effectiveness as continuous variables (e.g., Ansari et al., 2008; Derakshan et al., 2009; Ettinger et al., 2007; Helfinstein et al., 2008). In contrast, musical task grading has most often relied on the subjective judgements of expert musicians, which are formed after listening to the entirety of a performance (e.g., Lin et al., 2008; Kageyama, 2007). This strategy is notoriously vulnerable to halo and horn effects (Davidson & Coimbra, 2001; Elliott, 1995). In order to reliably capture anxiety-related changes in effectiveness in the present research, a continuous grading procedure was needed. Study 2A piloted a novel quantitative performance grading procedure that was developed as part of the present research. Objective precision was obtained in the grading of effectiveness outcomes. This is a significant contribution to the field since it drastically minimises error variance attributable to the subjective judgements of an examiner.

The experimental procedure designed to evaluate ACT predictions was complex, requiring the research administrator to run software on two separate computer displays and concurrently complete an examination administration form. Study 2A therefore also provided an opportunity for the researcher to practice administering the experiment in order to identify and modify procedural inefficiencies and minimise administration errors prior to conducting the full-scale experiment.

Research Aims

This pilot study was run in order to:

1. Standardise experiment administration through practice and repetition.
2. Standardise a novel grading procedure for quantifying the effectiveness of musician performances.

Study 2B

Study 2 evaluated the effect of anxiety and distraction on pianist processing efficiency and resultant performance effectiveness. Without working memory studies to draw upon in musical performance literature, the size of effects imposed by anxiety and distraction on cognitive processes could not be estimated. Dual task paradigms are effective at disrupting compensatory processes for anxious performers (Gazzaley, 2011). The effect of distractor interference on working memory functions has previously produced large group differences between high/low A-Trait performers within these paradigms (Berggren, Koster, & Derakshan, 2012). A similar design was therefore adopted for the present research. Each level of the sight reading task was presented once with no external distraction and no secondary task, once with neutral auditory distractors interspersed with an auditory target-response task, and once with social threat auditory distractors interspersed with the same auditory target-response task. Attentional bias studies have typically compared neutral and social threat distractor conditions (Eldar et al., 2010; Helfinstein et al., 2008). Helfinstein et al.'s (2008) neutral and social threat wordlists were used for the present study. The no distraction task condition was essentially a single task condition, and was included so that discrepancies in single and dual task efficiency indicators might be compared (replicating Berggren et al.'s [2012] comparison).

Established practice for designing a dual task requires that tasks prioritise independent sensory modalities (Duncan et al., 1997). Presenting stimuli to a single perceptual modality may overload perceptual processes rather than cognitive processes (e.g., Bishop, 2009). For example, concurrently performing two complex visual tasks is likely to disrupt stimulus perception at the visual cortex level, prior to engagement of higher-order working memory processing. This could be misinterpreted as working memory impairment since indices such as completion time or response latency are likely to be impacted in either case, but for very different reasons (Berggren & Derakshan, 2012). Attentional Control Theory specifically postulates a relationship between anxiety and central executive processes. Dual tasks therefore need to be modally dissimilar to avoid perceptual overload.

An auditory presentation and response modality was selected for the secondary task in the present study. Although sight reading requires auditory perception to monitor accuracy, it is primarily a visuomotor task involving the planning and production of motor movements to correspond with visually presented notation (Peretz & Zatorre, 2005). Visuospatial tasks are unlikely to be inhibited by secondary verbal response tasks (McLeod, 1977). Furthermore, previous studies have demonstrated the capacity for simultaneous processing of music and speech cues (Zatorre, Belin, & Penhune, 2002) and supported hypotheses of partial independence between music and speech perceptual systems (Reineke, 1981). These studies offer a measure of theoretical justification for the structure of the dual task used in the present research.

The two distraction-present conditions (neutral; social threat) were used to evaluate categorical findings in attentional control research. Specifically, A-Trait has been observed to impair processing efficiency to a greater extent when task-irrelevant social threat distractors are presented than when task-irrelevant neutral distractors are presented (Cisler & Koster, 2010; Eysenck & Derakshan, 2009). Furthermore, A-Trait has been observed to exact a significantly lower cost on processing efficiency (compared to either neutral or social threat conditions) when no task-irrelevant external distractors are presented during primary task performance (Berggren & Derakshan, 2012; Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). The same pattern of results should emerge in the present study.

Operationalisation of Key Variables

Participants were exposed to a randomly allocated order of all nine possible conditions (3 task difficulty conditions x 3 distraction conditions). Trait anxiety (A-Trait) was measured using the Trait scale from Spielberger’s (1983) State Trait Anxiety Inventory (STAI). Primary task processing efficiency was estimated by measuring piece completion time. Secondary task processing efficiency was operationally defined as the mean reaction time on the target-response task (RT). For each condition, mean RT was calculated using true positive responses only. Primary task completion time and secondary task RT latency are frequently adopted measures of processing efficiency in previous attentional control studies (Berggren & Derakshan, 2012; Eysenck et al., 2007). Primary task performance effectiveness was measured by scoring three performance criteria and combining these into a single composite measure (Composite) on which higher scores represent poorer performances. Cognitive load interference was estimated by tallying false positives, misses, and incorrect responses on the target-response task (Error Tally). This provided a calculation of location errors; that is, the number of times working memory capacity was exceeded during each of the dual task conditions.

Primary Task Efficiency Hypotheses

Study 1 produced qualitative estimates of task difficulty variation between the three sight reading tasks. Before ACT predictions could be evaluated it was important to confirm that task load varied quantitatively between the pieces. The between-groups design used in many ACT studies (comparing high/low A-Trait groups) does not allow individual differences to be equated between the groups. It is possible that high/low A-Trait groups differ in more than just their processing efficiency. This means it is impossible to disentangle task load (task only) from workload (task load x individual differences) effects. This is a crucial point, because Attentional Control Theory predicts that the effect of task load on processing efficiency will be exacerbated by high levels of anxiety, except when adequate compensatory resources can offset such anxiety effects (Eysenck et al., 2007). The present study was a pure repeated measures design. It was therefore possible to examine the variation in processing efficiency predicted by primary task load and the impact of anxiety on this variation (workload). As can be seen in Figure 4, it was hypothesised that:

> *Hypothesis 1A: Piece will have a significant main effect on musical task Completion Time such that Completion Time will increase linearly with task difficulty.*

Hypothesis 1B: There will be a significant Piece x A-Trait interaction for musical task Completion Time. Specifically, the linear effect of Piece on Completion Time will become more pronounced across increases in A-Trait.

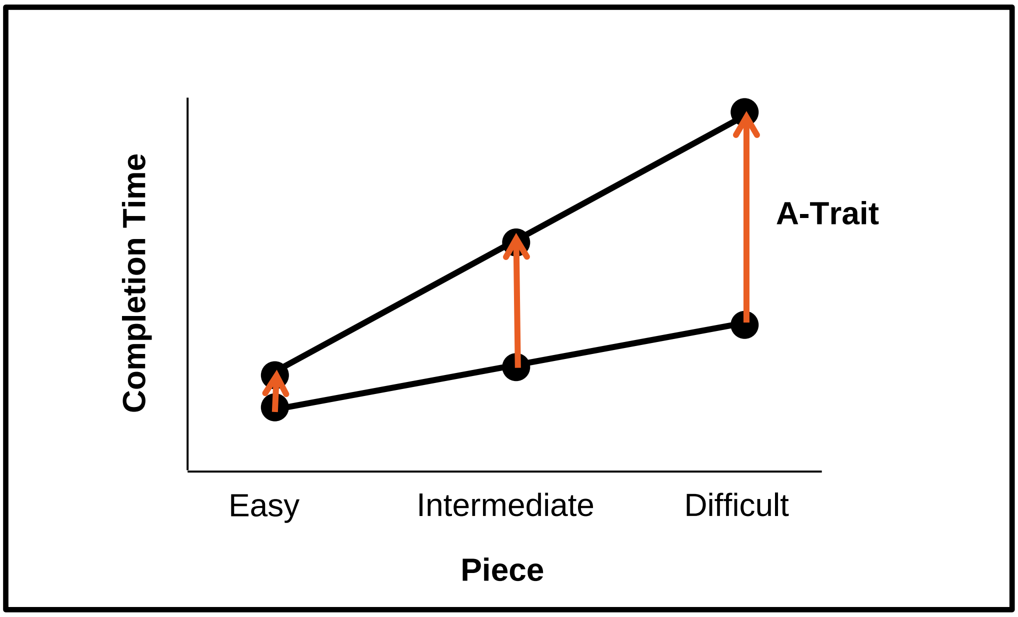

Figure 4. Hypothesised difference in Completion Time across three levels of Piece. Arrows indicate the continuous distribution of A-Trait scores (from low to high) against Completion Time outcomes for each piece.

Attentional Control Theory predicts that task-irrelevant distractors produce greater processing impairments in those with high A-Trait (Eysenck et al., 2007). This is due to a shift in attentional focus that prioritises stimulus-driven processes over goal-directed processes. Threatening task-irrelevant distractors further exaggerate A-Trait effects (Fox, Russo, Bowles, & Dutton, 2001). In the present study, these effects should be evidenced by a reduction in efficiency on the sight reading task when distractors are presented and particularly when these distractors contain threatening content. It was hypothesised that:

Hypothesis 2: There will be a significant A-Trait x Distraction interaction for musical task Completion Time. Specifically, Completion Time will increase linearly as a function of A-Trait; this linear increase will be greatest for Social Threat Distraction and smaller for Neutral Distraction (depicted in Figure 5).

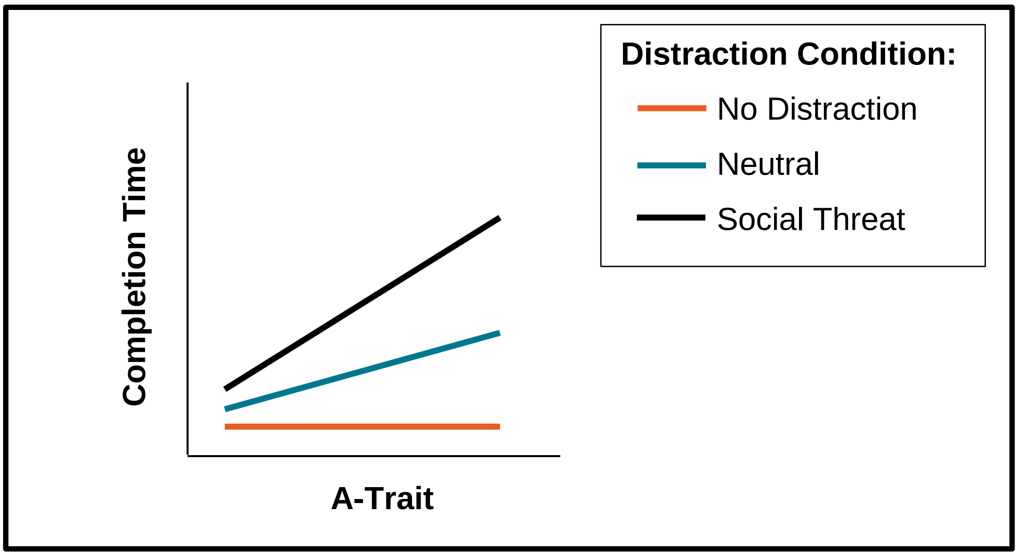

Figure 5. Hypothesised relationship between Trait Anxiety (A-Trait) and Completion Time across three levels of Distraction.

Primary Task Effectiveness Hypotheses

It was necessary to disentangle task load from workload. Task load was conceptualised as the variation in performance outcomes (effectiveness) produced by changes in the processing requirements of the primary task. Attentional Control Theory predicts that A-Trait moderates the level of impairment observed in effectiveness indicators. Essentially, the A-Trait x Piece interaction is a measure of workload effects. Moderately difficult tasks appear to activate compensatory processes in anxious performers so that performance impairment is minimised (Eysenck et al., 2007). These protective factors are increasingly ineffective once working memory requirements exceed capacity limits (Berggren & Derakshan, 2012). It was predicted that the sight reading task used in the present study would produce increasingly greater impairment as task load increased, and that the magnitude of these impairments would increase as a function of A-Trait (depicted in Figure 6). Specifically:

Hypothesis 3A: Piece will have a non-linear main effect on task performance effectiveness, as measured by Composite, such that there will be a significant increase in Composite from Easy to Intermediate and from Intermediate to

Difficult; however the latter increase will be significantly greater than the former.

Hypothesis 3B: There will be a significant Piece x A-Trait interaction for task performance effectiveness, as measured by Composite. Specifically, the non-linear effect of Piece on Composite will become more pronounced across increases in A-Trait.

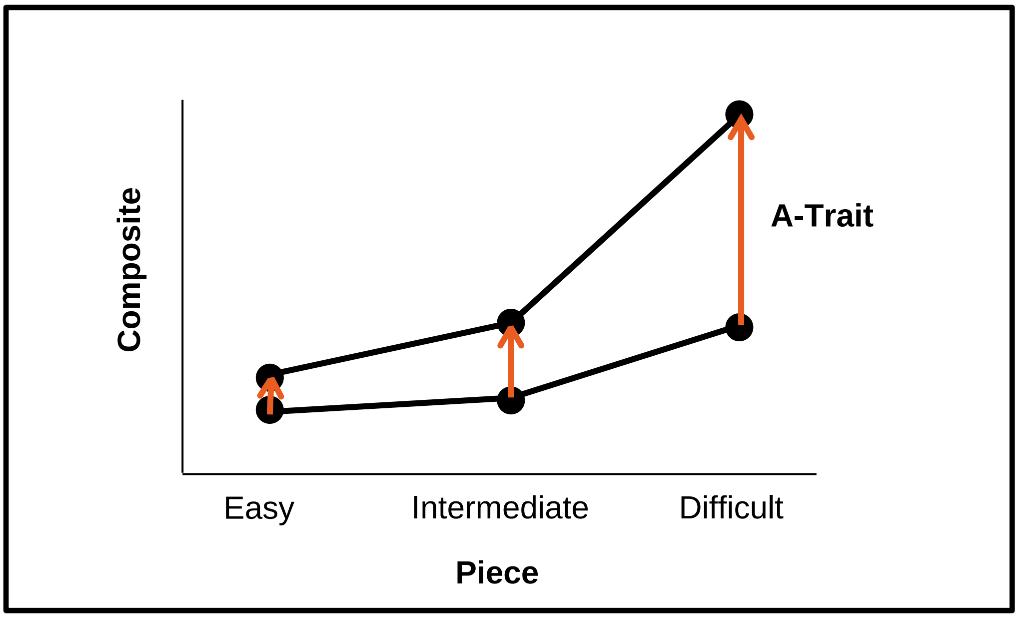

Figure 6. Hypothesised difference in performance effectiveness (Composite) across three levels of Piece. Arrows indicate the continuous distribution of A-Trait scores (from low to high) against Composite outcomes for each piece.

Attentional Control Theory makes separate predictions regarding efficiency and effectiveness. Observed performance is unlikely to be affected in easy tasks that do not require a substantial working memory investment (e.g., Bishop, 2009). Single tasks that impose a high working memory load may also be performed equally regardless of A-Trait if compensatory resources are employed (Eysenck et al., 2007). Dual tasks are one of the most effective methods for disrupting these compensatory strategies so that true A-Trait processing differences can be observed (Berggren & Derakshan, 2012). In the present study, it was proposed that the dual task would create increasingly noticeable performance deficits as the secondary processing load increased. Specifically, performing a sight reading task without distraction would produce better effectiveness scores than doing so with distraction. The saliency of social threat distractors to those with high A-Trait is likely to further exacerbate these outcome differences. Therefore:

Hypothesis 4: There will be a significant A-Trait x Distraction interaction for task performance effectiveness, as measured by Composite. Specifically, Composite will increase linearly as a function of A-Trait; this linear increase will be greatest for Social Threat Distraction, smaller for Neutral Distraction, and smallest for No Distraction (depicted in Figure 7).

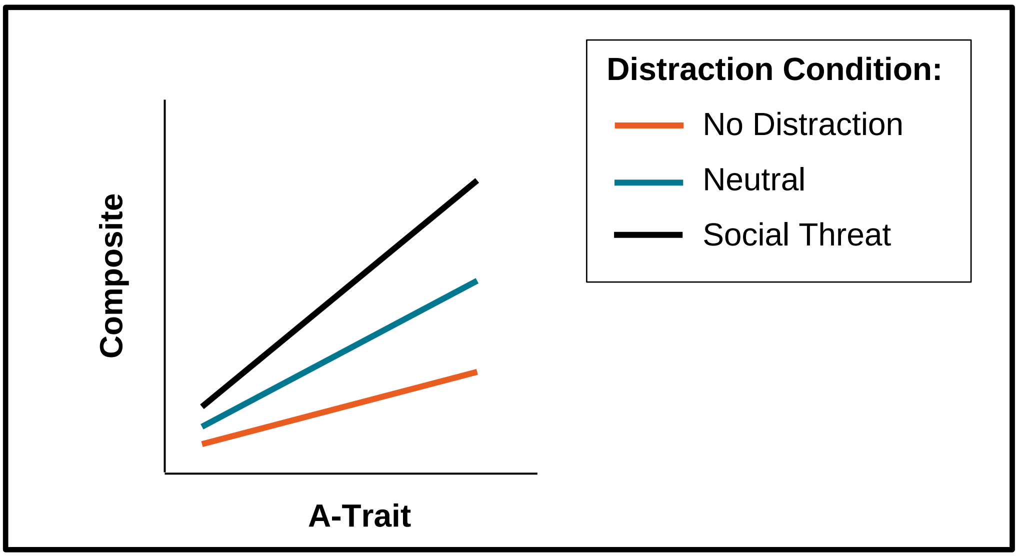

Figure 7. Hypothesised relationship between Trait Anxiety (A-Trait) and performance effectiveness (Composite) across three levels of Distraction.

Secondary Task Efficiency Hypotheses

Secondary task reaction time was included so that anxiety-related changes in attentional focus could be estimated for the musician sample. Attentional Control Theory predicts that anxiety upsets the balance between goal-directed and stimulus-driven attentional systems (Eysenck et al., 2007). Consequently, an attentional bias favouring the distractor modality should emerge as a function of A-Trait when social threat distractors are presented (as evidenced by faster reaction times). No attentional bias tends to emerge between high/low A-Trait participants when distractors are neutral (Bar-Haim et al., 2007). It was therefore hypothesised that:

Hypothesis 5: There will be a significant A-Trait x Distraction interaction for RT. Specifically, RT will remain stable across A-Trait levels in the Neutral Distraction condition, but significantly decrease across levels of A-Trait in the Social Threat Distraction condition (depicted in Figure 8).

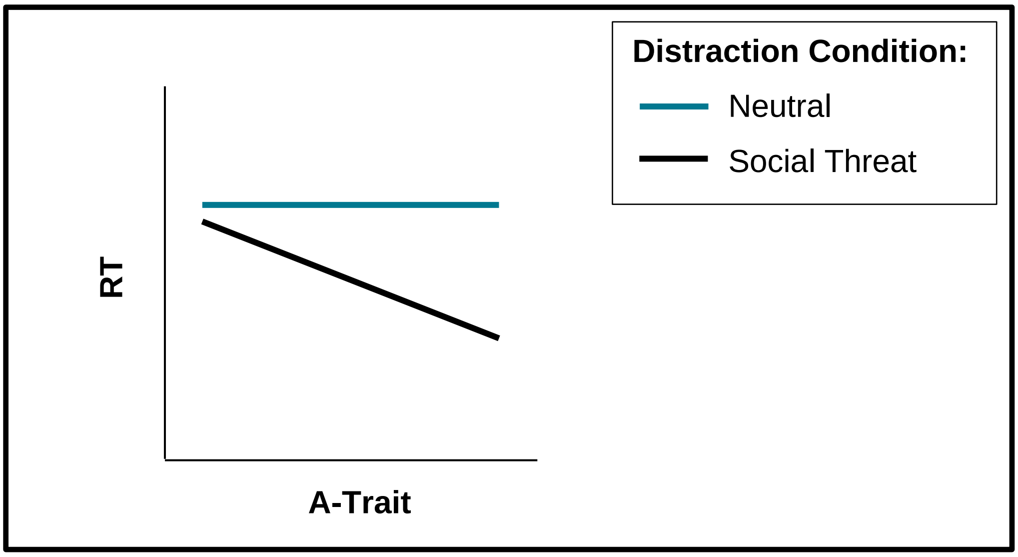

Figure 8. Hypothesised relationship between Trait Anxiety (A-Trait) and Reaction Time (RT) across two levels of Distraction.

The target-response task also allowed anxiety-related shifting effects to be estimated. Attentional Control Theory presumes that A-Trait disrupts the capacity to shift between tasks (Eysenck et al., 2007). This has most frequently been observed by measuring the latency between presentation of a secondary task and onset of correct responses. It was therefore hypothesised that:

Hypothesis 6: There will be a significant A-Trait x Piece interaction for RT. Specifically, RT will increase linearly as a function of A-Trait; this linear increase will be greatest for the Difficult piece, smaller for the Intermediate piece, and smallest for the Easy piece (depicted in Figure 9).

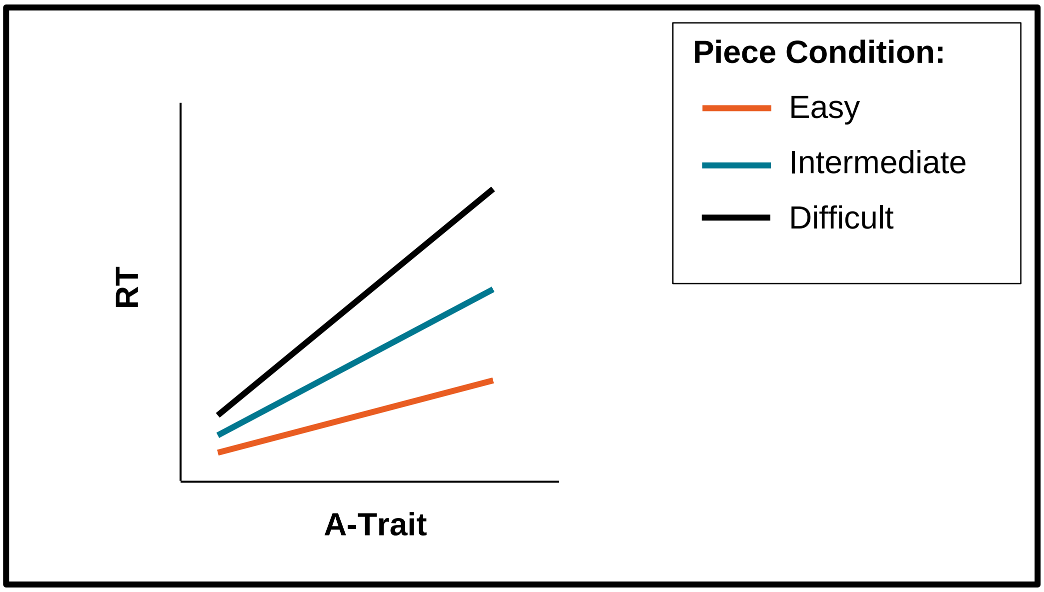

Figure 9. Hypothesised relationship between Trait Anxiety (A-Trait) and secondary task Reaction Time (RT) across three levels of Piece.

Cognitive Load Hypotheses

A high cognitive load can impose demands that exceed working memory limits (Gazzaley, 2011). The increased competition for cognitive resources inherent in a dual task paradigm tends to exacerbate error rates, particularly in the task of lowest priority because of the increase in cognitive load (Derakshan & Eysenck, 1998; Eysenck, Payne, & Derakshan, 2005; MacLeod & Donnellan, 1993). Thus, a sufficiently large increase in primary task difficulty should produce a higher Error Tally on the secondary task (lowest priority) in performers in the present study. This would be observed as a positive, linear Piece effect on Error Tally. Attentional Control Theory predicts that high A-Trait further increases the likelihood of interference effects (Eysenck et al., 2007). As a result, the capacity to shift attentional resources from one task to another would be impeded, producing either response errors in, or non-attendance to, the secondary task. It was therefore hypothesised that:

Hypothesis 7: There will be a significant A-Trait x Piece interaction for Error Tally. Specifically, Error Tally will increase linearly as a function of A-Trait; this linear increase will be greatest for the Difficult piece, smaller for the Intermediate piece, and smallest for the Easy piece (depicted in Figure 10).

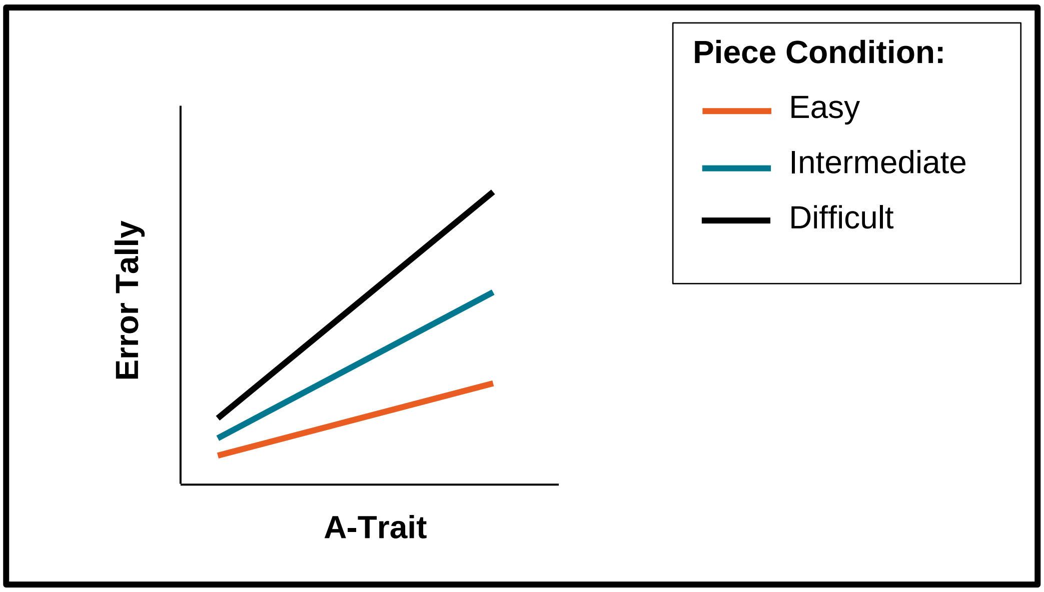

Figure 10. Hypothesised relationship between Trait Anxiety (A-Trait) and secondary task Error Tally across three levels of Piece.

Attentional Control Theory also predicts that the capacity to inhibit task-irrelevant distractors is impaired by anxiety, particularly when the distractors are threatening (Eysenck et al., 2007). It was therefore hypothesised that:

Hypothesis 8: There will be a significant A-Trait x Distraction interaction for Error Tally. Specifically, Error Tally will increase linearly as a function of A-Trait; this linear increase will be greatest for the Social Threat Distraction condition (depicted in Figure 11).

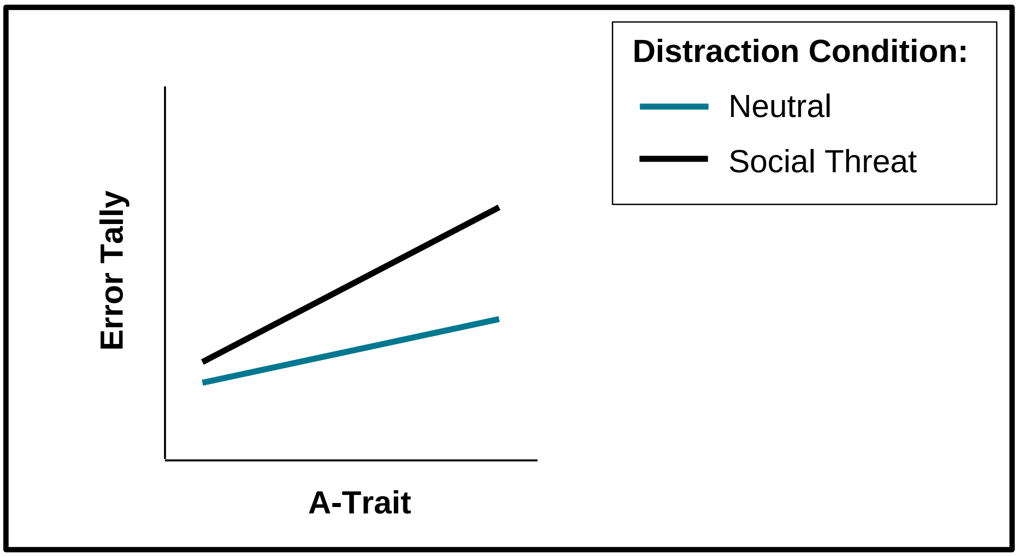

Figure 11. Hypothesised relationship between Trait Anxiety (A-Trait) and secondary task Error Tally across two levels of Distraction.

Three-Way Interactions (Task Difficulty x Distraction x A-Trait)

Significant three-way interactions have been produced in previous anti- and pro-saccade studies (Ansari et al., 2008; Ansari & Derakshan, 2011; Derakshan et al., 2009). However these interactions have only been observed in the context of single task paradigms. That is, participants in these studies did not engage in two simultaneous tasks. Berggren et al. (2012) included a secondary task (counting backwards in threes from a two digit number) to determine whether the interaction of A-Trait x primary task condition on reaction times and error rates varied in the presence/absence of a dual task load. This three-way interaction was not significant. There is therefore no evidence to support predictions of three-way interactions in the present study. Nevertheless, the results of the three-way interaction significance tests are reported in the Study 2 statistical analysis overview (p. 135).

Chapter 5. Study 1

Task difficulty has been overlooked in musical performance anxiety (MPA) research. As discussed in Chapter 3, participants have typically been allowed to choose their own performance pieces (e.g., Abrams & Manstead, 1981; Brotons, 1994; Egner & Gruzelier, 2002; Hamann & Sobaje, 1983; LeBlanc et al., 1997; Yoshi et al., 2009). There is no way to disentangle anxiety-related outcomes from task-related outcomes in these studies. That is, task load cannot be differentiated from work load (Staal, 2004). The present study fills this gap in the literature by conducting the first exploratory evaluation of musical task difficulty. The significance of this is twofold: (i) it provides a theory-driven basis upon which to quantifiably evaluate the relative importance of component features of task difficulty, and (ii) it provides a basis upon which to intentionally manipulate the content of musical tasks to vary task difficulty.

Musical pieces contain many technical and expressive components that have been used to determine their difficulty. Various arbitrary rating systems have been devised to group pieces into difficulty categories for teaching and examination purposes (e.g., Bauer, 1994; Butler, 1973; Hinson, 1987; Magrath, 1995; Thompson, 1976). Fewer researchers have attempted to differentiate pieces on the basis of a standardised set of criteria. The Ralston Repertoire Difficulty Index prioritised seven technical characteristics for determining the difficulty of vocal pieces (Ralston, 1999). Scanlan (1988) compiled a similar set of technical criteria for grading the difficulty of piano music. Although Scanlan’s criteria have been generally accepted, there is little agreement over the weighting of these criteria across difficulty levels (Winston, 2003). In fact, Scanlan’s criteria do not provide a quantitative rating of task difficulty; rather, they assist teachers/examiners to determine into which of three difficulty categories a piece best fits. No study has exhaustively investigated the component features of task difficulty beyond technical factors.

Winston (2003) suggested that teachers need to consider intra-performer factors when selecting performance pieces for students. Her work implies that the technicality of a piece interacts with musician factors to create the experience of difficulty. Winston goes so far as to suggest that pieces should be selected to match the character and mood of a student. No research has identified the extent to which individual differences such as these might impact task difficulty. The present study is the first to examine this from the perspective of musicians themselves. Rather than assuming an expert role, I (the researcher) chose to use a qualitative (inductive) process, in which experienced musicians drew upon their own musical experiences to identify the component features of task difficulty. Furthermore, it is the first study to utilise such data to validate the component structure of experimental musical tasks.

Cognitive load research might offer some insight into the nature of 'task difficulty'. In relation to 'task difficulty', one might suppose that greater structural complexity (more notes, articulations, and dynamics) will impose a higher cognitive load and therefore be more difficult. Although supported in cognitive performance literature (Berggren & Derakshan, 2012), this assumption has not been corroborated by empirical investigation using musical tasks. Entering this phase of the research, I (the researcher) was aware that I expected this relationship to emerge in the interview content. To address this source of bias, I attempted to evaluate the interaction between my assumptions and the emergent themes in my discussion of the results.

Method

Design and Analysis

A qualitative design was adopted in this study since there is no recognised method of quantifying the validity and difficulty of experimental musical tasks within performance literature. I analysed interview transcripts via thematic analysis. This methodology is strongly recommended when a researcher's primary interest is in identifying dominant meta-themes from a qualitative data set (Onwuegbuzie & Teddlie, 2003). The analysis was inductive, allowing the distinction, evolution, or removal of categories to be influenced additively by each interview. Goetz and LeCompte (1984) propose that a qualitative researcher's goal should be "to reconstruct the specific categories that participants [use] to conceptualise their own world view" (p. 6). As such, I selected categories that were either directly referred to by participants, or adequately reflected the content of participant responses. Where my own choice of wording for an emergent category was used, I sought to explain this through empirical argument (as per Constas, 1992). Moreover, I only did this when no specific name was given to a recurring idea by participants.

The linearity of difficulty between the three musical tasks evaluated in this study was also assessed using the same qualitative methodology. Of particular importance were data relating to the face validity of the difficulty increments between pieces and the perceived linearity of the difficulty curve. Participant responses were analysed thematically and have been presented in an aggregated format. Finally, participant feedback and task difficulty findings were used to revise the intermediate piece and evaluate the content validity of the three tasks.

Participants

Eight third- and fourth-year tertiary level piano students (females = 7; age range = 18-22; mean years playing = 14.5, SD = 0.75, range = 13-16) participated in this study. Of these, all had completed or were currently completing an Associate Diploma in Music, Australia (AMusA), all were involved in regular formal performance, and four were regularly engaged in paid piano work. Participation was voluntary, and all participants were informed that their involvement in the study was deemed an indication of consent. Sampling saturation was reached after interviewing eight participants, since no new information was emerging regarding dominant themes.

Apparatus

Four questions were developed as a skeletal structure for the first part of each interview (Table 2). Two structured sets of questions and procedures (outlined in Appendices A and B) were used for the second part of the interview. All interviews were recorded on a Sony ICD-B600 digital recorder.

The scores and recordings of three variations of Telemann’s *A Graceful Dance* (Appendix C) were presented during the interview (including “original”, “some notes removed”, and “many notes removed” variations). This piece is a 1994 Grade 1 AMEB piano piece, which has not been used in the AMEB curriculum for a number of years. The AMEB system contains eight grades. Although Grade 1 is the easiest level, completion of any graded examination requires a lot of practice. Sight reading a novel Grade 1 piece is therefore more difficult than performing a practiced

Grade 1 piece. The title and composer was removed prior to conducting interviews so that participants could not identify the piece from these sources of information. The simplicity of this piece means that it lends itself well to small, specific manipulations. The ‘difficult’ variation of the piece was unchanged from the original. The ‘intermediate’ variation had an identical treble to the original with all slurs and many of the articulation markings removed, and a simplified (fewer notes) bass line. To construct the ‘easy’ variation, the researcher identified the dominant chordal points in the song and removed all notes from treble and bass that did not coincide with one of these points. Thus, there are 1-3 notes in the treble and bass per bar for the entire song, and no articulations or dynamics markings. This was considered the simplest way to present the song without affecting its harmonic structure.

Table 2

Study 1 Interview Questions

Questions
1. What sorts of things do you think make a piece of music difficult?
2. When you envisage a difficult musical piece, what [thoughts, images] come to mind?
3. Can you describe a situation in which you were required to, or chose to, play a difficult piece of music?
4. Can you explain to me what characteristics a performer might have that would make a piece of music more difficult for that person?

Procedure

Participants were given an information sheet (Appendix D) outlining the nature of the study. Once this was read, the researcher asked if the interview could begin, and started the digital recorder. The start of each interview was largely unstructured, allowing small-talk while demographic details were informally collected. After a couple of minutes, participants were asked the first structured question. No time or content limit was allocated for this section; rather, the researcher assisted participants in exploring, communicating, and clarifying their opinions until these were exhausted. This same format was used as the researcher introduced each of the subsequent questions on the interview question sheet. If participants expressed difficulty in brainstorming ideas for the first and fourth questions, the researcher prompted them by asking open, non-leading questions about their opinions regarding themes that had emerged from previous interviews.

In the second part of the interview, participants were shown/played the musical scores and recordings. A coin flip determined whether they were shown the music (heads) or played the recordings (tails) first. ‘Heads’ indicated the administration of Appendix A followed by Appendix B, and ‘tails’ indicated reverse administration. Additionally, the presentation order of the three pieces (ABC, BCA, CAB, and so on) was randomly allocated.

Results

Interviews were transcribed verbatim and coded using a line-by-line approach. Informational content explaining the nature of ‘task difficulty’ was the primary focus of analysis. Two broad, interacting factors were revealed to affect task difficulty. These included extra-personal factors (characteristics of a piece of music that affect the difficulty of the piece, as experienced by all musicians) and intra-personal factors (those characteristics of a musician that influence the experienced difficulty of a musical piece for that person). Questions one and four produced explicit topical content regarding the intra- and extra-personal factors contributing to the difficulty of a musical task. Question two evoked deeper discussion regarding those components of difficult musical tasks that participants were most afraid of. Question three revealed the components of musical pieces that engaged participant attention during performance of difficult pieces. Responses for questions two and three did not reveal any new content; rather, they qualified and deepened information regarding the categories identified by questions one and four. Results have therefore been presented within two sections (‘extra-personal factors’ and ‘intra-personal factors’) in a quantitatively-informed order of importance (determined by the number of participants who discussed content pertaining to each emergent category). Within this section I will report key participant data and demonstrate the correspondence between participant data and any relevant psychological constructs. The relationships between emergent themes are depicted in Figure 12.

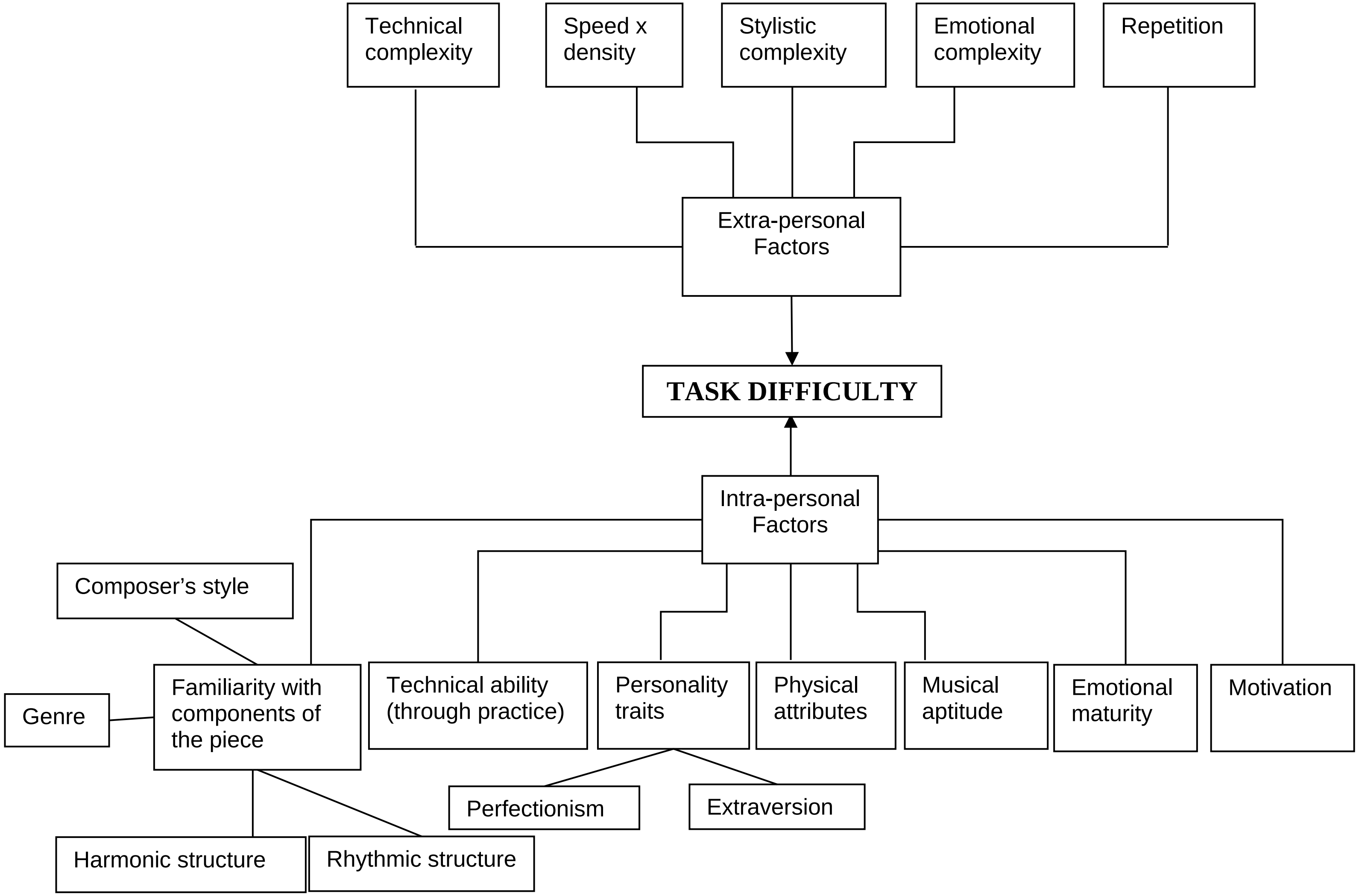

Figure 12. Figurative representation of the thematic composition of musical task difficulty.

Extra-Personal Factors

Technical complexity.

Technical components were the most frequently discussed and important elements that participants identified as contributing to task difficulty. Participant four (P4) was the first to explicitly mention technique. After listing a number of difficult structural components in music, she explained that “after [my teacher] wants me to use all those techniques [playing these songs] has actually become quite hard”. This comment links technique adherence to a perceived increase in musical difficulty. P4 then proceeded to explain that “anyone can play [a] piece, but not everyone can play it nicely…using your techniques like arm weight…I think that makes it difficult.” Again a direct connection is made between technical requirements and task difficulty.

Similar explicit statements were also made by P5, P6, and P7. Moreover, the remaining participants all identified difficulty-increasing aspects of specific techniques, although an umbrella category was not mentioned. Technical factors positively related to ‘task difficulty’ included: frequency and length of movements between registers (P2, P4, and P7); pedalling requirements (P4, P7); number of voices (P4, P7); frequency, speed, and complexity of ornaments (P5, P8); complexity of fingering (P5, P7, and P8); complexity of rhythmic structure (P1, P3, P4, P5, P7, and P8); frequency of harmonic modulations (with more distant harmonic changes posing a greater difficulty) (P4, P5); and complexity of articulations and dynamics (P1, P2, P5, P7, and P8).

Speed x density of notes.

Participants indicated that there is an interaction between the speed of a piece and the density of notes within that piece, such that increases in one factor or the other will not be as difficult as increases in both factors. Four participants expressed a belief that faster songs are more difficult (P1, P2, P5, and P7). P2 qualified this belief though, stating that if there is “lots to play in fast pieces then it’s a little bit harder”. This was mirrored by P6, who said that musical difficulty “would have a lot to do with the density of notes…sheer volume I guess”. These comments indicate that for these particular musicians, note density adds to the difficulty in a separate though interactive way with the speed of a piece. Moreover, dense sections that are patterned or repetitive were distinguished as being significantly easier than those that are less patterned or repetitive (P3, P6). Such sections "[do not contain] a continuous flow of notes but an erratic flow of notes" (P3). Additionally, P6 suggested that music "becomes easier…where I can find patterns to understand it". So more difficult pieces tend to be faster and contain dense, less patterned notation.

Participants did not limit the difficulty posed by density to note density specifically. P8 suggested that "lots of notes and…lots of little articulations" increases task difficulty. P3 concurred, explaining that "lots of dots, crescendos, accents here and there…the more in there the harder it is to play". These statements implicate both dense notation and dense articulation as potential increasers of task difficulty.

Stylistic complexity.

Some genres of music are more difficult because composers within these genres utilise techniques that are very complex or abstract. Participants in the current study gave many examples of composer- or style-specific considerations. P5 stated that "classical has to be nice and crisp"; P1 suggested that when playing "Bach, [I] make sure I'm counting the whole way through"; and P6 explained that it is important to "work out all the key changes…with 20th century music". Whilst familiarity (discussed in the next section) might reduce the effect of stylistic complexity on task difficulty somewhat, some styles of music are harder by virtue of their technical requirements. For example, some 20th century composers divorce dynamics, harmony, rhythm, and pitch, often requiring significant thought and calculation to reintegrate these components. A majority of participants in the present study confessed to experiencing significantly more difficulty with 20th century classical music than other styles because of these factors (P1, P2, P3, P6, and P8). It is important to note that, unlike the previous three factors, no participants specifically argued that stylistic complexity increased task difficulty, however the frequent discussion of stylistic considerations seems to indicate the presence of an influential factor. Although the content of this theme was derived from participant data, verification of this category was primarily established via empirical reasoning (Constas, 1992); that is, the informational sources described above expressed congruent content that was unrelated to previously identified categories. Therefore I propose that the category ‘stylistic complexity’ best describes the participant data outlined above.

Emotional complexity.

The expression of emotion in a piece often requires adherence to dynamics and articulation. Participants suggested that the more complex these characteristics are, the harder it will be to convey the emotional content of a piece. In fact, many seemed to agree with P8’s sentiment that sometimes “you can convey the emotion easily…and other times…there’s something there but you can’t quite put it across” (similarly mentioned by P1, P3, and P7). This factor was not implicated as a mere superfluous addition to ‘technical complexity’. Participants proposed that some pieces of music contain more complex emotional content than others; not technically, but experientially. P1 explained her frustration at often mastering the technical components of a piece without expressing the emotional substance contained in the piece:

> I often play a piece, and I thought it sounded really good, but it hasn’t communicated anything. It’s just been notes. And I might have [articulated well] but actually I didn’t feel anything; I just played it.

In P1’s experience, expressing emotional content during a performance seems to require the performer to do more than correctly articulate musical phrases. She strongly contended that “communicating …something of depth, some meaning, that’s what you’ve got to really take the time to think about”.

Repetition.

Participants proposed that repetition within a piece provides immediate local familiarity, which reduces task difficulty. P7 suggested that “If there’s a lot of repetition then I guess it’s easier to learn the notes because it’s the same”. Similarly, P6 claimed that if:

> There’s no repetition there’s no familiarity. Like no immediate local familiarity, and it becomes more difficult to just progress through it because you really have to think while you’re learning it without falling back on anything you remember just by repetition.

The inclusion of repetitions within a piece reduces difficulty since the quantity of novel content is reduced.

Intra-Personal Factors

Familiarity with components of the piece.

One's familiarity with aspects of a piece of music appears to be the most widely recognised intra-personal influence on task difficulty. Participants specifically referred to the benefits of being familiar with the composer's style, genre of the piece, harmonic structure, rhythmic structure, and musical repetition. Even though 'familiarity' was the key similarity between these factors, they were discussed quite separately by participants. Therefore, I will also report and discuss each of these factors independently in this section.

Composer's style. When participants discussed this point, they tended to agree that knowing the composer makes a piece easier for them to play. P1 admitted that when approaching a piece "I would think about what composer it is…because if [they are] really foreign…that would make it difficult for me at first". Other participants also agreed that "you have to know the composer" (P5), since "if you're unfamiliar with the composer or style then of course it becomes more difficult and there's more conscious thinking about it, therefore it's more challenging" (P6). This suggests that being familiar with the composer provides important information about a piece, consequently reducing the quantity of processing required when playing the piece. Specifically, participants suggested that knowing a composer's style may provide clues regarding the techniques (P3), nuances (P1, P3), and stylistic tendencies (P4, P5, and P6) utilised in a piece.

Genre. Similar to composer familiarity, the familiarity of a musician with the genre of a piece can affect the perceived difficulty. P3 acceded that "the genre – the style of music – is something that affects whether [a piece] is difficult or not". Some participants proposed that this is because familiar genres "feel more natural". For example, in discussing 20th century music P5 explained that "I hate modern pieces because sometimes you just can't understand [them]...it's all just 'alien'. I'm not used to it". This quote links her level of understanding of such pieces with her familiarity with the genre. Interestingly, many participants expressed a tendency and preference to play within genres they understand (P1, P3, P5, and P6). For example, P3 preferred playing blues, stating that "I don't find any of that difficult because I find it really natural". The specific result of her familiarity with this style is that "I don't have to think about what I'm doing [as much]". Familiarity seems to reduce the amount of conscious processing these musicians put into playing a piece.

Harmonic structure. Participants linked familiarity with the harmonic structure (P1, P5, and P6) and harmonic changes (P4, P6) within a song to task difficulty. In discussing song preferences, P1 admitted that "If I get to choose pieces…I'll choose flats…I generally like working in flats". She explained that most of the pieces she has chosen to play have been written in flats. Such a choice logically implies that flats have been more commonly experienced. It is therefore unsurprising that key signatures in flats "make more sense in my mind" (P1). P4 further elaborated this point to include familiarity with harmonic changes within a song. She suggested that "harmony changes you're used to [are] not that unpredictable so they're not that difficult". Similarly mentioned by other participants, these harmonic changes include modulations (P1, P5, and P6) and accidentals (P5, P6).

Rhythmic structure. Familiarity with the rhythmic structure of a song, including time signature and syncopation, seems to reduce task difficulty. P8 believed that:

> Awkward time signatures and different rhythmic patterns and syncopation…that's tricky…it's not something that you come across often. Something as simple as quavers and semiquavers and going between the two is fine because you see that often. But things like the three over two you don't see as much and never practice…if you don't encounter it a lot.

Implicit in this quote is the supposition that a lack of familiarity with complex rhythmic and polyrhythmic phrasing is directly responsible for the perceived difficulty of a musical piece. Other participants held comparable beliefs. For example, P7 said that:

> I haven't really played much non-standard, but maybe even 5/4 would be different - an unusual feel…4/4 just feels more natural than 5/4… most pieces would be like 4/4, 3/4, 6/8, 2/4, something like that… [I've] experienced those more often.

She went on to suggest that if a musician experienced complex time signatures more frequently “[one] would get used to it”.

P6 added a cultural component to this discussion, noting that Western musicians are “familiar with not only binary time signatures, but also with overall binary structures…typical ABAB forms”. This speculation fits well with the other quotes given above, indicating that a familiarity with binary rhythmic structure in Western music affects the perceived difficulty of musical tasks. Participants essentially agreed that “there’s something about having experienced those time signatures more frequently that makes them easier” (P6).

Technical ability through practice.

A number of participants emphasised that if the technical requirements of a piece were greater than the technical ability of a musician, the piece would be more difficult to play. In answering question four, P3 explained her belief that the difficulty of a piece can be affected by “technical ability I suppose…if [a piece is] a step up from what I’m used to”. This statement connects the technical requirements of a piece (mentioned above) with the technical capacity of the musician in determining task difficulty. Similarly, P5 said that a piece is easier for a person who has developed “more technical skills… [by doing] a lot of practice”, and P7 proposed that “practice helps in that your technique is better”. These participants all agreed that the technical ability of a musician, developed primarily through practice, is able to influence the perceived difficulty of a musical piece.

A number of participants identified specific technical abilities that a musician may progressively master to reduce the difficulty of subsequent pieces. These included: the control of arm weight and finger work (P4, P5, P6, P7, and P8); the correct articulation and modulation of volume, pitch, and tone (P8); and the capacity to play articulated phrases smoothly and up to speed (P5, P6, and P7).

Personality traits.

Some participants proposed that one’s personality might affect the difficulty of a piece of music. The two components of personality most often discussed included perfectionism and extraversion. Although participants did not specifically use these three terms, their wording very closely resembled these psychological constructs. In each section this resemblance will be discussed in further detail. It is important to note that 'personality' was discussed using words that reflect general character traits, rather than those of a specific personality theory.

Perfectionism. A commonly mentioned character trait was the tendency to have "high expectations" and a "desire to win". When mentioned, this trait was generally linked with an increase in task difficulty. P4 typified this perspective when she explained that "I used to have such high expectations of myself. I want to play the best…I like to compete with others…I want to be the best…that make some pieces difficult for [me] that [I] would say might not be so difficult for other people". In this comment P4 links personal expectations and a desire to "be the best" with increased difficulty relative to others. She then went on to elaborate on the manifestation of such self-expectations in her playing, including "[fixing] up all those details", the belief in "endless space for improvement", and a personal drive to "keep on refining and refining and refining it". P6 also indicated an observed link between high self-expectations and task difficulty, suggesting that "if the performer… demands too much of themselves, that's going to make any piece difficult for them to play because they're not always happy with what they're doing". He agreed that "someone who expects a lot of themselves…would find most pieces more difficult".

Introversion. Some participants believed that musical pieces are easier when they require a similar amount of energy to that typically displayed by a musician. For example, P2 acknowledged that "I'm sort of a shy girl. When I have to play big movements like Rachmaninoff…when I have to complete big movements with body gestures and stuff, then I can't really do it because my personality is not really as showy and as active as the music". In this comment, P2 links the difficulty she experiences when playing "big" songs to her "shy" personality. She agreed that "if a song is not in line with what your personality is then it's more difficult". Similarly, P6 explained that "someone who's not necessarily the most buoyant or chirpy person might find it difficult to convey that character in a certain piece, whereas they might put a dark and sombre…one can convey that character a lot easier". This quote also outlines the increased difficulty one experiences when attempting to convey a mood that is incongruent with one's personality. Finally, P7 expressed a belief that "if [a musician is] introverted and shy and [has] to play a piece that's really aggressive…it might be hard musically and technically…technically it might need bigger movements and they might be a bit shy to do that”. All three of these participants connect “introversion”, “shyness”, and/or “not buoyant or chirpy”, with increased difficulty when playing “showy”, “big”, and/or “aggressive” pieces. Although no participants discussed the difficulty experienced by extraverted musicians when playing quiet songs, P3 did admit she finds “slow pieces more difficult”, explaining that she tends to find the expression used in fast pieces easier to convey.

Physical attributes.

A variety of physical attributes were individually connected with task difficulty by participants, including posture (P4), hand size (P2, P3, P5, and P7), and strength (P2, P3, and P7). P7 suggested that “a smaller person would actually bring something to a softer more mellow song that a more energetic or bigger build person would bring to a faster song”. This was particularly discussed in relation to strength and hand size. P3 claimed that she has “trouble getting chords” because of her “little hands”. This was a similar experience for other participants: “because my hands aren’t that big…I try to stretch as much as I can…makes it really hard” (P4); “I can’t stretch very far, so if I have to…I find it really hard to connect each note because my hands will be hurting so much” (P5). These participants find pieces with bigger chords and hand movements more difficult because of their smaller hand size. Small hands do not necessarily make a piece more difficult though, since they can also be a “mechanical advantage” (P7). Whilst “bigger hands” were typically connected with “much more power” (P2, P7), they may also result in a musician “accenting when [they] don’t need to” (P7). P2, P3, P4, P5, and P7 all indicated a preference for softer songs because they are easier to play mechanically.

It is important to tease apart the independent influences of strength and hand size. P3 admitted that “my hands are tiny” but “I’ve got a very heavy touch on the piano [meaning] it’s harder for me to play soft”. In this excerpt both factors are perceived as influencing P3’s experience of musical pieces, though in a different way to the other small handed participants previously quoted. Whilst a smaller amount of strength appears to accompany small hand size for some of the participants, it was not always the case. Small hands appear to increase the difficulty of pieces requiring large movements and chords, whereas strength seems to influence the difficulty of a piece based on the heaviness of touch required for a song.

Musical aptitude.

The data I have used to justify this category does not specifically refer to ‘musical aptitude’. In spite of this, I selected ‘musical aptitude’ as a category since it encompasses the broad content offered by participants regarding three musical ‘abilities’ upon which individuals may differ. All of the data referred to below to justify this position were discussed by participants in response to question four only, and were specifically talked about in terms of abilities that one does or does not have. The three abilities discussed by participants included sense of rhythm, aural ability, and one’s capacity to conceptualise a structural meta-view of a piece while playing it. These abilities do not explicitly implicate musical aptitude as an emergent category. Nevertheless, this content is not adequately accounted for by the other intra-personal categories that emerged from this analysis, and does appear to be conceptually related when viewed within the umbrella of ‘musical aptitude’.

The most frequently discussed ability by participants was a musician’s capacity to learn to conceptualise a piece of music from an overall harmonic and stylistic perspective (macro-view) as opposed to a note-by-note/articulation-by-articulation perspective (micro-view). P1 offered that “if you have an overall view of the piece… it will probably be easier”. She agreed that “a more global approach, rather than…a detailed approach” would result in an easier experience of a piece of music, including such components as the key signature and tempo in her definition of ‘overall view’. P2 further elaborated on this point, adding that “[trying] to understand music by harmonic structures [is] much easier”. She explained that:

> When I was in lower levels I didn’t have harmonic structural understanding as I have now so when I first learnt the music I just looked at each note by note, not by a whole chord structure which is much easier. I was in a narrow view – a much narrower view, and didn’t really think about musical things like the dynamics. I was more focused on just being able to play the notes.

These comments suggest that the capacity to conceptualise a macro-view of a musical piece results in an easier experience of that piece than approaching it in a note-by-note manner. Furthermore, these experienced musicians talked about this capacity as though it is something that was not accessible at lower levels; it has developed with musical skill over time. Reflecting on when she was first learning piano, P3 stated that “[picking] apart the songs, and [picking] apart every tiny little section…having to play exactly what it’s got…that’s what I [found] difficult”.

Another ability mentioned in the interviews is a musician’s aural ability. P3 argued that musicians will find music more difficult if they “are tone deaf [and] can’t pitch notes properly”. Similarly, P7 commented that “their aural ability…if they can hear stuff that doesn’t sound right…play it how they want it to sound”. This ability to hold in mind the intended pitch and distinguish between right and wrong notes within a harmonic structure aurally was an important contributor to task difficulty in the minds of these participants.

The final component of musical aptitude mentioned by participants was sense of rhythm. P3 proposed that individuals who “lack a sense of rhythm” will find music more difficult. The primary difficulty associated with this factor for musicians was a difficulty with the “coordination of your hands… [with] different rhythmic patterns and syncopation”. Essentially this means that the difficulty of non-standard rhythmic phrases for a particular individual will be negatively related to rhythmic ability.

Emotional maturity.

In order to fully convey the emotional complexity of a piece, a musician needs to be able to understand the emotions contained within the piece. A number of the participants strongly argued that less emotionally mature individuals will find it more difficult to convey such depth. For example, P8 indicated that “conveying the emotions of a piece would be difficult depending on your age and maturity level”. She then proceeded to outline her experience of child prodigies, who “may be technically advanced and able to play the notes really fast but you don’t get as much out of it emotionally”. She compared this to “a three year old trying to sing a pop song about love”. According to P8, the importance of emotional maturity seems to be that one is able to understand and experience the feelings provoked during a piece, and therefore convey these feelings to others. Other participants shared this perspective too. P5 suggested that “when you’re older you have more experience…if you’re a young person you might not get some of the emotional things that go into a piece”. These perspectives communicate a belief that a musician’s capacity to experience the feelings contained within a song personally would make conveying such feelings to an audience an easier task to accomplish. Moreover, the participants seem to implicitly agree that the capacity to *reflect upon* emotional experiences similar to those in the music one chooses to play is the best way to improve one’s capacity to convey such emotion.

Motivation.

Motivation was the final intra-personal category suggested to influence task difficulty. Two of the participants suggested that individuals who are more motivated to learn or play a song will find such a task easier to accomplish. P8 admitted that as a child “it was tougher to learn songs…than it otherwise would be” because she did not want to play piano. Consequently, she “put [her] energy into resisting rather that learning”. The manifestation of her lack of motivation was a resistance to playing and practicing, and this resistance directly affected the perceived difficulty of musical pieces. P7 agreed that “greater motivation would make a piece easier…in that you would do more preparation”. The manifestation of her motivation (increased practice) seems to have had a direct impact on the perceived difficulty of musical pieces. The commonality between these perspectives might suggest that motivation is a key factor affecting task difficulty.

Face Validity of the Three Musical Tasks

Data obtained in the second stage of the interview process were analysed using the same coding strategy. Participants unanimously recognised the difficulty progression of the three variations, regardless of the presentation order of tasks or conditions. When asked about the perceived linearity of changes between the pieces though, seven participants agreed that changes between the easy and intermediate variations were smaller than those between the intermediate and hard variations. P1 suggested that “alternating the minims for crotchets with an extra rest” in the first section of the intermediate piece “would increase the difficulty”. P5 agreed that the intermediate variation required “more notes on the left hand…put crotchets rather than just a minim”. Similar changes were suggested by P2, P3, P4, P6, and P8 – all of whom indicated that increased content in the bass would make the piece a more realistic mid-point between the other two variations. Across these participants, there was a consensus that the reduced number of quavers and articulations in the intermediate piece were appropriate alterations. Although arbitrary, these characteristics were discussed similarly across the seven participants.

Only one participant thought that the easy and intermediate pieces differed most. P7 thought that “the easiest piece to the second piece is a slightly bigger gap than the second piece to the hardest piece”. The combination of “the right hand [having] a lot more” and “articulation changes” make the piece “too hard to do, unless they’re really used to dynamics”. Despite these data appearing quite different to that of other participants on first glance, a number of other participants commented on the difficulty that articulations in the first piece create. Six participants suggested reducing the number of articulations in the intermediate variation. Only P6 recommended including all articulations in the intermediate piece, though this suggestion was made to accompany a reduction in bass notes. P6 alternatively suggested using all notes and no articulations. Thematically, a proposed increase in bass content and decrease in the number of articulations appeared commonly across participants.

Discussion

Interpretation of Findings

Two composite factors emerged from participant interviews: intra-personal factors (characteristics of the performer) and extra-personal factors (characteristics of the piece). Rank ordered by data quantity, intra-personal factors included familiarity with components of the piece (further divided into composer’s style, genre, harmonic structure, and rhythmic structure), technical ability through practice, personality traits (perfectionism and extraversion), physical attributes, musical aptitude, emotional maturity, and motivation. Extra-personal factors included technical complexity, the interaction of speed and density, stylistic complexity, emotional complexity, and repetition.

In accordance with previous studies, the present results suggest that technical complexity is the most important determinant of task difficulty (Ralston, 1999; Scanlan, 1988). The present study extended the available research by identifying the component features of technical complexity. Prior to this the construct was at best ambiguously defined (Winston, 2003). Importantly, four other task-related factors were also identified by participants. Some of these have been incorporated under the umbrella of ‘technical complexity’ in previous contributions (e.g., complexity of melodic line [including note density] by Ralston). The present results indicate that all five extra-personal factors are at least partially independent. Future researchers can evaluate the relative importance of each of these factors in determining task difficulty.

My expectation that structural complexity (number of notes, articulations, and so on) would contribute to “task difficulty” in a positive, linear fashion concurred with participants’ experiences. Technical complexity, both written as, and inferred from, structural components was the most frequently and comprehensively discussed extra-personal factor. Whilst I assumed that this would be represented entirely by quantitative increases in articulations, participants proposed that some articulations are more difficult than others by virtue of the processing and movement required accomplishing them. Since it is unlikely that specific articulations could be itemised or rank ordered in a manner that reflects quantitative and equal variations in difficulty, it is suggested that experimental task variations in future studies use all articulations, then remove them in a concrete manner to reduce difficulty (i.e., replace all ornaments with single notes for a reduced difficulty variation; or remove all indications of gradual dynamics changes such as crescendos). These suggestions lessen the impact of extraneous variability in experimental comparisons across musical pieces. Removing nuisance variables associated with the experimental task allows more accurate conclusions to be drawn regarding the features that do vary (Keppel & Wickens, 2004).

In accordance with my expectations, note density emerged as a significant thematic influence on task difficulty. The interaction of this factor with speed was not foreseen, however it is indirectly consistent with task load research, which has demonstrated that time limitations increase the load of a task and the consequent likelihood of errors (Staal, 2004). It is important to consider the possibility that this theme was produced by my own expectations and bias. Researcher bias and validity are discussed further on pages 112-114.

Winston’s (2003) implication that performer factors co-contribute to the perception of task difficulty was supported in the present study. Indeed, participants identified a range of intra-personal factors that might impact the perceived difficulty of a piece. These themes are reminiscent of the language used in stress and performance literature to differentiate task load from workload (Staal, 2004). Essentially the same task can be perceived differently according to factors that each performer brings to the performance arena (Staal). This finding reinforces that musical performance researchers need to equate task-related factors in order to draw valid conclusions about the effect of psychological variables.

Since the findings of the present study were exploratory in nature, no further conclusions can be drawn in comparison to broader psychological/musicological theory. Each of the extra-personal factors identified in the present study can be independently manipulated and evaluated in controlled quantitative research. Furthermore, the intra-personal factors provide purposeful direction for future correlational and experimental studies in the musician performance domain.

Evaluation of the Exploratory Process

This study relied on an iterative process for thematic emergence that aligns closely with Constas' (1992) guidelines for valid qualitative research. The first of these requires that qualitative data collection be both participative and investigative. Although I compiled the data and named some of the emergent categories, authority for the verification of categories lay primarily with participants (i.e., non-imperialistic approach). I adopted a preference for using participant words for naming themes rather than suggesting the names that best fit my understanding of the data. All occurrences in which similar content was discussed across participants without suggested categorical headings have been indicated. This transparency will allow future researchers to gather evidence and modify these categories where necessary.

One of the assumptions I held throughout this process was that tertiary musicians (who necessarily engage in learning and performance of a range of styles, composers and pieces) are knowledgeable and appropriate sources to use to identify the components of 'task difficulty'. Consequently, this sample group formed the sole source of verification for emergent categories. Constas' (1992) second guideline proposes that categories be demonstrated to be both exhaustive and mutually exclusive; that is, sampling continues until data can be accounted for entirely by previously identified categories, whose content cannot be listed or defined by other categories. My research fulfilled these criteria within a highly specific sample group. Future researchers may choose to explore whether the exhaustive and exclusive criteria met within this sample are comparable to those found in other musician sample groups.

Finally, Constas (1992) encourages that qualitative data analyses utilise an entirely iterative approach. Creation, alteration, and cancellation of categories are considered during and following analysis of each participant's individual data. I engaged in this process actively, comparing results from each new participant to the already available pool of participant data. This process resulted in the evolution and alteration of all categories reported in this study until they comprehensively accounted for new data; that is, information provided by the last participant did not add new information regarding the categories that have been identified in this study.

Validity of the Three Musical Tasks

Dependability.

Dependability is the qualitative equivalent of reliability analysis, and requires the researcher to: (i) use low-interference descriptors; (ii) evaluate the consistency of interpretation between interview transcripts; (iii) avoid premature closure of the construct definition process; (iv) treat participants as researchers, allowing them to comment on the emergent definition of constructs; and (iv) utilise multiple researchers or peer evaluations (Baxter & Eyles, 1997).

In the present study, thematic categories were primarily derived from verbatim participant language. Any exceptions to this were clearly identified, with quotation support from multiple participants offered for proposed category creation. In the absence of multiple researchers, this transparency allows the reader to contribute to decisions regarding the dependability of thematic categories.

Analysis was conducted alongside data collection. Whenever key emergent themes were alluded to in a manner similar to previous participants the researcher made a general request for further information. Thus, it is likely that saturation was ensured prior to closure of the data collection process. It is therefore unlikely that definition of emergent constructs was completed prematurely.

Face validity.

Participants unanimously agreed that the difficulty of the pieces varied such that the “no notes removed” condition was most difficult and the “many notes removed” condition was least difficult. Since presentation order was randomised (for both the order of pieces and the order of exposure to music and score information), this unanimity implies stability in the perceptual experience of difficulty that experienced piano players have with these task variations.

Content validity.

Content validity could only be established post-hoc, since there was no literature to guide variation of the musical task prior to the present qualitative analysis. This form of validity is specifically related to extra-personal factors (characteristics of the piece), which are the only emergent contributors to task difficulty that can be accurately manipulated. Experimenters utilising these pieces in the future must ensure that their participant sample is sufficiently heterogeneous that it could reasonably be assumed that intra-personal factors vary in the sample as they do in the musician population of interest.

The primary manipulation across the piece variations was the removal of notes and articulation/dynamics markers. Removing articulations reduces the complexity of technical performance requirements, whereas removing notes reduces the density of the piece. According to participants in the present study, these manipulations should directly influence the experienced difficulty of the pieces. Since speed should remain constant (technically) between the pieces, any changes in performance that are predicted by the piece can therefore be solely attributed to the density component of the speed x density interaction and/or changes in technical complexity.

Stylistic complexity and repetition both exist uniformly across the three variations since they are all derived from the same piece, and the form of each is identical. Emotional complexity is also likely to be constant, since the harmonic changes in each of the variations are equivalent. Changes in difficulty across the variations are therefore unlikely to be due to these factors.

Data-Driven Changes to the Intermediate Piece

Participants only suggested making changes to the intermediate piece. Therefore, I limited my alterations to this piece, treating the other two as ‘anchor’ conditions. At this point I experienced a dilemma. As a researcher, I recognise that it is ideal to vary a single element of a task per condition, so that measurement variability is reduced and changes in the dependent variables can uniquely be attributed to the manipulation (Seltman, 2012). As a musician who has played *and* taught amateur level pieces, I am aware that many amateur musicians will ignore dynamics markings when sight reading. Solely varying the articulations in the first task manipulation may therefore alter the performance quality of advanced musicians and those who attempt the dynamics changes, with very little impact occurring on those who simply ignore the changes (systematic bias). On the other hand, many dynamics changes would not make sense if there are insufficient notes across which to express the change. This particular dilemma is an artefact of the difficulty level of the task. Had the original experimental piece been more difficult, the range of pianists who could be expected to successfully sight read the piece would be restricted. This would increase the reliability of results when articulations alone are manipulated. Conversely, the restricted range would drastically reduce the generalisability of results. There are benefits and disadvantages to either decision.

My adaptation of the intermediate piece was, by necessity, accomplished post hoc. The solution I chose was to vary technical complexity *and* density simultaneously when moving from the difficult to intermediate piece. All articulations were removed *and* bass minims that did not co-occur with treble minims were re-represented as a crotchet and crotchet rest (as per participant recommendations in the present study). Since the revised intermediate piece (Appendix E) contains no articulations or dynamics indicators within the musical score, the intermediate and easy pieces now differ solely in the density of notes.

When using these variations as experimental conditions in the future, it is recommended that dynamics adherence be ignored in the grading of piece performance. Subsequent evaluations of the variance that piece manipulations effect on performance quality would then provide an indication of the impact that changes in note density *alone* had on performance quality indicators. Moreover, findings could be triangulated by correlating multiple indicators across all experimental conditions. High linear correlations are desirable here, since this means that the indicators largely test the same underlying component of task difficulty (note density). If a subsequent principal components analysis (PCA) demonstrates a single factor loading for these indicators, they could be combined into a single performance quality composite variable. This would both simplify subsequent analyses and quantifiably demonstrate that the piece variations reliably manipulate note density.

Future Experimental Task Design

Components of task difficulty contributed by intra-personal factors may be dealt with in similar ways to many other experimental procedures. When possible, random selection of participants from a broader population should be used to ensure a sample is representative of the population of interest. This is not always possible, particularly when conducting research with a highly specific demographic. When a convenience sample is used, potential extraneous characteristics need to be measured concurrently to, or immediately following, the experimental procedures and equated so that variation due to these factors can be removed (Seltman, 2012). Randomisation of experimental conditions with strict design and procedural controls should be observed.

Task design is a key shortfall in previous music experimentation. Based on the extra-personal characteristics identified by piano players in the current study, the following recommendations are suggested when designing variations of a single music task:

1. Systematic reductions in the number of notes: Reducing the number of notes in a piece whilst maintaining a consistent speed requirement will reduce the difficulty of the piece. Maintaining the defining harmonic structure of the piece is a crucial consideration when adopting this approach.
2. Systematic simplifications of technical components: Removal or simplification of technical requirements is likely the most relevant method of varying task difficulty, since ‘technical complexity’ was the most strongly emergent theme. There are a number of procedures that a researcher may adopt to accomplish this: ornaments can be replaced by single notes; tenuto, staccato, accent markings (and so on) can be removed; pedalling can be removed. It is unlikely that harmonic modulations or rhythmic structure

could be altered without affecting the nature of the piece. Although fingering may be simplified, it is important that researchers remember that pianist perceptions of simplification might not be in accordance with the researcher's own views or experience. It is therefore suggested that researchers *remove* rather that *modify* in order to alter the difficulty of a piece.

3. Removal of repetition markers: Some experimenters may desire to alter the number of repetitions in particular sections, so as to reduce opportunity for performers to develop familiarity. In this case the researcher would need to ensure comparable change across piece variations (such as removal of *all* repeat markings as a method of increasing task difficulty).

Finally, it is not advised that researchers change the speed or stylistic components of a piece, since this would likely change the nature of the piece. Musical genres and particularly specific pieces are often defined by their rhythmic and idiosyncratic components (Bispham, 2009). Altering these is akin to qualitatively changing the nature of a piece.

Chapter 6. Study 2

The three task variations developed in Study 1 were used as experimental tasks in an evaluation of Attentional Control Theory (ACT) predictions within the musical performance arena. The benefit of using these tasks is that variation in efficiency and effectiveness outcomes could be equated without the extraneous influence posed by between-subject threats to internal validity. This is the first such undertaking in musician performance anxiety (MPA) research.

Trait anxiety appears to impose a large effect on the efficiency of central executive functions (Eysenck et al., 2007). Specifically, those with high A-Trait demonstrate an impaired ability to inhibit distractors and shift attention between multiple tasks compared to those with low A-Trait (Ansari et al., 2008; Derakshan et al., 2009; Ettinger et al., 2007). However there are some scenarios in which high A-Trait participants perform as effectively as, or better than, those with low A-Trait (Eysenck et al., 2007). Attentional Control Theory is the only performance anxiety model that can explain such observations. In these cases (often involving easy tasks), high A-Trait participants are believed to have drawn upon auxiliary resources and motivation, which increases their processing efficiency beyond the level of less anxious performers (Berggren & Derakshan, 2012). Preliminary neuropsychological evidence supports these findings (Ansari & Derakshan, 2011; Berggren & Derakshan). Dual task paradigms seem to exacerbate anxiety effects and reduce the likelihood that compensatory processes will obscure anxiety-related impairments to processing efficiency (Gazzaley, 2011). It therefore seems logical to use a dual task paradigm to test ACT hypotheses in complex real-world tasks.

In order to evaluate ACT, a method of grading performance effectiveness is needed. Many musical researchers have recommended the use of subjective expert ratings to calculate performance effectiveness (Johnson, 1997; Mills, 1991). This strategy has produced low inter-rater reliability (e.g., Kageyama, 2007) and is sensitive to examiner biases (Davidson & Coimbra, 2001; Elliott, 1995). As discussed in Chapter 3, only one quantification rubric has been published with comprehensive validation data (Performance Examination Report: Wrigley, 2005). This rubric was developed to grade tertiary musician performances. It evaluates elements of technique that are irrelevant for amateur pieces and performances.

Furthermore, it provides an overall score for each criterion, rather than a continuously derived score based on performance of all elements in the piece. Despite demonstrating excellent reliability and validity within tertiary grading contexts, the present study required a grading strategy that would be sensitive to changes in performance effectiveness across the duration of a performance. No study has published a standardised set of continuous rating criteria that accomplish this goal. The development of such a procedure will enable future musical researchers to grade performance effectiveness in a consistent and standardised fashion.

As discussed in Chapter 2, previous perceptuomotor studies have identified a link between anxiety, attention, and performance outcomes (Causer et al., 2011; Smith et al., 2001; Wilson et al., 2007).The present study is the first to test A-Trait effects on inhibition, shifting, *and* attentional load in a perceptuomotor task. In fact, it is the first piece of research to comprehensively evaluate the predictive utility of ACT hypotheses using a complex performance task and without dichotomising A-Trait. Since the goal-monitoring and motor adjustment mechanisms underlying musical performance are similar to those observed across a range of other performance domains (Ganushchak & Schiller, 2008; Ruiz et al., 2011; Ullsperger & von Cramon, 2004), the present study can be used to guide design considerations and hypotheses in broader perceptuomotor research.

Study Overview

Two linked experiments are reported here: the first is a pilot study, which was designed to test run the experimental procedure and validate a novel performance effectiveness grading system, both of which were developed for the purposes of the present research. The second is a controlled experimental investigation of ACT predictions, which incorporated the design modifications and performance effectiveness grading system developed in the pilot study. The pilot study was run to accomplish three goals:

(i) To provide the researcher with practice at administering the experiment

(ii) To identify and find solutions for unexpected problems and inefficiencies in the experimental procedure

(iii) To develop a standardised set of objective criteria for quantifying performance effectiveness.

The second study was run to test eight ACT-related hypotheses. These were each outlined and explained in Chapter 4.

General Method

Overview

In each experiment, participants performed two simultaneous tasks. The primary task was a musical sight reading task (three difficulty levels: easy, intermediate, and difficulty). The secondary task was an auditory target-response task requiring participants to respond with the word “tick” when they heard the word “tock”. This target word was distributed amongst two auditory distractor wordlists (neutral, social threat). Participants were exposed to each piece once in each of the two distractor-present conditions and once without distractors or a secondary task (nine conditions total). This dual task paradigm resembles those used in previous ACT studies (e.g., Berggren et al., 2012). As discussed in Chapter 4, the inclusion of a musical task required that distractors be presented as auditory stimuli rather than visual stimuli.

Primary Task Apparatus

The difficult (Appendix C), *revised* intermediate (Appendix E), and easy (Appendix C) variations of Telemann’s *A Graceful Dance* validated in Study 1 were used as musical sight reading tasks in the present research. When performing a sight reading task, performers are required to play a novel piece of music that they have not previously encountered, often with little or no preparation time. Sight reading is a frequently examined performance skill throughout all levels of musical training (Wristen, Evans, & Stergiou, 2006). It is also predictive of solo performance quality ratings (McPherson, 1997; Saunders & Holahan, 1997). Sight reading tasks are therefore well-suited for use in performance research. Benefits of using a sight reading task over practiced tasks include: (i) standardisation of historic exposure and practice effects, (ii) standardisation of task requirements, and (iii) increased reliability of quantitative scoring procedures since all participants play the same pieces. Although creating valid variations of a musical task is difficult, these tasks were manipulated according to a set of ‘task difficulty’ criteria identified by experienced piano players, so as to maximise content validity. These pieces have also demonstrated acceptable face validity with experienced piano players (see pp. 113-114 for validity details). All three pieces played at 104 beats per minute. The 28 bars should therefore take 64.6 seconds to play from onset of the first note to completion of the final note.

A CASIO PX120 Privia weighted keyboard with attached music stand was set up in a distraction free laboratory (diagrammatically represented in Figure 13). A PC was connected through a PreSonus AudioBox external sound card via MIDI cable to the keyboard Line-In/Line-Out. Performances were recorded as MIDI files using Cubase LE4. A laptop was set up with an attached Logitech ClearChat Comfort USB headset plus microphone to present the target-response task and auditory distractors. DMDX was used to run the two distractor wordlists and calculate reaction times to target words. This program is widely used in language and dual task literature as it captures reaction times accurately to one millisecond and calculates computer-related timing errors (Forster & Forster, 1999). The code for each level of Distraction is presented in Appendices F, G, and H. Pre-recorded verbal instructions were used to ensure equivalence of instructions across participants (text in Appendix I). Presentation of all spoken instructions was controlled by DMDX. This minimised time delays associated with experimenter error. A plain black music display folder was used to present the nine performance tasks. Pre-recorded verbal instructions navigated the participant through page turning after each piece was completed.

Secondary Task Apparatus

Two wordlists, previously compiled by Helfinstein et al. (2008), were employed for the distractor task. The first contained 64 threatening social/evaluative words (e.g., worthless, mistake, silence). The second contained 64 neutral words (e.g., cabinet, door, foot). Helfinstein et al. derived social threat words from four previous studies. The neutral words were selected from a larger database containing pleasure ratings (Likert ratings from 1-9) for 1000 English words. To qualify for inclusion, each word was required to have a pleasure score within .5 points of the median rating for the entire list. There are some important differences between the wordlists. These wordlists have produced a similar pattern of attentional bias to that observed with neutral and threatening faces in dot probe tasks (e.g., Eldar et al., 2010; White, Suway, Pine, Bar-Haim, & Fox, 2011). Both complete wordlists are presented in Appendix J.

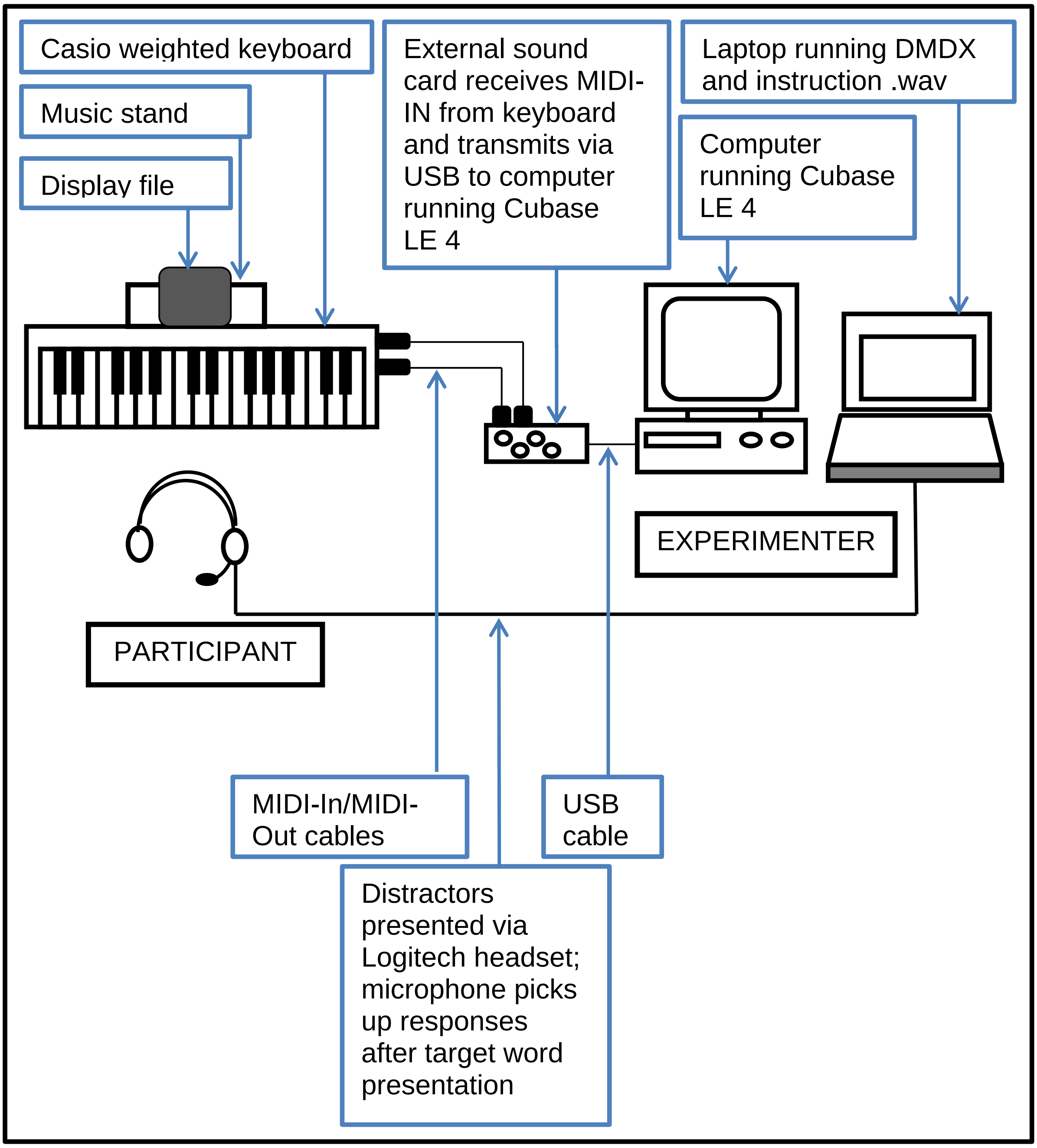

Figure 13. Diagrammatic representation of the laboratory setup.

The target word ("Tick") was randomly distributed by DMDX up to 16 times throughout each wordlist. All words were recorded during a single recording sessions using the same male voice. All syllables were spoken monotonously, with a downward inflection on the final syllable. The audio file for each word was edited using PRAAT, a free soundwave analysis program that allows editing of soundwaves to closer than one millisecond accuracy (Boersma & Weenink, 2009). Distractor words were presented at a rate of one per 3000ms (three seconds). Each presentation of the target word and possible response period totalled 4000ms (four seconds), after which another word was presented.

General Apparatus

An Experiment Administration Sheet (Appendix K) was used by the researcher to record data pertaining to experimental mechanics before and during participant performance. The researcher recorded: the participant code; the number of re-tests required for the practice word response task to be completed correctly; the order of tasks to be administered; the DMDX listing number for each target word presented (so that reaction times could be tracked systematically across the whole piece); and the false positive tally, counting the number of times per trial that participants offered the target response in the absence of the target word.

Procedure

Experimentation took place in a laboratory at Curtin University (WA, Australia). Prior to experimentation the researcher randomly assigned each participant a combination of tasks and distractor conditions that were computed using an online randomiser. Upon arrival, participants were given an information sheet to read (Appendix L). This outlined participant rights and responsibilities, incentives provided, and contact details should questions or concerns arise as a result of participation. Informed consent was assumed if a participant chose to engage in the experiment. As can be seen in Figure 13, the researcher sat to the right of the participant. The entire experimental procedure took 30-50 minutes to complete, largely depending on the ease with which participants were able to sight read the music. No participant withdrew from the study.

Participants were asked to sit at the piano, put on their headset, and open to page one of the file. On this page was a written command to “please follow the instructions spoken through the headset”. The researcher then activated the pre-recorded instructions. These described the requirements and mechanics of the experiment and gave each participant the opportunity to practice the word response task. When the practice task ended, the researcher started recording on Cubase and activated DMDX, running the file associated with the first testing condition. During each performance the researcher completed an input line on the Experiment Administration Sheet. Upon completion of each piece, the researcher activated the DMDX file associated with the next condition until all nine conditions had been attempted. After the ninth piece, the researcher played the final pre-recorded instructions, which advised the participant that the experiment was over and their headset could be removed.

Once experimentation, analysis, and interpretation stages were completed, participants who had indicated an interest in the results of the study were individually emailed a summary of findings.

Study 2A: Pilot Study

Participants

A heterogeneous convenience sample of ten piano players was recruited from music schools and private piano tutors across the Perth Metropolitan Area. Piano players aged 12 and over and currently engaging in weekly practice and/or practical piano lessons qualified to participate in the pilot study. All participants provided details regarding the highest graded examination they had completed and the training system within which this occurred. Table 3 displays participant demographic statistics and qualifications by gender. As can be seen, the ten participants represented a range of experience levels, having completed anywhere from zero examinations through to diploma qualifications. Of these, three had attempted no graded exams, five had completed their highest exam in the Australian Music Examinations Board (AMEB) system, one had completed her highest exam in the Associated Board of Royal Schools of Music (ABRSM) system, and one had completed her highest exam in a Chinese examination system. Participants were compensated $20 for their participation. None of the participants were involved in Study 1 or used again for Study 2B.

Table 3

Participant Demographic Statistics and Qualifications by Gender

	Gender		
Variable	Female (*n* = 6)	Male (*n* = 4)	Total (*n* = 10)
Age			
M (*SD*)	16.2 (4.8)	17.0 (8.5)	16.5 (5.3)
Range	12-21	12-28	12-28
Years Playing			
M (*SD*)	9.8 (6.3)	8.5 (4.8)	9.3 (5.5)
Range	2-18	4-15	2-18
Highest Exam	0-9	0-6	0-9

Note. A-Trait = Trait Anxiety. Although Australian examination systems typically range from grades one through eight, a score of nine was given to participants who had completed grade eight and a subsequent associate diploma within a system.

Grading Apparatus

The musical scores for the easy, intermediate, and difficult piece performance were printed so that the researcher could use these in the grading process. CuBase MIDI files were also produced for each performance. MIDI notation provides an accurate visual depiction of the onset, length, and velocity (corresponding with volume) of each note.

Procedure

During experimentation, the researcher made detailed notes regarding software glitches, unexpected participant behaviour, and disruptions to the standardised administration of the experiment. After the experiment had been completed by all ten participants, the researcher began grading the pieces. For each piece, the researcher used the musical scores, audio recordings, and CuBase MIDI notation to mark: (i) the percentage of notes played correctly, (ii) the number of notes played incorrectly, and (iii) the number of repeated chunks. These three categories of data were directly related to the structural manipulations used in Study

1 to vary difficulty between the tasks (i.e., removal of notes). They also improved on past musical quantification procedures by measuring both positive (correct) and negative (incorrect) aspects of performance (Kageyama, 2007).

A set of criteria was developed to grade all phenomena that occurred during the 90 performances (ten participants x nine pieces). Performances by the first five participants were then re-graded using the completed set of criteria. During this final re-grading it was noted that all correct, incorrect, and repeated notes were able to be scored using the standardised criteria.

Results and Discussion

This section reports important findings regarding software standardisation, experimenter errors, participant behaviours, and the development of an objective grading system. All administration concerns apart from one software glitch were dealt with prior to participant seven (P7). After this, administration was errorless for P7, P8, and P10, and errorless apart from a software glitch for P9. Problems were solved as they arose.

Software standardisation.

Three software glitches occurred during the pilot study. CuBase crashed midway through all nine of P1's performances (first glitch). An evaluation of user blogs found that this occurred for others when multiple background processes were running concurrently to CuBase. After deactivating unnecessary background processes this problem ceased.

The second software glitch was observed when one of the distractor words ("handshake") was presented twice during P4's fourth performance. On inspecting the DMDX social threat programming code, the experimenter realised that the audio file for "handshake" had been included a second time in the code for "humiliated". This problem was solved by replacing the incorrect code with the appropriate file extension. All words in the neutral and social threat wordlists were then re-checked and no other errors of this sort were identified.

The final software glitch occurred immediately after P9 was told to begin playing his second performance piece. A Windows "update and restart" message appeared on the machine running CuBase. The experimenter pressed "Enter" to begin the recording, and instead the computer rebooted itself. The participant continued playing, unaware that this had occurred, since the second computer running the auditory distractor task was still functioning. In order to prevent this from happening again, the Windows automatic update messages were turned off on both computers.

Experimenter errors.

The experimenter was required to simultaneously manage two computers (running the primary and secondary tasks respectively), make notes on the administration record form, and transfer DMDX audio response ("tock") files into the relevant participant condition file after each performance and while participants utilised the 30 second preparation time. This onerous task load resulted in a number of errors across the first six administrations of the experiment. Prior to P1's performances, the researcher forgot to adjust MIDI input/output settings in the participant Cubase file. Although MIDI notation was still produced, this was not accompanied by auditory recordings. To eliminate the likelihood of this occurring in future performances, the researcher created a CuBase template file with all settings correctly adjusted. Subsequent administrations of the experiment were run using this template file.

The experimenter made a second error by activating the wrong distraction condition file for P1's third performance. The participant was exposed to the social threat condition, rather than the no distraction condition. To minimise the risk of such administration faults, the researcher wrote the name of each condition in the "Condition" column of the experiment administration sheet prior to subsequent administrations (e.g., "Easy, Neutral"). This error did not occur again.

Finally, the experimenter forgot to shift audio response ("tock") files to the relevant participant condition file after P2's third performance, and again after P5's fifth performance, and again after P6's seventh performance. This meant that there were a number of audio files with the same names, since DMDX automatically names the file after the stimulus item number (e.g., "86"). This was not a concern in the pilot study, since the audio files were irrelevant to the pilot study results. To prevent this from occurring in the full-scale experiment, the researcher put a 'sticky note' on the computer monitor, which read "Remember to transfer the files". This strategy was useful because I (the experimenter) benefit from visual reminders and utilise this strategy in a range of other tasks. After doing this, the error did not reoccur.

Participant behaviour.

Some “tock” responses were very quiet (P3, P5, and P8). There was a risk that such responses would not be able to be accurately differentiated from background piano music. When soundwaves were analysed, the onset of “t” produced an immediate (often < 10ms) peak in the wave. This peak was observable even when “tock” seemed barely audible in the laboratory. Thus, the Logitech headset was sensitive enough for adequate foreground/background separation to occur on these trials. Participant volume did not reduce the accuracy of measurements.

Two participants (P5, P10) made the musical task easier for themselves by playing treble only. This strategy qualitatively altered the nature of the piece being performed. The processing load imposed on these performers was significantly lower than that experienced by the rest of the sample, who attempted to play with both hands regardless of error production. To minimise the likelihood of this issue presenting in the full-scale experimental study, a line was added to the participant information sheet, stating that “in order to qualify for participation, you must be able to sight read Grade 1 AMEB equivalent piano music, playing both hands together”. Additionally, the experimenter determined that any participant adopting this strategy in the full-scale study would need to be removed from the analysis, since their results would not be comparable to those obtained by the rest of the sample.

Development of standardised performance grading criteria.

The complete performance effectiveness grading criteria were as follows: Correct notes were circled in black and incorrect notes either enclosed in a blue square (if notated) or scored with a blue square above the stave (if not notated). The maximum correct notes score was 214 for the difficult variation, 174 for the intermediate variation, and 118 for the easy variation. This was then converted to an inverse percentage (inverse = 100 - actual percentage), so that all pieces were comparable on this outcome regardless of note count. Incorrect notes did not count against correct notes. A note was correct if it was played in a place that corresponded to the musical score; that is, immediately after the previous correct note on the score, but not after the next correct note on the score.

There was no upper bound for the incorrect note tally. Incorrect notes included: a wrong note, regardless of whether it was corrected; any note within a repeated chunk that was incorrect; a single note played in addition to correct notes at any point in the piece (including repetition of a correct note). A note that was missed or held incorrectly because it appeared twice in a row without a tie resulted in one point being subtracted from the total correct note count, but did not add to the incorrect note count. Correct notes played with an adjacent (incorrect) note accidentally (sounding like a grace note) were scored as both a correct *and* incorrect note, adding one mark to both tallies. To code this, a black circle was placed around the note, and a blue square on the stem of the note.

An arrow was drawn at any point on the score at which the performer repeated a chunk of music and a number placed above the arrow to indicate the number of additional attempts made at that chunk. A chunk was defined as any combination of two or more notes repeated to re-attempt part of the piece during performance. This could include a single treble and bass note played together, but could not include a lone bass or treble note. Examples of scoring decisions have been provided in Table 4.

The development of these grading criteria was necessarily accomplished ad hoc, since it was impossible to predict all possible phenomena that might occur as part of one's performance. For each piece, the researcher tallied correct notes, incorrect notes, and repeated chunks. The criteria for inclusion in each of these categories evolved as grading progressed, so that the final set of criteria objectively dealt with all notation occurrences that arose across the 90 pilot performances. No additional modifications were needed after grading P8's performances; P9 and P10's performances did not require new scoring considerations (equivalent of sampling saturation). To confirm the comprehensiveness of the final criteria, the researcher re-graded the first 45 performances. Importantly, all notation phenomena were able to be graded without further criteria modification and without making subjective judgements.

Table 4

Scoring and Rationale for Eight Performances of a Notated Passage

Notation	Notes played	Correct	Incorrect	Chunks	Rationale
E-B-B-C	E-B-B-C	4	0	0	All correct notes played in correct order.
	E-ₐB-B-C	4	1	0	All correct notes played in correct order with addition of an unintentional grace note (C).
	E-A-B-CB-C	4	2	0	All correct notes played in correct order with addition of an incorrect passing note (A) and an unintentional grace note (C).
	F-B-B-C	3	1	0	E not correctly played *and* played incorrectly.
	B-B-C	3	0	0	E not correctly played *but* not played incorrectly.
	E-B-C-B	3	1	0	B was omitted before the C, therefore not correctly played. Correct score for the C, but not for the subsequent B, which is considered an incorrect note.
	E-B B-C	3	0	0	B was tied and therefore not played both times, however not played incorrectly.
	E-B [pause] E-B-B-C	4	2	1	E-B is correct the first time, but incorrect when repeated (also adding to the chunk tally). B-C is then correct since these are the next notes in the notated series.

Study 2B: Full-Scale Experiment

Participants

A heterogeneous convenience sample of 29 piano players was recruited from music schools, secondary schools, and private piano tutors across the Perth Metropolitan Area. Piano players aged 12 and over and currently engaging in weekly practice and/or practical piano lessons qualified to participate in the experiment. During the recruitment phase, any music teachers who were interested in advertising the study to their students were send further information and the contact details of the experimenter. Of the 3000 expressions of interest that the researcher received over an 18 month period, most failed to respond to follow-up communications and only the 29 participants used here attended the experiment. The implications of these recruitment difficulties are discussed in Chapter 7. Participants were compensated $20 for their participation. None of the participants were involved in Study 1 or Study 2A. All participants were able to sight read with both hands playing together.

Participants completed an A-Trait measure and provided details regarding the highest graded examination they had passed and the training system within which this occurred. Table 5 displays participant demographic statistics, qualifications, and anxiety statistics by gender. As can be seen, the 29 participants represented a range of experience levels, having completed anywhere from zero examinations through to diploma qualifications. Within the sample, nine participants had completed their highest exam in the AMEB system, ten in the ABRSM system, five in the St Cecilia School of Music system, three in the Suzuki music system, and one in an overseas training system (category: Other). One participant had completed no graded exams (category: None). To resolve group non-equivalence, the Suzuki, St Cecilia, Other, and None categories were combined into a single ‘Others’ category. Table 6 displays participant demographic statistics, qualifications, and anxiety statistics within AMEB, ABRSM, and Others training systems.

Table 5

Participant Demographic Statistics, Qualifications, and Anxiety Statistics by Gender

	Gender		
Variable	Female (n = 21)	Male (n = 8)	Total (n = 29)
Age			
M (*SD*)	21.3 (10.1)	18.1 (3.6)	20.4 (8.8)
Range	12-52	12-24	12-52
Years Playing			
M (*SD*)	12.9 (9.8)	9.1 (4.6)	11.9 (8.7)
Range	3-40	3-17	3-40
A-Trait			
M (*SD*)	40.7 (11.0)	38.1 (4.5)	40.0 (9.7)
Range	20-61	31-45	20-61
Highest Exam	0-9	3-9	0-9

Note. A-Trait = Trait Anxiety. Although Australian examination systems typically range from grades one through eight, a score of nine was given to participants who had completed grade eight and a subsequent associate diploma within a system.

In the State-Trait Anxiety Inventory (STAI) test manual, norms are provided for US high school and university student samples (Spielberger, Goruch, Lushene, Vagg, & Jacobs, 1983). The mean A-Trait score in each of these samples ranged from 37.7 to 41.6. Subsequent studies have provided clinical and non-clinical normative data for the scale in less restrictive samples. Knight, Waal-Manning, and Spears (1983) collected A-Trait scores for 81.4% of a community population in New Zealand: $M(SD)_{Females}$ = 33.1 (7.8); $M(SD)_{Males}$ = 36.9 (8.9); $M(SD)_{Total}$ = 35.0 (not provided). More recently, Crawford, Cayley, Lovibond, Wilson, and Hartley (2011) collected A-Trait scores in a non-clinical Australian sample: $M(SD)_{Total}$ = 36.4 (11.4). As can be seen in Table 5, A-Trait means and SDs for the present sample are within Spielberger et al.'s (1983) range of mean scores and only slightly higher than more recently produced normative data (difference < 1*SD*).

Table 6

Participant Demographic Statistics, Qualifications, and Anxiety Statistics within Three Training System Categories

	System		
Variable	AMEB (*n* = 9)	ABRSM (*n* = 10)	Others (*n* = 10)
Age			
M (*SD*)	25.8 (14.4)	19.4 (3.2)	16.6 (1.6)
Range	12-52	18-23	12-21
Years Playing			
M (*SD*)	18.3 (12.9)	10.2 (3.7)	7.7 (3.4)
Range	4-40	3-14	3-12
A-Trait			
M (*SD*)	35.9 (9.3)	40.8 (9.2)	42.8 (10.1)
Range	20-48	26-61	30-58
Highest Exam	3-9	3-9	0-9

Note. A-Trait = Trait Anxiety; AMEB = Australian Music Examinations Board; ABRSM = Associated Board of the Royal Schools of Music; Other = category comprising all other participants. Of these, five were examined within the St Cecilia School of Music, three within the Suzuki music system, one in an overseas program, and one had attempted no examinations. Although Australian examination systems typically range from grades one through eight, a score of nine was given to participants who had completed grade eight and a subsequent associate diploma within a system.

Apparatus and Measures

The laboratory setup and materials were equivalent to those used in the pilot study. In addition, the standardised grading criteria developed as part of the pilot study were used to quantify performance effectiveness.

The STAI is a self-administered questionnaire containing separate State Anxiety (A-State) and Trait Anxiety (A-Trait) subscales. Only the A-Trait subscale was used for the present research (Appendix M). This subscale contains 20 statements regarding the way individuals “generally feel”. Participants circle their responses on a 4-point Likert scale, ranging from 1 = almost never, to 4 = almost always. Of the 20 statements, 11 are anxiety-present items, such as “I am tense”, and nine are anxiety-absent items, such as “I feel pleasant”. Scores are obtained by reversing anxiety-absent responses and then adding these reversed scores to the sum of the anxiety-present responses. Scores range from 20 to 80, with higher scores indicating higher A-Trait.

Test-retest reliability of the A-Trait subscale is reported at $.65 < r < .86$ (Spielberger et al., 1983). The A-Trait subscale has appropriate concurrent validity, with correlations of $r = .75$, .80, and .52 with the IPAT Anxiety Scale (Cattell & Scheier, 1963), Taylor Manifest Anxiety Scale (Taylor, 1953), and the Zuckerman Affect Adjective Checklist (Zuckerman & Lubin, 1965) respectively (Spielberger et al.). Moreover, it is less contaminated by the effects of depression and anger than these other scales (Spielberger et al., 1995). The STAI has been widely used to measure anxiety for both clinical and research purposes.

Procedure

The procedure was equivalent to the pilot study. All of the modifications made during the pilot study were incorporated. After completing the experiment, participants filled out the A-Trait subscale from the STAI and provided demographic details (age, years playing, highest exam passed, and examination system within which the highest exam was passed) before leaving.

Musical performance data were de-identified prior to grading by applying a randomly allocated task number, all of which were connected to a separately accessed participant identification code. Three back-up copies of data were kept on a personal computer, laptop, and external hard drive (all password protected). The researcher completed all grading and reaction time analyses (without access to participant codes). Additional examiners were not required. The objectivity and comprehensiveness of the grading criteria ensured that no subjective decisions needed to be made. Although the difficulty conditions were identifiable when listening to a recording, associated distractor conditions were not.

The researcher used PRAAT to determine the exact length of each piece. This was rounded to the nearest 10 milliseconds to account for onset inaccuracies in the recordings. PRAAT was also used to calculate reaction times from voice onset of “tick” to voice onset of “tock”, accurate to the nearest millisecond. The target and response words both started with “t”, a stop consonant. In English, stop consonants produce a burst in amplitude that is preceded by a silent interval (Suen & Beddoes, 1974). The silent interval allows more accurate estimation of voice onset that other English phonemes might allow. Average reaction time was calculated for each of the six relevant experimental conditions (Distraction [2] x Piece [3]) by computing the mean of all true positive reaction time scores. An error tally was also produced for each of these six conditions by summing the number of false positives, misses, and incorrect responses.

Design and Statistical Analysis

This study employed a 3 x 3 repeated measures experimental design, with randomisation of experimental conditions. Variable codes and definitions have been provided in Table 7. Three independent variables were used: Piece (three levels: easy, intermediate, and difficult), Distraction (three levels: no distraction, neutral distraction, social threat distraction), and A-Trait (continuous independent variable). Two outcomes were used to measure efficiency: Completion Time (to nearest 10 milliseconds) and Reaction Time (RT) on the target-response task (to the nearest millisecond). Error Tally was used to estimate the number of target location errors during each performance. Since the secondary task was excluded during the No Distraction condition, RT and Error Tally were evaluated in the context of a 3 x 2 repeated measures design. Effectiveness (performance quality) was graded using three outcomes: inverse percentage of correct notes played (Inverse_PC); number of incorrect notes played (No_Incorrect); and number of chunks repeated (Chunks). These were analysed using a Principal Components Analysis (PCA) and then, on the basis of the PCA solution, summed to compute a single composite score of effectiveness for each participant (variable: Composite). Higher Composite scores represent poorer effectiveness ratings.

All hypotheses were analysed using mixed effects linear regression as implemented through SPSS's (version 20) Generalised Linear Mixed Models (GLMM) procedure. With three fixed effects, it was initially assumed that the 3-way interaction should be tested (Piece x Distraction x A-Trait). Pasta (2011, p. 7) argues that "one approach is to start with all possible interactions and systematically remove higher-order interactions that are not statistically significant". In accordance with this recommendation, the 3-way interaction was tested and then removed because it was non-significant for all outcomes (see Appendix N).

Table 7

Variable Codes and Definitions Used in Study 2 Statistical Analyses

Variable	Definition	Coding
Fixed Effects		
Piece	Specifies three levels of the sight reading task, ranked by ascending difficulty	1 = Easy 2 = Intermediate 3 = Difficult
Distraction	Specifies three levels of auditory distraction that were presented alongside the primary task	1 = No distraction 2 = Neutral 3 = Social threat
A-Trait	Participant score on the A-Trait subscale of the STAI	Numeric value (20-80)
Outcomes		
Completion Time	Length of time taken to perform a piece (recorded in seconds to 2 decimal places)	Numeric value (>0)
Composite	Linear transformation of Sum (Composite = Sum + 1)	Numeric value (≥1)
RT	Average reaction time in target-response task during each performance (milliseconds)	Numeric value (>0)
Error Tally	Additive tally of false positives, misses, and incorrect responses on the target-response task	Numeric value (≥0)

Table 7

Variable Codes and Definitions Used in Study 2 Statistical Analyses (Continued)

Variable	Definition	Coding
Effectiveness Indices		
Inverse_PC	Inverse percentage of correct notes played (100 minus % correct notes played)	Numeric value (≥0)
No_Incorrect	Number of incorrect notes played during performance	Numeric value (≥0)
Chunks	Number of repeated chunks during performance	Numeric value (≥0)
PCA Computations		
Factor_Score	Standardised factor scores derived from factor loading coefficients	Numeric value (*z*-scores)
Sum	Sum of Inverse_PC, No_Incorrect, and Chunks	Numeric value (≥0)
Participant Variables		
ID	Participant code	Numeric value (>0)
Gender	Participant gender	1 = Male 2 = Female
Age	Participant age	Numeric value
Yrs_Play	Number of years the participant had played the piano at the time of testing	Numeric value
Exam	Highest graded exam passed at the time of testing	0 = No exams passed 1-8 = Established grades 9 = Associate Diploma
System	Training system within which the highest graded exam was passed	1 = AMEB 2 = ABRSM 3 = Others

The most participant hungry effect in the statistical model was the 3 x 2 interaction. According to methods outlined in Potvin and Schutz (2000), 30 participants will provide a 70% chance of detecting moderate 3 x 2 interactions (eta squared = .06) at an alpha-level of .05. All other main effects and interactions had acceptable beta probability estimates (> .8).

In order to optimise the likelihood of convergence, a separate GLMM analysis was run for Completion Time, Composite, Reaction Time (RT), and Error Tally. Each analysis consisted of one random effect (participant), two categorical fixed effects (Distraction, Piece), and one continuous fixed effect (A-Trait). Distraction and Piece were within-subject factors; in order for GLMM to treat them as such, they were nested within participants in a hierarchical data structure. Being a generalised procedure, GLMM allows for the specification of an appropriate theoretical distribution for each outcome (Wand, 2007). The observed distribution was positively skewed for all outcomes, suggesting that an appropriate theoretical distribution might be provided by the gamma function (Sun, Speckman, & Tsutakawa, 1999). Each outcome's distribution was therefore modelled by the gamma function and then linked to the fixed effects with an identity function. The identity function is used to link outcome and fixed effects when no transformation of the outcome is required.

Some participants scored perfect scores in each of Inverse_PC, No_Incorrect, and Chunks (therefore Sum = 0). Outcomes defined by a Gamma distribution in GLMM require all values be greater than zero. To accommodate this, a linear transformation was applied to the Sum variable (Composite = Sum + 1). Composite was used as the sole effectiveness outcome in all GLMM analyses.

The mixed effects regression approach to the analysis of within-subject factors has important advantages over the traditional repeated measures ANOVA approach. The repeated measures ANOVA assumes compound symmetry for the covariance matrix (i.e., sphericity). Compound symmetry is a restrictive assumption that requires equal variances across levels of the repeated measures factors and equal covariances between all pairs of levels (Keppel & Wickens, 2004). In contrast, mixed effects regression does not assume compound symmetry; various types of covariance matrix can be specified to accommodate violations of sphericity (Littell, Pendergast, & Natarajan, 2000).

All post hoc analyses were conducted in the context of the GLMM analysis using least significant difference (LSD) comparisons. This procedure controls the family-wise error rate when conducting multiple comparisons (Keppel & Wickens, 2004). It provides a more elegant and powerful test than a Bonferroni-corrected *t*-test or Tukey post hoc comparisons (Seaman, Levin, & Serlin, 1991).

Partial eta squared (η_p^2) was calculated as an effect size measure for all analyses and interpreted based on Cohen's (1988) conventions. Some writers recommend avoiding η_p^2 because it cannot be used to interpret unique variance and it tends to overestimate effect size (e.g., Levine & Hullett, 2002). Partial eta squared *is* nevertheless useful when more than one fixed effect is manipulated in a study. Each added factor is likely to increase outcome variation rather than increase predicted variance (Baguley, 2009). In such cases, η_p^2 provides an effect size estimate for each fixed effect after removing additional variation created by other effects so that effect size is not unnecessarily watered down.

A-Trait is an inherently continuous variable and was therefore treated as such in the omnibus analysis. A-Trait was subsequently categorised however, in order to: (i) perform LSD comparisons, (ii) create interpretable graphs of interactions, and (iii) establish a basis for comparison with previous studies that have dichotomised A-Trait. The researcher created a new variable (TA_Group) with three levels (Low, Moderate, and High) of roughly equal sizes (n = 10, 9, and 10 respectively) for this task. It was assumed that trichotomisation would retain something of the continuous nature of the variable whilst also allowing true differentiation of "high" and "low" groups. Table 8 displays participant factors for each of the three A-Trait groups. As part of their evaluation of anxiety treatment effects, Fisher and Durham (1999) collated the clinical A-Trait means for six previous treatment outcome studies: $M(SD)_{Total}$ = 57.00 (9.45); Range of clinical means = 47-61. As can be seen in Table 8, the High A-Trait group mean is within the range of clinical means observed in previous studies. The range of scores obtained by the Moderate A-Trait group also resembles the range of normative means published by Spielberger et al. (1983: Range = 37.7 - 41.6). Finally, the Low A-Trait group mean is lower than all non-clinical normative means reported in previous research (e.g., Crawford et al., 2011; Knight et al., 1983; Spielberger et al., 1983).

Table 8

Participant Demographic Statistics and Qualifications within Three A-Trait Groups

	A-Trait group		
Variable	Low (n = 10)	Moderate (n = 9)	High (n = 10)
Age			
M (*SD*)	24.4 (14.1)	18.7 (3.1)	18.0 (2.7)
Range	12-52	12-23	12-21
Years Playing			
M (*SD*)	16.1 (13.4)	8.9 (3.7)	10.3 (3.9)
Range	3-40	3-13	4-17
A-Trait			
M (*SD*)	30.3 (4.9)	38.8 (1.7)	50.7 (5.5)
Range	20-35	36-41	45-61
Highest Exam	3-9	3-9	0-9

Note. A-Trait = Trait Anxiety. Although Australian examination systems typically range from grades one through eight, a score of nine was given to participants who had completed grade eight and a subsequent associate diploma.

Results

Data Screening

A total of 261 observations were produced (29 participants x 9 observations). Of these, 174 contained RT and Error Tally data (29 participants x 3 Piece conditions x 2 Distraction conditions). One cell of RT data was missing; this participant failed to respond to all target words presented in one of the nine conditions so a mean could not be calculated. Consequently, GLMM analyses of RT were conducted using 173 observations. This does not impact the reliability of GLMM analyses (Tonidandel, Overall, & Smith, 2004).

Boxplots were produced for each outcome across all conditions (Appendix O). The large number of outliers and variation in instrumental cases across conditions further justifies using GLMM because it is not sensitive to resultant violations of normality (Sun et al., 1999).

Relationships Between Variables

Non-parametric zero-order intercorrelations were calculated for all demographic variables. As can be seen in Table 9, there was a positive linear correlation between age and years playing. The large distribution of scores within these two variables was due to many of the younger participants having not played as long as the older participants. There was also a positive linear correlation between highest exam passed and years playing. Non-parametric bivariate correlations were calculated between A-Trait and each of the demographic variables. Despite the heterogeneity of the sample, no significant relationships were observed ($p > .05$).

Table 9

Non-Parametric Zero-Order Intercorrelations for Gender, Age, Yrs_Play, Exam, System, and A-Trait

	1	2	3	4	5
1. Gender	-	-	-	-	-
2. Age	.10	-	-	-	-
3. Yrs_Play	.20	.70***	-	-	-
4. Exam	.37	.14	.47**	-	-
5. System	.12	-.05	-.23	-.08	-
6. A-Trait	.09	-.12	-.17	-.08	.18

Note. Yrs_Play = number of years a participant had spent actively learning piano; Exam = highest graded examination passed; System = Training school/system within which the highest exam was passed; A-Trait = Trait Anxiety.
* $p <.05$
** $p <.01$
*** $p < .001$

Principal Components Analysis

A Principal Components Analysis (PCA) was conducted to assess the suitability of combining Inverse_PC, No_Incorrect, and Chunks into a single Composite outcome of effectiveness. A separate analysis was conducted on the data within each of the nine experimental conditions respectively (Piece [3] x Distraction [3]). Bartlett's test of sphericity was significant for all conditions ($p < .001$). Kaiser-Mayer-Olkin values ranged from unacceptable (.378) to moderate (.749). High partial correlations were observed between all combinations of paired measures. This pattern of data was to be expected given that the three measures were created as triangulated indicators of effectiveness.

The PCA produced a strong single factor solution in each of the nine conditions. Component scores and extracted sum of squares loadings for the three effectiveness outcomes within each of the nine conditions have been displayed in Tables 10 and 11 respectively. A single factor solution provided justification for the creation of a Composite effectiveness outcome. Two different computation procedures were performed: (i) a sum of the three measures (variable: Sum) and (ii) a calculation of standardised factor scores derived from the PCA factor loadings (variable: Factor_Score). A near-perfect bivariate correlation was observed between these computations: $r(259) = .99$, $p < .001$. Despite being a more elaborate procedure, the standardised factor scores did not improve the accuracy of the computation. The simpler option (Sum) was adopted and transformed (Composite = Sum + 1) to use in subsequent GLMM analyses.

Table 10

Single Factor Component Scores for Three Measures of Effectiveness in each of the Nine Experimental Conditions

Distraction condition	Piece condition	Effectiveness measures		
		Inverse_PC	No_Incorrect	Chunks
No Distraction	Easy	.99	.99	.96
	Intermediate	.94	.99	.85
	Difficult	.87	.99	.79
Neutral	Easy	.90	.99	.86
	Intermediate	.98	.99	.95
	Difficult	.96	.98	.93
Social Threat	Easy	.95	.98	.82
	Intermediate	.92	.99	.83
	Difficult	.90	.99	.82

Note. Inverse_PC = 100 – percentage of correct notes played in a piece; No_Incorrect = the number of incorrect notes played in a piece; Chunks = the number of re-attempts at a combinations of two or more notes during performance of a piece.

Table 11

Extracted Sum of Squares Loadings for Three Measures of Effectiveness in each of the Nine Experimental Conditions

Distraction condition	Piece condition	*SS* Loadings (%)
No Distraction	Easy	95.96
	Intermediate	85.78
	Difficult	78.82
Neutral	Easy	84.87
	Intermediate	94.37
	Difficult	91.82
Social Threat	Easy	84.62
	Intermediate	84.15
	Difficult	81.80

Assumption Testing

Output for assumption testing has been presented in Appendix P. In each of the experimental conditions, skewness and kurtosis statistics were calculated for Completion Time, Composite, RT, and Error Tally. These were compared to a table of critical values (http://mvpprograms.com; n = 30, α = .025) to detect departures from the normal curve. As can be seen in Table P1, 29 out of the 30 distributions were significantly positively skewed.

Mauchly's Test of Sphericity was violated for Completion Time and Composite. The error covariance matrices of these dependent variables after orthonormalised transformation were proportional to their identity matrices for Distraction (Composite only), Piece (Completion Time and Composite), and Distraction x Piece (Completion Time only) within-subjects effects. Probability statistics for these violations have been presented in Table P2. No violations of sphericity were observed for RT or Error Tally.

GLMM Analysis for Completion Time

Descriptive statistics for Completion Time (primary task efficiency) have been presented in Table 12. A GLMM analysis was run to evaluate fixed effects and interactions for Completion Time. Results generated from the GLMM analysis have been presented in Table 13. As can be seen, it took longer to complete more difficult pieces, but no consistent picture emerged across distraction conditions.

Table 12

Descriptive Statistics for Completion Time (in Seconds)

Distraction condition	Piece condition	*M*	*SD*	Range
No Distraction	Easy	74.04	30.08	38.50 - 155.22
	Intermediate	83.41	30.57	46.30 - 169.87
	Difficult	97.96	51.99	51.36 - 255.77
Neutral	Easy	79.56	30.00	41.72 - 166.05
	Intermediate	83.87	32.19	48.63 - 198.42
	Difficult	99.05	54.85	53.55 - 282.58
Social Threat	Easy	76.98	23.52	41.90 - 149.33
	Intermediate	85.78	31.06	46.62 - 162.30
	Difficult	96.31	49.01	51.78 - 272.97

Table 13

Statistical and Practical Significance of Fixed Effects and Interactions on Completion Time

Source	*F*	*df*1	*df*2	*p*	η_p^2
Piece	4.83	2	247	.009	.36
Distraction	0.23	2	247	.793	.03
A-Trait	0.35	1	247	.554	.01
Piece x Distraction	1.42	4	247	.229	.02
A-Trait x Piece	0.02	2	247	.983	.01
A-Trait x Distraction	0.02	2	247	.978	.01

There was a significant Piece effect on Completion Time. The very large effect size estimate shows that Piece predicted 36% of the variance in Completion Time after partialling out additional outcome variance produced by the other fixed effects and interactions. A series of LSD comparisons were conducted to produce pair-wise contrast estimates (Table 13). There was a significant estimated difference between all Piece pairs (Easy < Intermediate < Difficult). As can be seen in Table 14, 95% confidence intervals for the Easy-Intermediate contrast overlapped those of the Intermediate-Difficult contrast. The size of the discrepancy between these contrasts was therefore ambiguous and could not be further delineated. The latter contrast was therefore significantly larger than the former. Completion Time means and 95% confidence intervals have been illustrated in Figure 14.

Table 14

Piece Pairwise Contrasts for Completion Time

		95% CI			
Pairwise contrast	CE	LL	UL	p	η_p^2
Intermediate - Easy	5.81	3.62	8.00	< .001	.11
Difficult - Intermediate	6.40	3.17	9.63	< .001	.15
Difficult - Easy	12.21	8.32	16.10	< .001	.06

Note. CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

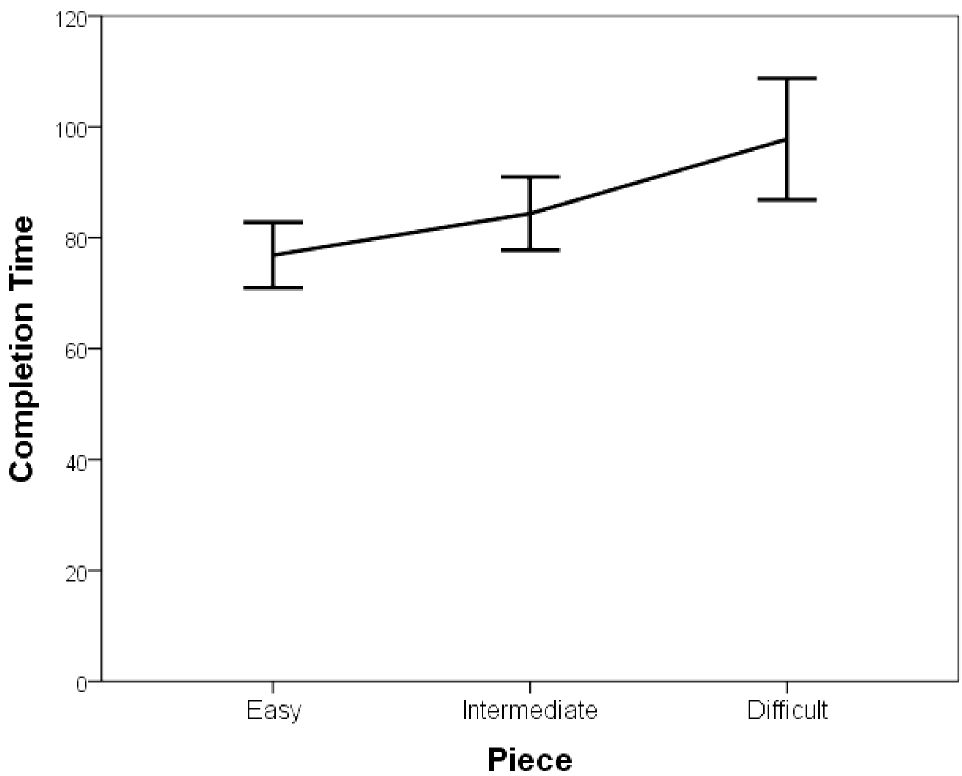

Figure 14. Completion Time means and 95% confidence intervals across three levels of Piece.

There was no significant main effect for either Distraction or A-Trait on Completion Time. The small effect size estimates show that these variables predicted 3% and 1% of the variance in Completion Time respectively, after partialling out additional outcome variance produced by the other fixed effects and interactions. There was also no significant Piece x Distraction interaction on Completion Time. The small effect size estimate shows that this interaction predicted 2% of the variance in Completion Time after partialling out additional outcome variance produced by the other fixed effects and interactions. Since these overall *F*-tests were non-significant, no pairwise comparisons were made.

There was no significant A-Trait x Piece interaction on Completion Time. The small effect size estimate shows that this interaction predicted 1% of the variance in Completion Time after partialling out additional outcome variance produced by the other fixed effects and interactions. In isolation, A-Trait was inversely related to Completion Time scores (see Figure 15), however this effect was non-significant (p = .554), weak (η_p^2 = .01), and constant across levels of Piece (see Figure 16). Since the overall *F*-test was non-significant, no pairwise comparisons were made.

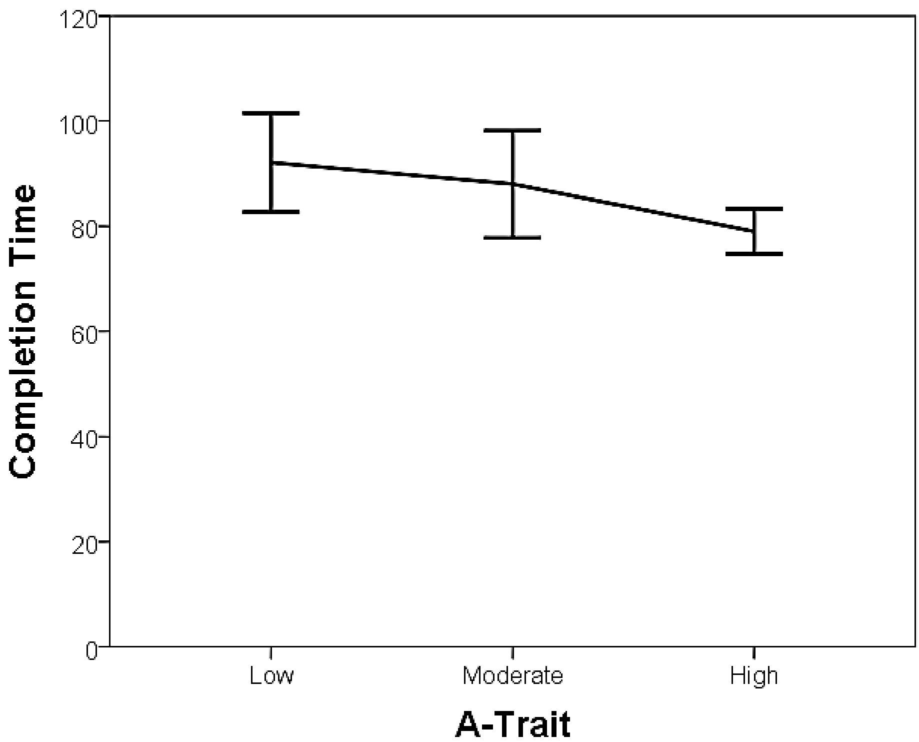

Figure 15. Completion Time means and 95% confidence intervals across three groupings of A-Trait.

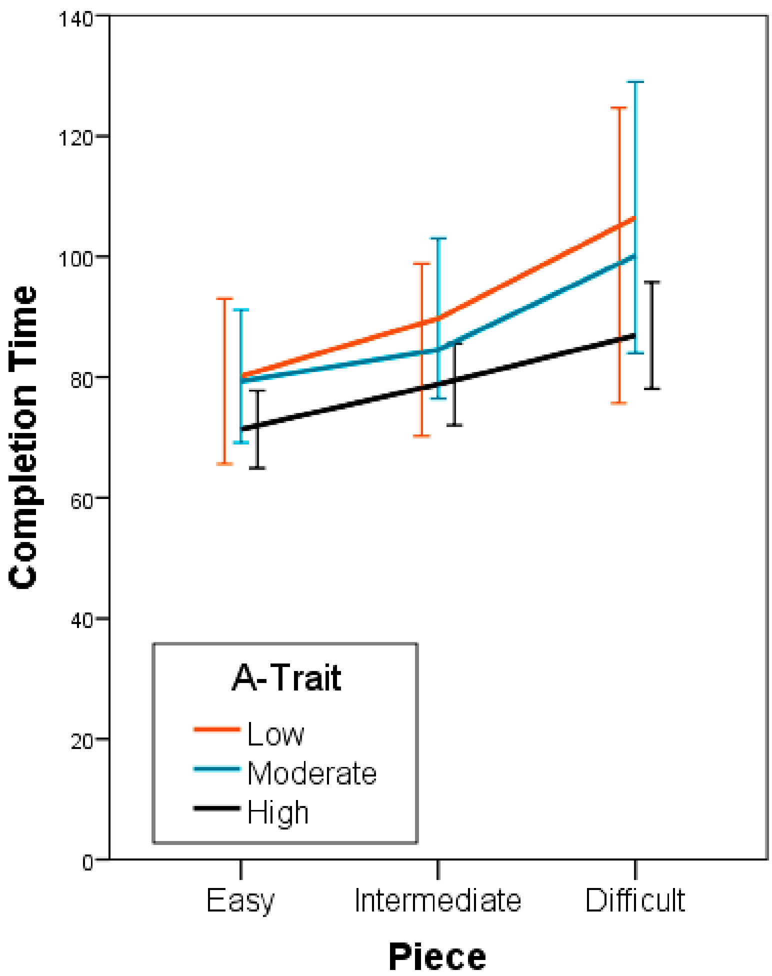

Figure 16. Completion Time means and 95% confidence intervals across three Piece conditions within each of three groupings of A-Trait respectively.

There was no significant A-Trait x Distraction interaction on Completion Time. The small effect size estimate shows that this interaction predicted only 1% of the variance in Completion Time after partialling out additional outcome variance produced by the other fixed effects and interactions. The non-significant A-Trait main effect on Completion Time remained constant across levels of Distraction (see Figure 17). Since the overall *F*-test was non-significant, no pairwise comparisons were made.

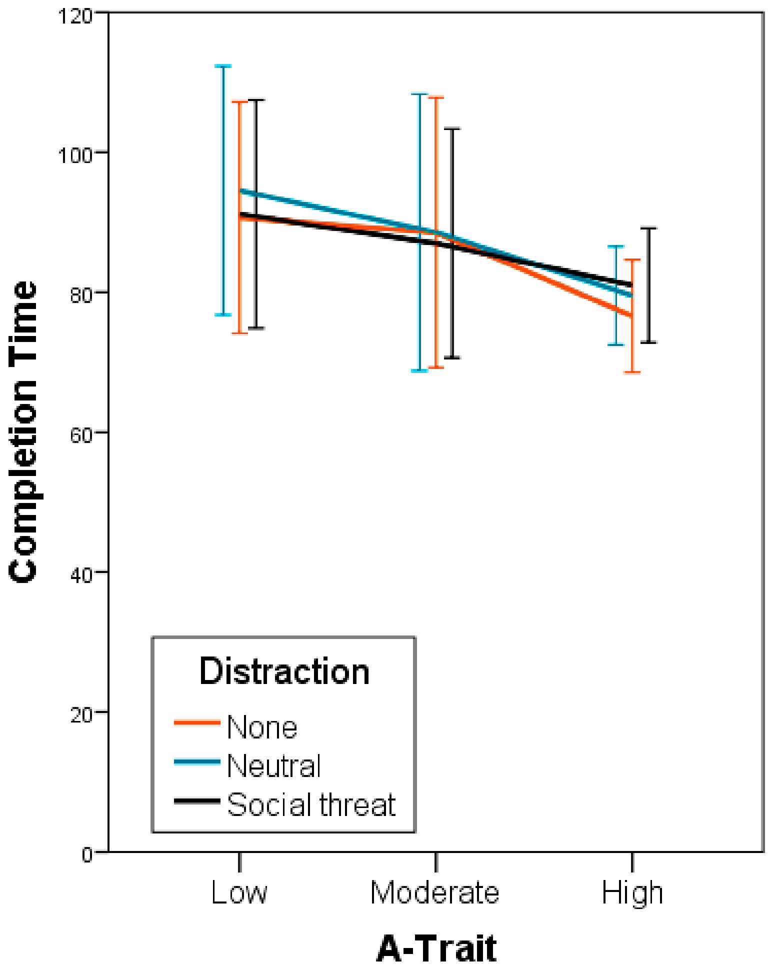

Figure 17. Completion Time means and 95% confidence intervals across three groupings of A-Trait within each of three Distraction conditions respectively.

GLMM Analysis for Composite

Descriptive statistics for Composite (primary task effectiveness) have been presented in Table 15. A GLMM analysis was run to evaluate fixed effects and interactions for Composite. Results generated from the GLMM analysis have been presented in Table 16. Poorer performance effectiveness occurred for more difficult pieces, as evidenced by higher Composite scores. No consistent picture emerged across distraction conditions.

Table 15

Descriptive Statistics for Composite

Distraction condition	Piece condition	*M*	*SD*	Range
No Distraction	Easy	13.60	26.97	1.00 - 129.67
	Intermediate	16.87	20.83	1.00 - 89.37
	Difficult	26.44	35.31	2.47 - 162.81
Neutral	Easy	13.12	21.03	1.00 - 102.56
	Intermediate	16.54	22.70	2.57 - 113.72
	Difficult	26.73	32.10	3.93 - 167.64
Social Threat	Easy	14.17	23.02	1.00 - 111.20
	Intermediate	17.72	22.97	1.00 - 98.64
	Difficult	29.52	35.72	2.47 - 169.89

Table 16

Statistical and Practical Significance of Fixed Effects and Interactions on Composite

Source	*F*	*df*1	*df*2	*p*	η_p^2
Piece	7.88	2	247	< .001	.39
Distraction	0.52	2	247	.595	.02
A-Trait	0.94	1	247	.333	.01
Piece x Distraction	1.31	4	247	.266	.01
A-Trait x Piece	2.57	2	247	.079	.00
A-Trait x Distraction	3.41	2	247	.035	.04

There was a significant Piece effect on Composite. The very large effect size estimate shows that Piece predicted 39% of the variance in Composite after partialling out additional outcome variance produced by the other fixed effects and interactions. A series of LSD comparisons were conducted to produce pair-wise contrast estimates (Table 17). There was a significant estimated difference between all Piece pairs (Easy < Intermediate < Difficult). As can be seen in Table 16, 95% confidence intervals for the Intermediate- Easy contrast did not overlap those of the Difficult- Intermediate contrast. The latter contrast was therefore significantly larger than the former. Composite means and 95% confidence intervals have been depicted in Figure 18.

Table 17

Piece Pairwise Contrasts for Composite

Pairwise contrast	CE	95% CI LL	95% CI UL	*p*	η_p^2
Intermediate - Easy	4.01	2.17	5.84	< .001	.07
Difficult - Intermediate	7.96	6.05	9.87	< .001	.24
Difficult - Easy	11.97	9.31	14.63	< .001	.22

Note. CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

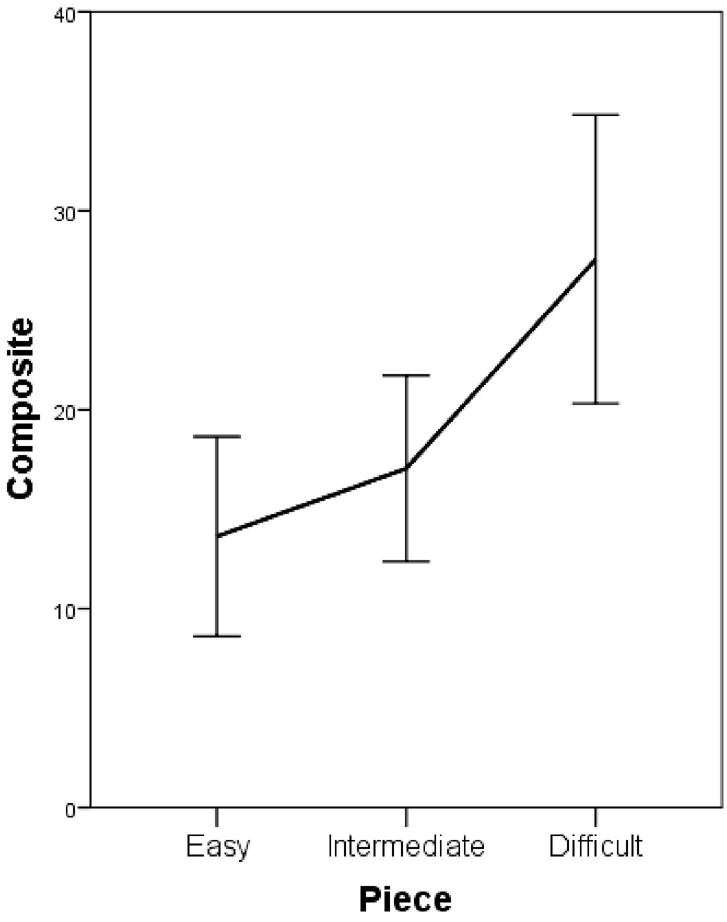

Figure 18. Composite means and 95% confidence intervals across three levels of Piece.

There was no significant main effect for either Distraction or A-Trait on Composite. The small effect size estimates show that these variables predicted 2% and 1% of the variance in Composite respectively, after partialling out additional outcome variance produced by the other fixed effects and interactions. There was also no significant Piece x Distraction or A-Trait x Piece interaction on Composite. The small effect size estimate for Piece x Distraction shows that this interaction predicted 1% of the variance in Composite after partialling out additional outcome variance produced by the other fixed effects and interactions. The A-Trait x Piece interaction did not predict variation in Composite scores. Since the overall *F*-test for each of the above fixed effects and interactions was non-significant, no pairwise comparisons were made.

There was a significant A-Trait x Distraction interaction on Composite. Means and 95% confidence intervals have been illustrated in Figure 19. The small to medium effect size estimate shows that this interaction predicted 4% of the variance in Composite after partialling out additional outcome variance produced by the other fixed effects and interactions. A series of LSD comparisons were conducted to produce pair-wise contrast estimates across three levels of Distraction and three groupings of A-Trait (Tables 18 and 19). There were no significant Distraction pairs observed for the Low A-Trait group. For the Moderate A-Trait group, the Neutral condition Composite mean was significantly lower than that of either the No Distraction or Social Threat conditions, whereas there was no significant difference between the No Distraction condition and Social Threat condition Composite means. For the High A-Trait group, the No Distraction condition Composite mean was significantly lower than the Neutral condition Composite mean whereas there was no significant difference between the Social Threat condition Composite mean and either the No Distraction condition Composite mean or the Neutral condition Composite mean. Within each Distraction condition, there were no significant A-Trait pairs after adjusting for family-wise error.

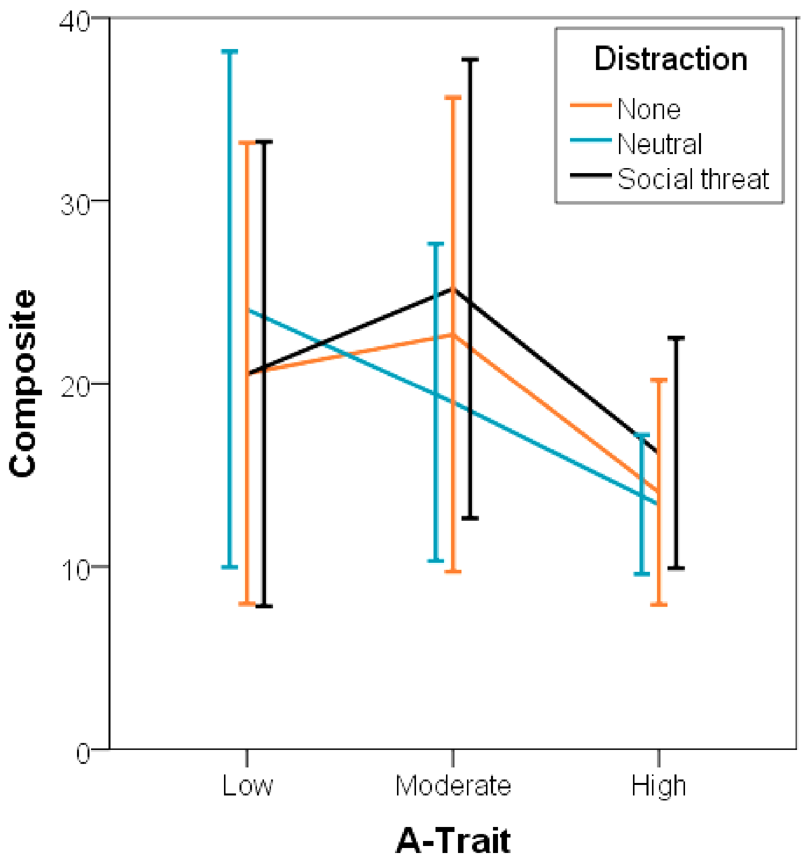

Figure 19. Composite means and 95% confidence intervals across three groupings of A-Trait within each of three Distraction conditions.

Table 18

A-Trait x Distraction Pairwise Contrasts for Composite

Distraction level	A-Trait pairwise contrast	CE	95% CI LL	95% CI UL	*p*	η_p^2
No Distraction	Low - Moderate	-1.69	-16.50	13.12	.823	.00
	Low - High	7.71	-4.40	19.82	.211	.00
	Moderate - High	9.40	-2.90	21.69	.134	.00
Neutral	Low - Moderate	1.27	-13.61	16.16	.866	.00
	Low - High	6.57	-5.44	18.58	.282	.00
	Moderate - High	5.30	-6.85	17.44	.391	.00
Social Threat	Low - Moderate	-2.79	-17.87	12.28	.716	.00
	Low - High	6.08	-5.96	18.11	.321	.00
	Moderate - High	8.87	-3.54	21.29	.161	.00

Note. CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

Table 19

Distraction x A-Trait Pairwise Contrasts for Composite

A-Trait level	Distraction pairwise contrast	CE	95% CI LL	95% CI UL	*p*	η_p^2
Low	ND - Neutral	-1.02	-2.86	0.82	.277	.00
	ND - Social Threat	0.53	-1.49	2.55	.607	.00
	Neutral - Social Threat	1.55	-0.17	3.26	.076	.01
Moderate	ND - Neutral	1.94	0.38	3.50	.015	.02
	ND - Social Threat	-0.58	-2.50	1.34	.553	.00
	Neutral - Social Threat	-2.52	-4.61	-0.43	.018	.02
High	ND - Neutral	-2.16	-3.84	-0.48	.012	.03
	ND - Social Threat	-1.10	-3.36	1.16	.338	.00
	Neutral - Social Threat	1.06	0.48	3.84	.395	.00

Note. ND = No Distraction; CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

GLMM Analysis for RT

Descriptive statistics for RT (secondary task efficiency) have been presented in Table 20. A GLMM analysis was run to evaluate fixed effects and interactions for RT. Results generated from the GLMM analysis have been presented in Table 21.

Table 20

Descriptive Statistics for Reaction Time (in Milliseconds)

Distraction condition	Piece condition	*M*	*SD*	Range
Neutral	Easy	932.86	301.64	624 - 1790
	Intermediate	902.34	221.07	638 - 1437
	Difficult	932.90	221.98	657 - 1485
Social Threat	Easy	896.55	236.79	602 - 1449
	Intermediate	876.17	223.57	590 - 1461
	Difficult	920.79	227.56	619 - 1501

Table 21

Statistical and Practical Significance of Fixed Effects and Interactions on Reaction Time

Source	*F*	*df*1	*df*2	*p*	η_p^2
Piece	0.46	2	163	.631	.04
Distraction	3.95	1	163	.048	.05
A-Trait	0.07	1	163	.795	.00
Piece x Distraction	0.08	2	163	.925	.01
A-Trait x Piece	1.45	2	163	.237	.02
A-Trait x Distraction	3.35	1	163	.069	.04

There was a significant Distraction effect on RT. Lower RT scores were produced in the Social Threat condition ($M_{difference}$ = 19.88). The small to medium effect size estimate shows that Distraction predicted 5% of the variance in RT after partialling out additional outcome variance produced by the other fixed effects and interactions.

There was no significant main effect for either Piece or A-Trait on RT. The small to medium effect size estimate for Piece shows that this variable predicted 4% of the variance in RT after partialling out additional outcome variance produced by the other fixed effects and interactions. A-Trait did not predict variation in RT scores. There were also no significant interactions on RT. The Piece x Distraction and A-Trait x Piece interactions both had small effect size estimates, whereas the A-Trait x Distraction interaction had a small to medium effect size estimate. These interactions predicted 1%, 2%, and 4% of the variance in RT respectively, after partialling out additional outcome variance produced by the other fixed effects and interactions. Since the overall *F*-test for each of the above fixed effects and interactions was non-significant, no pairwise comparisons were made.

GLMM Analysis for Error Tally

Descriptive statistics for Error Tally (secondary task location errors) have been presented in Table 22. A GLMM analysis was run to evaluate fixed effects and interactions for Error Tally. Results generated from the GLMM analysis have been presented in Table 23.

Table 22

Descriptive Statistics for Error Tally

Distraction condition	Piece condition	*M*	*SD*	Range
Neutral	Easy	0.34	0.77	1 - 4
	Intermediate	0.34	0.97	1 - 6
	Difficult	0.45	0.87	1 - 4
Social Threat	Easy	0.31	1.04	1 - 6
	Intermediate	0.38	1.08	1 - 6
	Difficult	0.38	0.94	1 - 5

Note. An Error Tally score of 1 = perfect performance.

Table 23

Statistical and Practical Significance of Fixed Effects and Interactions on Error Tally

Source	*F*	*df*1	*df*2	*p*	η_p^2
Piece	3.53	2	163	.032	.01
Distraction	2.84	1	163	.094	.00
A-Trait	2.39	1	163	.124	.02
Piece x Distraction	0.35	2	163	.704	.00
A-Trait x Piece	3.93	2	163	.021	.02
A-Trait x Distraction	3.36	1	163	.069	.00

There was a significant Piece effect on Error Tally. The small effect size estimate shows that Piece predicted 1% of the variance in Error Tally after partialling out additional outcome variance produced by the other fixed effects and interactions. This fixed effect could not be analysed further because the A-Trait x Piece interaction was also significant.

There was no significant main effect for either Distraction or A-Trait on Error Tally. The small effect size estimate shows that A-Trait predicted 2% of the variance in Error Tally after partialling out additional outcome variance produced by the other fixed effects and interactions. Distraction did not predict variation in Error Tally scores. There was also no significant Piece x Distraction interaction on Error Tally. This interaction did not predict Error Tally scores. Since these overall *F*-tests were non-significant, no pairwise comparisons were made.

There was a significant A-Trait x Piece interaction on Error Tally. The small to moderate effect size estimate shows that A-Trait x Piece predicted 2% of the variance in Error Tally after partialling out additional outcome variance produced by the other fixed effects and interactions. A series of LSD comparisons were conducted to produce pair-wise contrast estimates across three groupings of A-Trait and three Piece conditions (Tables 24 and 25). After controlling for family-wise error, a number of important contrasts were observed. In the Easy condition there were no significant A-Trait contrasts. In the Intermediate condition, Error Tally means for the Low A-Trait group were significantly lower than those observed for the Moderate or High A-Trait groups, whereas there was no significant difference between the Moderate and High A-Trait Error Tally means. There were no significant contrasts between A-Trait group Error Tally means in the Difficult condition. All of these comparisons have been graphically depicted in Figure 20.

There was no significant A-Trait x Distraction interaction on Error Tally. The effect size estimate shows that this interaction did not predict variation in Error Tally scores, even after partialling out additional outcome variance produced by the other fixed effects and interactions. Since the overall *F*-test was non-significant, no pairwise comparisons were made.

Table 24

A-Trait x Piece Pairwise Contrasts for Error Tally

Piece level	A-Trait pairwise contrast	CE	95% CI LL	95% CI UL	*p*	η_p^2
Easy	Low - Moderate	0.06	-0.23	0.35	.694	.00
	Low - High	-0.33	-0.74	0.09	.118	.02
	Moderate - High	-0.39	-0.81	0.03	.071	.02
Intermediate	Low - Moderate	-0.48	-0.95	-0.01	.048	.02
	Low - High	-0.45	-0.78	-0.11	.009	.04
	Moderate - High	0.03	-0.53	0.59	.916	.00
Difficult	Low - Moderate	-0.16	-0.61	0.29	.486	.00
	Low - High	-0.06	-0.44	0.31	.737	.00
	Moderate - High	0.16	-0.37	0.56	.683	.00

Note. CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

Table 25

Piece x A-Trait Pairwise Contrasts for Error Tally

A-Trait level	Piece pairwise contrast	CE	95% CI LL	95% CI UL	*p*	η_p^2
Low	Easy - Intermediate	0.16	-0.40	0.36	.114	.02
	Easy - Difficult	-0.11	-0.37	0.15	.419	.00
	Intermediate - Difficult	-0.27	-0.50	-0.04	.024	.03
Moderate	Easy - Intermediate	-0.37	-0.78	0.03	.071	.02
	Easy - Difficult	-0.33	-0.58	-0.08	.011	.04
	Intermediate - Difficult	0.05	-0.43	0.52	.839	.00
High	Easy - Intermediate	0.04	-0.07	0.15	.441	.00
	Easy - Difficult	0.16	-0.05	0.37	.141	.01
	Intermediate - Difficult	0.12	-0.02	0.25	.099	.02

Note. CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

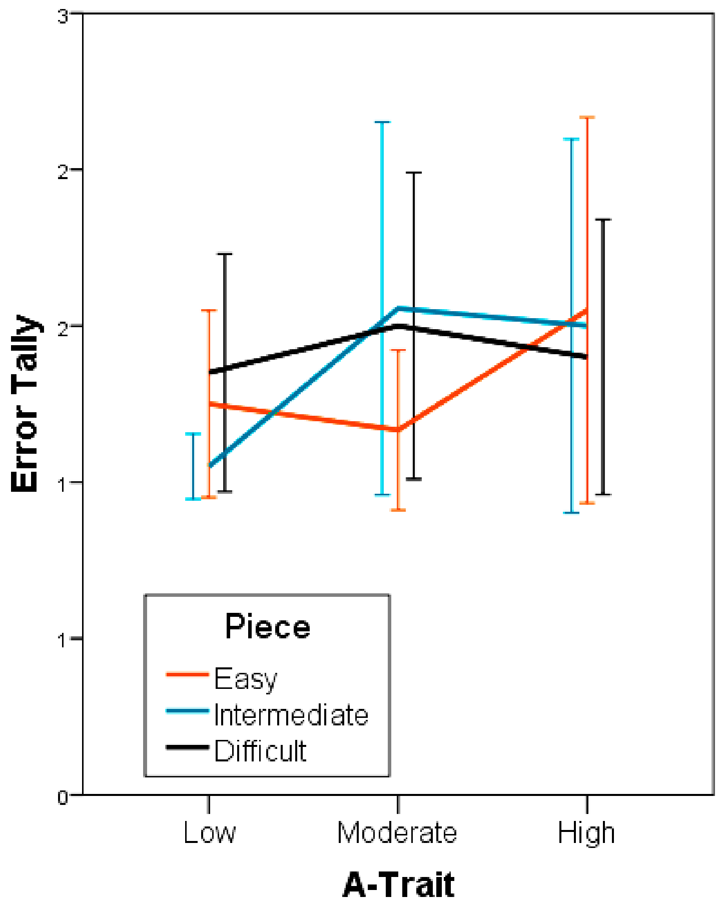

Figure 20. Error Tally means and 95% confidence intervals across three groupings of A-Trait within each of three Piece conditions.

Secondary Analyses Using Categorised A-Trait

The A-Trait x Distraction interaction for each of the four outcomes was re-evaluated after creating three categorical groupings for A-Trait (variable: TA_Group; Levels: Low, Moderate, High). Interactions have been reported in Table 26. It should be noted that the statistical and practical significance of each effect was computed after partialling out additional outcome variance produced by the other fixed effects and interactions.

Table 26

Statistical and Practical Significance of TA_Group x Distraction Interactions for each Outcome

Outcome	*F*	*df*1	*df*2	*p*	η_p^2
Completion Time	0.16	4	242	.958	.07
Composite	33.88	4	242	< .001	.00
RT	3.32	2	159	.039	.08
Error Tally	7.34	2	160	.001	.09

There was no significant TA_Group x Distraction interaction on Completion Time. The medium effect size estimate shows that the TA_Group x Distraction interaction predicted 7% of the variance in Completion Time after partialling out additional outcome variance produced by the other fixed effects and interactions. Since the overall *F*-test was non-significant, no pairwise comparisons were made.

There was a significant TA_Group x Distraction interaction on Composite, however this interaction did not predict variation in Composite scores. Pairwise comparisons for this analysis were reported on page 151.

There was a significant TA_Group x Distraction interaction on RT. The medium effect size estimate shows that the TA_Group x Distraction interaction predicted 8% of the variance in RT after partialling out additional outcome variance produced by the other fixed effects and interactions. A series of LSD comparisons were conducted to produce pair-wise contrast estimates across two levels of Distraction and three levels of TA_Group (Tables 27). After controlling for family-wise error, a number of important contrasts were observed. For the Low group, the Neutral condition RT mean was significantly higher than the Social Threat condition RT mean. There was no significant difference between the Neutral and Social Threat condition RT means for either the Moderate or High groups. No TA_Group pairs significantly differed in either Distraction condition. All of these comparisons have been graphically depicted in Figure 21.

Table 27

Distraction x TA_Group Pairwise Contrasts for RT

TA_Group level	Piece pairwise contrast	CE	95% CI LL	95% CI UL	*p*	η_p^2
Low	Neutral - Social Threat	74.10	8.17	140.02	.028	.03
Moderate	Neutral - Social Threat	-35.19	-87.54	17.16	.186	.01
High	Neutral - Social Threat	13.73	-47.81	75.28	.660	.00

Note. TA_Group = Trait anxiety group; CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

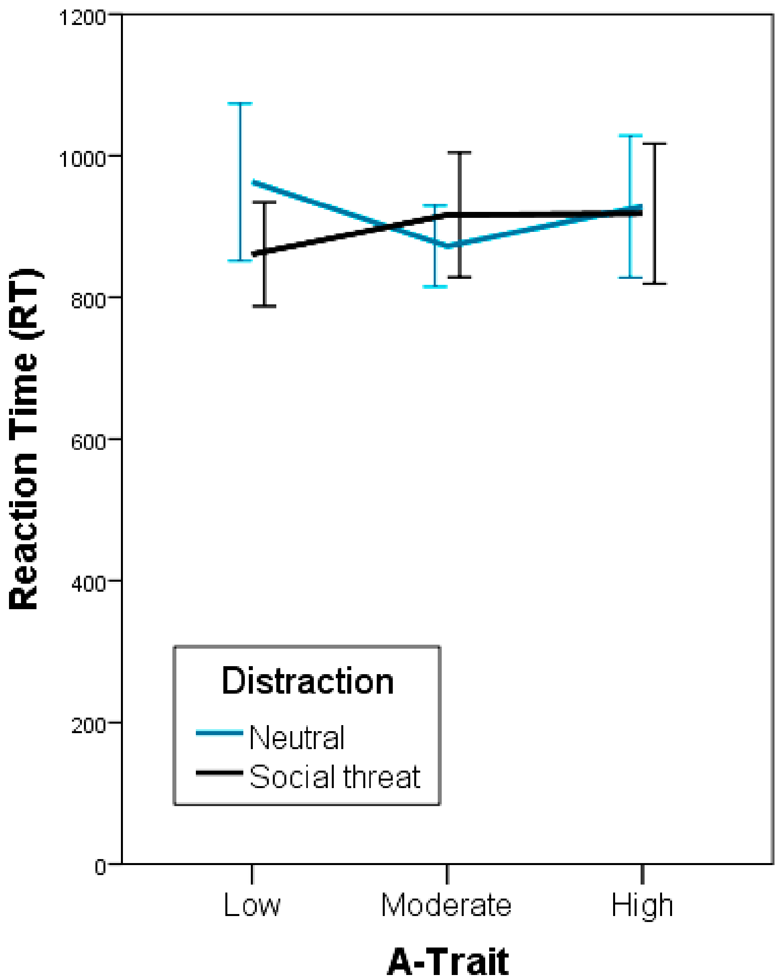

Figure 21. Reaction Time (RT) means and 95% confidence intervals across three groupings of A-Trait within each of two Distraction conditions.

There was a significant TA_Group x Distraction interaction on Error Tally. The medium effect size estimate shows that the TA_Group x Distraction interaction predicted 9% of the variance in Error Tally after partialling out additional outcome variance produced by the other fixed effects and interactions. A series of LSD comparisons were conducted to produce pair-wise contrast estimates across two levels of Distraction and three levels of TA_Group (Tables 28 and 29). After controlling for family-wise error, a number of important contrasts were observed. In the Social Threat condition, the Error Tally mean for the Low group was significantly lower than those observed for the Moderate or High groups, whereas there was no difference between the Moderate and High group Error Tally means. For the Low group, the Neutral condition Error Tally mean was significantly higher than the Social Threat Error Tally mean. For the Moderate group, the Neutral condition Error Tally mean was significantly lower than the Social Threat Error Tally mean. Finally, there was no significant difference between the Neutral and Social Threat condition Error Tally means for the High group. All of these comparisons have been graphically depicted in Figure 22.

Table 28

TA_Group x Distraction Pairwise Contrasts for Error Tally

Distraction level	TA_Group pairwise contrast	CE	95% CI LL	95% CI UL	*p*	η_p^2
Neutral	Low - Moderate	0.11	-0.21	0.43	.488	.00
	Low - High	-0.09	-0.49	0.30	.646	.00
	Moderate - High	-0.20	-0.57	0.17	.282	.01
Social Threat	Low - Moderate	-0.50	-0.88	-0.12	.010	.04
	Low - High	-0.47	-0.80	-0.14	.006	.05
	Moderate - High	0.03	-0.47	0.53	.909	.00

Note. CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

Table 29

Distraction x TA_Group Pairwise Contrasts for Error Tally

TA_Group level	Piece pairwise contrast	CE	95% CI LL	95% CI UL	p	η_p^2
Low	Neutral - Social Threat	0.34	0.12	0.57	.003	.05
Moderate	Neutral - Social Threat	-0.27	-0.48	-0.05	.015	.04
High	Neutral - Social Threat	-0.04	-0.17	0.10	.622	.00

Note. TA_Group = Trait anxiety group; CE = Contrast estimates; CI = confidence interval; LL = lower limit; UL = upper limit. Pairwise contrasts are written as subtraction equations.

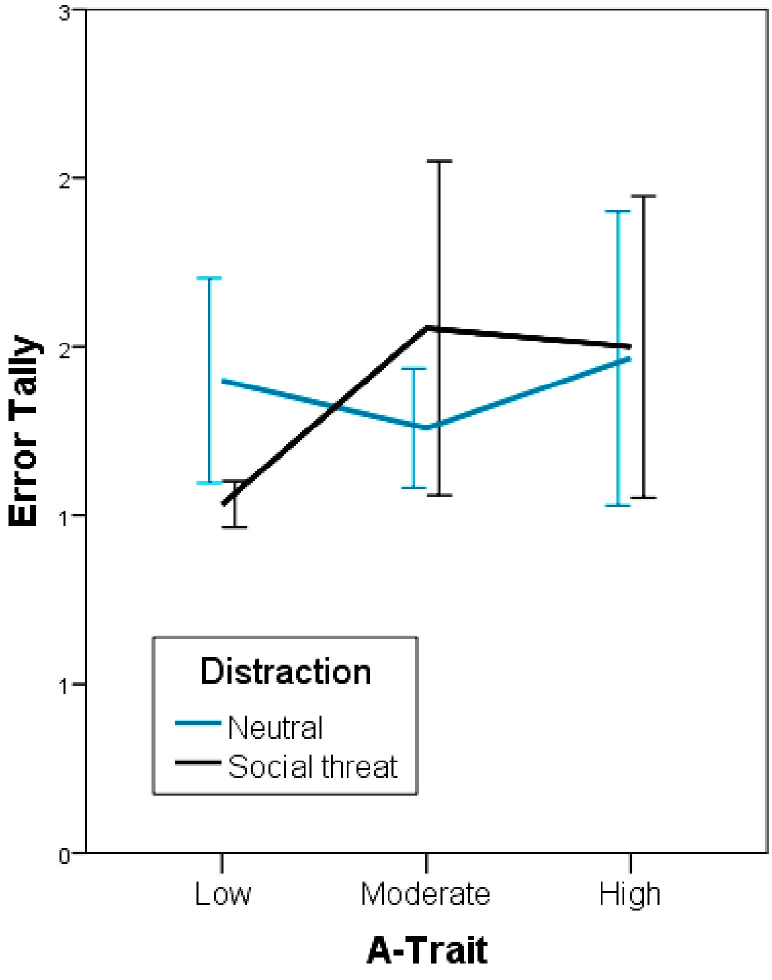

Figure 22. Error Tally means and 95% confidence intervals across three groupings of A-Trait within each of two Distraction conditions.

Discussion

The present study evaluated a number of hypotheses that were derived and adapted from Eysenck et al.'s (2007) Attentional Control Theory (ACT). Some of the central hypotheses were unsupported when A-Trait was treated as a continuous variable. Firm conclusions regarding the explanatory power of ACT for musical performance tasks therefore cannot be made. That said, task difficulty-related effects were sizeable, demonstrating the contextual relevance and potential threat that musical task load factors impose on musician performers and particularly those with higher Trait Anxiety.

Hypothesis 1A

Piece will have a significant main effect on musical task Completion Time such that Completion Time will increase linearly with task difficulty.

Hypothesis 1A was supported in the present study. Performers took longer to complete more difficult sight reading tasks. As expected, the intermediate piece took longer to complete than the easy piece and the difficult piece took longer to complete than the intermediate piece. The average increase in completion time observed from easy to intermediate to difficult appeared constant when graphed; that is, as tasks became more difficult, there seemed to be a steady increase in the amount of extra time needed to complete a piece. The gradient of the completion time pattern implied linearity but was statistically ambiguous. Therefore it cannot be concluded that these pieces would produce the same steady increase in completion time in the musician population as was observed in this sample. Nevertheless, these results demonstrate that task difficulty successfully manipulated the attentional load imposed by the primary task.

Hypothesis 1B

There will be a significant Piece x A-Trait interaction for musical task Completion Time. Specifically, the linear effect of Piece on Completion Time will become more pronounced across increases in A-Trait.

Hypothesis 1B was not supported. Speed of processing – as measured by the time taken to perceive, interpret, and behaviourally recreate musical notation – was not impacted by A-Trait. Task difficulty was the strongest source of variation for completion time. The effect of this task load factor was not moderated by other measured variables.

According to ACT, task load effects on processing efficiency should be exacerbated when A-Trait is high (Eysenck et al., 2007). Exceptions to this might occur when a task is excessively easy or auxiliary resources have been drawn upon to compensate such interactions (Berggren & Derakshan, 2012). The former is unlikely in the present research since performance effectiveness indices were also significantly impacted by increases in task difficulty. The latter exception is also unlikely to have occurred for two key reasons: (i) dual task paradigms similar to the one employed in the present study have previously produced exacerbated A-Trait x Task load effects on processing efficiency (Derakshan & Eysenck, 1998; Eysenck et al., 2005), and (ii) secondary task location errors increased alongside increases in primary task difficulty and A-Trait, implicating the manifestation of anxiety-related shifting impairments that deprioritise the secondary task rather than the musical task, in line with task instructions. It is likely that the sight reading task was the highest priority for participants and therefore participant processing and performance on the sight reading task was almost solely influenced by task load factors such as task difficulty. So when attentional capacity was overtaxed participants favoured the musical task and performance of the secondary task suffered instead.

Hypothesis 2

There will be a significant A-Trait x Distraction interaction for musical task Completion Time. Specifically, Completion Time will increase linearly as a function of A-Trait; this linear increase will be greatest for Social Threat Distraction, smaller for Neutral Distraction, and smallest for No Distraction.

Hypothesis 2 was not supported. When treated as a continuous variable, the small effect of A-Trait on piece completion time did not vary across the different distraction conditions. Re-coding A-Trait as a categorical variable dramatically increased the effect size, however the high *p*-value suggests that this was likely a statistical artefact resulting from the creation of arbitrary groups.

The unexpectedly low impact of both distraction and A-Trait on completion time can be best understood in the context of the dual task results. Sight reading task difficulty had a non-significant effect on secondary task reaction time, however the effect size estimate suggests that there was insufficient power to observe a true effect. Results for Hypothesis 1 indicated that participants prioritised the attentional load imposed by the sight reading task. This may have displaced attentional deficits such that processing efficiency on the secondary task was preferentially impeded (consistent with the small to moderate effect of task difficulty on reaction time). Although necessarily tentative, this conclusion is consistent with previous studies (Fox et al., 2001) and also with the increased distraction and A-Trait effect sizes observed after re-coding A-Trait as a categorical variable. Treating A-Trait as a categorical variable increases the likelihood of observing false effects, however it also increases the likelihood of capturing true effects in the absence of adequate statistical power (MacCallum et al., 2002; Streiner, 2002). This conclusion needs to be more effectively evaluated in the future so that A-Trait categorisation is not needed to adequately interpret the results.

Hypothesis 3A

Piece will have a non-linear main effect on task performance effectiveness, as measured by Composite, such that there will be a significant increase in Composite from Easy to Intermediate and from Intermediate to Difficult; however the latter increase will be significantly greater than the former.

Hypothesis 3A was supported in the present study. Performance impairment became more pronounced as task difficulty increased. The intermediate piece was performed poorer than the easy piece and the difficult piece was performed much poorer than the intermediate piece. Indeed, performance impairment was substantially more noticeable for the difficult piece.

Previous musical performance studies have failed to evaluate task difficulty effects (e.g., Abrams & Manstead, 1981; LeBlanc et al., 1997; Yoshi et al., 2009), despite a body of evidence recommending that task difficulty impacts musical performance effectiveness (Halbeck, 1992; Winston, 2003). The present results support these recommendations. Indeed, task difficulty imposed the largest influence on both the efficiency and effectiveness of sight reading performances. Without including task difficulty in an analysis, allowing participants to choose their own pieces is likely to mask significant anxiety effects.

Hypothesis 3B

There will be a significant Piece x A-Trait interaction for task performance effectiveness, as measured by Composite. Specifically, the non-linear effect of Piece on Composite will become more pronounced across increases in A-Trait

Hypothesis 3B was not supported. Performance effectiveness was roughly equivalent across the sample, regardless of A-Trait. After disentangling task load and workload factors, it was evident that A-Trait did not moderate the effect of task difficulty on the quality of participant performances. Theoretically, tasks that exceed working memory capacity limits should produce noticeable impairments on task effectiveness measures (Berggren & Derakshan, 2012). If viewed within a framework in which participants preferentially attended to the musical task, these results nevertheless make sense. As with completion time and reaction time indices, anxiety-related attentional deficits manifested as location errors on the secondary task rather than performance errors on the sight reading task.

Hypothesis 4

There will be a significant A-Trait x Distraction interaction for task performance effectiveness, as measured by Composite. Specifically, Composite will increase linearly as a function of A-Trait; this linear increase will be greatest for Social Threat Distraction, smaller for Neutral Distraction, and smallest for No Distraction.

The combined impact of A-Trait and distraction on sight reading performance impairment was complex and only partially supported the directional relationships proposed in Hypothesis 4. Participants with the lowest A-Trait performed equivalently on the sight reading tasks, regardless of the presence/absence or content of auditory distractors. Attending to distractors of either sort therefore did not inhibit the capacity of these participants to manage the shifting requirements of the dual task. These results are supported by studies in which low A-Trait participants have demonstrated no difference in performance effectiveness across distraction conditions (Derakshan et al., 2009; Eldar et al., 2010). Such participants appear to be able to maintain attentional flexibility when engaging in more taxing tasks.

Participants with moderate A-Trait performed best on the sight reading task when concurrently managing a dual task load with neutral distractors. Indeed, their performance was better when performing in the presence of neutral distractors than it was in the absence of distraction. Moderate A-Trait participants also performed as poorly on the sight reading task when exposed to threatening distractors as they did in the absence of distraction.

These findings somewhat resemble an inverted-U performance curve, however they are better explained in the context of ACT findings. As A-Trait increases, so too does the predicted magnitude of a particular anxious state (Eysenck et al., 2007). This can trigger the use of compensatory strategies that might, to a point, boost effectiveness indices (Berggren & Derakshan, 2012). Easterbrook's (1959) tunnelling hypothesis similarly predicts that anxiety limits the breadth of attentional focus during performance, which can initially improve performance by increasing attentional focus on task goals. Participants in the present study demonstrated this attentional tunnelling, as evidenced by anxiety-related secondary task deficits in the neutral condition. According to both theoretical positions, moderately anxious performers would be expected to perform best when anxiety optimises these compensatory mechanisms and worse when either under-aroused or overtaxed. Present observations are consistent with both of these theories, but do not support an inverted-U explanation since the former impairment is directly related to under-arousal whilst the latter is produced by anxiety-related working memory deficits (i.e., not two poles of a uni-dimensional construct).

Finally, participants with the highest A-Trait scores performed best on the sight reading task when they did not have to manage an added distractor load. In accordance with the above argument, these participants demonstrated evidence that the dual task load overtaxed working memory capacity limits earlier for them than it did for those with lower A-Trait.

Hypothesis 5

There will be a significant A-Trait x Distraction interaction for RT. Specifically, RT will remain stable across A-Trait levels in the Neutral Distraction condition, but significantly decrease across levels of A-Trait in the Social Threat Distraction condition

Hypothesis 5 was partially supported. Performers were faster at responding to the target word (secondary task) when it was distributed amongst threatening distractors compared to when it was presented amongst neutral distractors. This effect occurred regardless of participant A-Trait, however the effect size estimates and the approaching significance of anxiety moderation effects suggests that the study was underpowered in this regard. Indeed, when A-Trait was re-coded as a categorical variable, it imposed a much larger influence on the relationship between distraction and reaction time, with a lower probability that results were produced by chance. An inspection of these results found that an attentional bias to threat occurred for low A-Trait participants, whereas moderate and high A-Trait participants were no faster when exposed to either type of distraction. These results appear inconsistent with previous evidence for anxiety-related attentional biases (e.g., Eldar et al., 2010; Helfinstein et al., 2008). However the concurrent equivalence of location errors between moderate and high A-Trait categories suggests these participants were already operating at or above working memory capacity limits.

Hypothesis 6

There will be a significant A-Trait x Piece interaction for RT. Specifically, RT will increase linearly as a function of A-Trait; this linear increase will be greatest for the Difficult piece, smaller for the Intermediate piece, and smallest for the Easy piece.

Hypothesis 6 was not supported. A-Trait did not affect reaction time on the secondary task, therefore an evaluation of moderation effects was unnecessary. A-Trait did however moderate the effect of primary task difficulty on secondary task location errors. This suggests that when participants were able to successfully shift to the secondary task, neither anxiety nor the difficulty of the sight reading task impacted efficiency. In accordance with ACT, it was not efficiency in the task per se, but rather the shifting function that was impacted by the combined influences of A-Trait and primary task load (Eysenck et al., 2007).

Hypothesis 7

There will be a significant A-Trait x Piece interaction for Error Tally. Specifically, Error Tally will increase linearly as a function of A-Trait; this linear increase will be greatest for the Difficult piece, smaller for the Intermediate piece, and smallest for the Easy piece.

H7 was partially supported in the present study. The effect of A-Trait on secondary task location errors varied depending on the difficulty of the sight reading task, although not in the predicted direction. When performing the easiest piece, all participants made an equivalent number of location errors, irrespective of A-Trait. When performing the intermediate piece, those with low A-Trait made fewer location errors than those with moderate to high A-Trait. When performing the difficult piece, all participants made an equivalent number of location errors, irrespective of A-Trait. These results directly align with Eysenck et al.'s (2007) ACT since they demonstrate that concurrent increases in primary task load and participant A-Trait were directly related to shifting impairments, as evidenced by a failure to locate the target word and/or attend to the production of the required response.

Hypothesis 8

There will be a significant A-Trait x Distraction interaction for Error Tally. Specifically, Error Tally will increase linearly as a function of A-Trait; this linear increase will be greatest for the Social Threat Distraction condition.

Results for H8 were not supported when A-Trait was treated as a continuous variable. Anxiety had no effect on the ability of participants to correctly locate target words when exposed to neutral or threatening distractors. Interestingly, once A-Trait was re-coded as a categorical variable, the moderation effect of A-Trait on the relationship between distraction and location errors was much larger, with a far lower probability that results were produced by chance. Exposure to threatening distractors was subsequently associated with a greater number of location errors for those with moderate or high A-Trait compared to those with low A-Trait. Low A-Trait performers made the fewest location errors when exposed to threatening distractors, moderate A-Trait performers made the fewest location errors when exposed to neutral distractors, and high A-Trait performers made an equivalent number of location errors regardless of the content of auditory distractors. Effect sizes were congruent with previous dual task evaluations of ACT in which A-Trait has been dichotomised (Ansari et al., 2008; Berggren et al., 2012; Derakshan et al., 2009), but only emerged *after* converting A-Trait to a categorical variable. Therefore the validity of the present categorical outcomes cannot be determined.

General Conclusions

Anxiety-related impairment to attentional control was detected in the present dual task experiment, but in an unexpected direction. Performers with the most anxious dispositions tended to process and perform *equivalently* to those with lower anxiety on the musical task. Hypotheses made in the present study assumed that the primary task was neutral, much like a digit span task. Perhaps a performance piece is actually a threatening stimulus to musicians, and becomes increasingly so as the perceived difficulty of the piece increases. This theory might explain the consistently higher anxiety observed in musician samples compared to performers from other domains (Hamilton & Kella, 1992; Marchant-Haycox & Wilson, 1992; Simon & Martens, 1979; Sternbach, 1995).

Equivalent musical performance came at a cost; as the difficulty of the musical task increased, so too did anxiety-related shifting impairments in the target-response task. These failures were equally poor, regardless of the emotional content of distractors. Highly anxious performers have been previously observed to preferentially attend to threatening distractors (Eldar et al., 2010; Fox et al., 2001), which provides evidence of a shift toward stimulus-driven attentional prioritisation (Eysenck et al., 2007). Contrary to previous research, distractor content and anxiety did not interact to produce location errors for those with moderate to high anxiety. It appeared that highly anxious performers were *equivalently* focused on the task, regardless of the emotion content (or even the presence) of distractors. This pattern of results implies that the sight reading task was an attentional priority for all participants. Nevertheless, there is still evidence that the stimulus-driven system imposed a stronger influence on attentional allocation in those with higher A-Trait.

Easterbrook’s (1959) tunnelling hypothesis predicts that higher anxiety will increasingly limit the breadth of attentional focus during performance, which can improve performance to a point. If viewed within this framework, the current results do not contradict Attentional Control Theory at all. Eysenck et al. (2007) proposed that this pattern of results only occurs when the stimuli contained in a task are themselves threatening. If musical tasks are indeed threatening, and if the level of perceived threat is proportionate to the perceived difficulty of the task, then a shift to stimulus-driven attentional prioritisation might in fact favour the highly salient stimuli in the musical score. The ability of highly anxious participants to perform at an equivalent level to those with lower anxiety might not be evidence of an equivalent capacity to maintain a top-down goal focus. Indeed, increases in the difficulty of the sight reading task produced poorer performance on the secondary task for moderate to high A-Trait participants. This is evidence that their top-down attentional flexibility was impaired. Therefore, results suggest at attentional bias toward the musical score at the expense of secondary goals. The greater the anxiety of the performer, the less able they were to utilise the shifting function to manage the dual load. The present results suggest that musical stimuli are more threatening, and therefore more difficult to disengage from, than auditory social threat words in a controlled experimental setting.

Finally, attentional prioritisation of the musical task masked the ability to capture inhibition effects in the present study. Inference might suggest that the reduced attentional flexibility demonstrated by moderate to high A-Trait musicians could manifest as inhibition effects in less controlled performance settings. Nevertheless, the present study only observed anxiety-related impairments to the shifting function.

Chapter 7. General Discussion

The present research has made a number of important contributions. Specifically, this was the first piece of research to empirically evaluate the constituent nature of task difficulty in a musical context and utilise this information to develop experimental tasks. This contribution was also the first to develop a set of musical grading criteria that allow researchers to objectively score participant performance on amateur musical tasks. Finally, these two contributions were used to develop a novel experimental paradigm, within which each of the central predictions in Eysenck et al.'s (2007) Attentional Control Theory (ACT) were tested. Results: (i) were consistent with Eysenck et al.'s prediction that those with higher A-Trait will more readily prioritise threatening stimuli in a bottom-up fashion; (ii) supported Eysenck et al.'s prediction that the shifting function is more readily impaired in those with high A-Trait; and (iii) failed to support Eysenck et al.'s prediction that the inhibition function is more readily impaired in those with high A-Trait. This chapter outlines emergent considerations, strengths, and limitations of the present research, after which theory-driven recommendations are offered for musicians and future ACT researchers.

Attentional Control Theory Conclusions

Eysenck et al. (2007) propose that anxiety has a direct influence on processing efficiency, which under certain conditions may manifest as reduced performance effectiveness. Indeed, high A-Trait is a stronger predictor of efficiency and effectiveness impairment than A-State, particularly under high load conditions (Blankstein et al., 1990; Byrne & Eysenck, 1995). In the present study, primary task efficiency (completion time) and effectiveness (composite) were both strongly influenced by primary task load (task difficulty). Processing efficiency deteriorated as task difficulty increased. The change in efficiency observed from the easy piece to the intermediate piece was comparable to the change in efficiency observed from the intermediate piece to difficult piece. Performer effectiveness worsened on the intermediate piece compared with the easy piece, however the impairment observed on the difficult piece compared to the intermediate piece was substantially larger. Therefore task difficulty affected efficiency and effectiveness in different ways. This implies that some internal factor/s may either protect against performance impairments for easier tasks or else exacerbate performance impairments on more difficult tasks. Although these results do not provide direct evidence of compensatory strategies (as discussed in ACT), future researchers can use the present musical pieces to evaluate conditions (internal and external) that exacerbate/protect effectiveness ratings across linear changes in efficiency.

Primary task efficiency and effectiveness were not influenced by A-Trait or by the interaction between A-Trait and task load. The null effect of A-Trait observed here runs contrary to ACT predictions (Eysenck et al., 2007) and suggests that no speed x accuracy trade-off occurred in the present study. However, it is possible that completion time was a poor measure of processing efficiency. Performance times on musical pieces differ substantially from those seen in discrete trials on cognitive tasks (e.g., Derakshan & Eysenck, 1998; MacLeod & Donnellan, 1993). Although the choice to use completion time as a measure of efficiency was based on previous studies, it may be that musical pieces are too long for this measurement to an accurate indicator. That is, the length of a musical piece may be influenced by factors other than processing efficiency. In the present study, it is possible that this error variance masked primary task efficiency results so that the experiment was not sensitive to detecting a speed x accuracy trade-off. Replications of the present research could be conducted using neural correlates of efficiency instead of completion time (e.g., Ansari & Derakshan, 2011; Bishop, 2007, 2009). Setting this up in a manner that retains the ecological validity of the musical context may be difficult. Nevertheless, neural correlates may also increase measurement accuracy.

According to ACT, task-irrelevant distractors impair efficiency and effectiveness indices for high A-Trait performers, since these performers are more likely to prioritise stimulus-driven attentional processes than low A-Trait performers (Eysenck et al., 2007). In addition, distraction effects appear to be moderated by task load (Graydon & Eysenck, 1989; Lavie et al., 2004). By using a dual task paradigm, the present study was able to evaluate the magnitude of shifts from goal-directed to stimulus-driven attentional processes. Instructions emphasised the importance of the musical (primary) task. Therefore significant A-Trait x distraction interactions on primary task outcomes provided evidence of a stimulus-driven attentional focus, whereas significant A-Trait x task load interactions on secondary task outcomes provided evidence of a goal-directed attentional focus. The interaction between A-Trait and distraction influenced primary task effectiveness, but not efficiency. These results occurred regardless of whether A-Trait was treated as a continuous or categorical variable. Non-significant completion time results may once again be due to the inappropriateness of completion time as an outcome for efficiency in musical research. However, the pattern of results produced for effectiveness was similar to those seen in previous studies. Moderate and high A-Trait performers both produced the poorest effectiveness ratings when exposed to social threat distraction. These results were most noticeable when A-Trait was trichotomised, which means that conclusions need to be considered cautiously. Nevertheless, it appears that distraction interacted with A-Trait in a manner consistent with ACT, particularly when these distractors contained threatening content.

No consistent pattern emerged for the interaction between A-Trait and task load. This may have been a product of task prioritisation. Participants were instructed to prioritise the sight reading task and so anxiety-related effects of task load impacted the accuracy of performances on the secondary task (error tally) instead. Previous perceptuomotor studies have shown that when clear instructions are given regarding task prioritisation, anxiety will impair performance on the de-emphasised task (Murray & Janelle, 2003; Williams, Vickers, & Rodrigues, 2002). Therefore it is not surprising that this occurred in the present study.

Eysenck et al. (2007) predict that anxiety increases the salience of the stimulus-driven attentional system. Those with high A-Trait are said to be particularly vulnerable to this, which makes it more difficult to inhibit task-irrelevant stimuli and shift attention flexibly in a goal-directed fashion (Derakshan et al., 2009). The most comprehensive evidence for these predictions has come from dual task research in which secondary task stimuli are at least as salient as primary task stimuli (e.g., Ansari et al., 2008; Berggren et al., 2012; Derakshan et al., 2009). In the present study, the tasks were not equally salient, yet moderate to high A-Trait performers demonstrated a poorer capacity to manage the dual task load than those with low A-Trait. Low primary task error rates demonstrate that, as instructed, these musicians favoured the primary task. As predicted by ACT, this did not occur for low A-Trait performers, who managed to perform accurately on the secondary task without significantly compromising primary task performance. This pattern of results supports Eysenck et al.'s hypothesis that anxiety impairs the shifting function and is consistent with (albeit not evidence of) Eysenck et al.'s hypothesis that anxiety increases the salience of the stimulus-driven attentional system.

The current findings suggest that the increased influence of the stimulus-driven attentional system occurs earlier in the A-Trait trajectory than has previously been acknowledged. A-Trait interactions were shown for moderate and high A-Trait participants. This suggests that the anxiety-related impairments typically associated with "high" A-Trait scores may actually emerge at lower A-Trait levels than has previously been predicted. Indeed, a similar pattern emerged for moderate and high A-Trait performers in the present study. This was not just an artifact of the anxiety groups, since the high A-Trait group had anxiety ratings that were consistent with those seen in previous high A-Trait samples (see Fisher & Durham, 1999) and the moderate A-Trait group had anxiety ratings consistent with Spielberger et al.'s (1983) non-clinical samples. It may be useful for future studies to manipulate task prioritisation directly, by using incentive conditions or increasing the ecology of distractors. For example, having an examiner (rather than just the researcher) present and visible during performance might increase the likelihood that anxiety-related primary task deficits will emerge. Or, if the distractor words are spoken by the examiner, they may be perceived as more salient than the musical task. Such studies, if conducted in conjunction with continuous (or multiple category) A-Trait measurement, can further delineate the nature of attentional shifts that occur across A-Trait levels.

Attentional Control Theory predicts that anxiety reduces efficiency on tasks that require distractor inhibition (Eysenck et al., 2007). Eysenck et al. (2007) propose that this effect is observed in all performers but is exacerbated for those with high A-Trait, particularly as task load increases. In contrast, Eldar et al. (2010) and Helfinstein et al. (2008) suggested that an attentional bias only emerges for high anxiety performers. Importantly, these researchers did not observe a significant A-Trait x distraction interaction on efficiency (measured using reaction time), and instead produced their significant results in the context of multiple *t*-tests without applying a Bonferroni correction. These results should therefore be interpreted with caution. In the present study, it was predicted that increases in A-Trait would result in a stronger attentional bias toward distractors, and particularly threatening distractors, as evidenced by faster reaction times to the target word when presented amongst social threat distractors. In addition, task difficulty was expected to moderate this relationship. Contrary to predictions, there was a general attentional bias toward threat in the sample when A-Trait was treated continuously. This was not moderated by task difficulty. When A-Trait was trichotomised, participants with low A-Trait demonstrated an attentional bias toward threatening distractors, however no bias was observed for moderate to high A-Trait participants. The present findings concurred with Eysenck et al.'s original conception that attentional bias to threat is not specific to high A-Trait performers but did not support the idea that these effects worsen across increases in A-Trait. The present results also disagree with those reported by Eldar et al. and Helfinstein et al. Moreover, since the present findings were produced in the context of the overall GLMM analysis, rather than multiple comparisons, it is unlikely that they are contaminated by family-wise error.

The present results did not appear to support Eysenck et al.'s (2007) inhibition predictions; A-Trait and task load did not moderate the effect of distraction on secondary task efficiency. However if observed in the context of task instructions and shifting effects, these results make sense. Moderate to high A-Trait performers made more location errors on the secondary task; that is they failed to shift attention more often than low A-Trait performers. It is possible that an inhibition effect did not emerge for these participants because they did not attend sufficiently to the secondary task to demonstrate a measurable effect. They acted as instructed, but did so to the detriment of the secondary task. These shifting impairments may have masked any inhibition impairments that otherwise might have emerged. Future studies can improve on this design by increasing the saliency of the secondary task. Once again, this might be achieved using incentive based instructions. Increased secondary task salience may also produce the sorts of task load moderation effects that are predicted within ACT.

Attentional Control Theory predicts that anxiety will impair processing efficiency (and often effectiveness) on tasks that involve the shifting function. This has been frequently observed on prospective memory tasks (Cockburn & Smith, 1994; Harris & Cumming, 2003; Harris & Menzies, 1999). The secondary task in the present study was similar to previous prospective memory studies, since it involved sporadically presented cues, which required a response from the performer. In accordance with these studies, the present results demonstrated that primary task load and A-Trait influenced the capacity of performers to shift attention successfully to the secondary task. Despite this indication that shifting impairments did indeed occur, there were too few trials with too much response variation to detect efficiency effects. Future studies can improve on this design by increasing the frequency of distractor words and also the number of target words distributed amongst distractor words. This would likely reduce the variation in reaction time scores and improve the probability of capturing efficiency effects alongside effectiveness effects.

Musical Performance Conclusions

The present research was the first to use an ecologically derived multi-component model of task difficulty to guide piece manipulation. Task difficulty was manipulated by reducing the number of notes to create increasingly easier pieces. In music this has the added effect of increasing note values, which reduces the speed with which notes must be perceived, processed, and played. Large variations in processing and performance outcomes were observed in Study 2 as a consequence of this task difficulty manipulation. As pieces became more difficult, gradual increases in completion time and reductions in performance quality were observed, regardless of individual performer characteristics. Furthermore, there was no ambiguity in the pattern of performance quality impairment across the three pieces. Indeed, task difficulty effects were very large despite considerable differences in experience, age, and training within the sample. Based on the size of these effects, it is reasonable to assume that these three pieces would produce large differences in completion time and performance quality in more selective samples.

Task difficulty was the most influential factor in determining the quality of a musical performance (eight times larger than all combined anxiety effects). Yet it has essentially been overlooked in previous musical performance research. Many MPA researchers have allowed participants to select their own performance pieces (Egner & Gruzelier, 2002; LeBlanc et al., 1997; Salmon et al., 1989). Those who have presented all participants with the same set of tasks have not attempted to quantify task load differences (e.g., Cheng et al., 2011). The present research provides evidence that this approach can introduce significant task-related systematic bias, as task difficulty was the strongest source of variation in performance outcomes. Therefore, it is critical that task difficulty be controlled when observing performance outcomes in music. By doing so, researchers can more accurately disentangle task-related and performer-related sources of outcome variation.

Trait anxiety did not independently impact performance quality in the present research. Instead, it was the effect of A-Trait on attentional processes *in the presence of distraction* that resulted in variations to performance outcomes. Easterbrook's (1959) tunneling hypothesis predicts that increased physiological arousal can boost performance to an extent, since resultant restrictions in perceptual breadth will produce increases in attentional focus toward the most salient cues. In accordance with this, neutral distraction improved the performance of musicians with moderate to high A-Trait relative to performing without external distraction. The level of additional stimulation imposed by the neutral task improved performance in the primary task, which participants had been instructed to prioritise. This effect did not occur for low A-Trait performers. It is possible that the neutral task did not pose a sufficient load to significantly affect attentional tunneling in these performers. Future studies can be conducted to evaluate the load conditions under which attentional tunneling is observed across levels of A-Trait. Finally, social threat distraction impaired secondary task performance for those with moderate A-Trait relative to performing without external distraction. These latter findings are consistent with Eysenck et al.'s (2007) supposition that A-Trait can indirectly reduce the quality of a performance by impairing the capacity to shift attention between tasks. It is important to note that social threat distraction produced ambiguous performance quality results for high A-Trait musicians. More research is therefore required to clarify the nature of this relationship.

Overall, the effect of anxiety on musical performance outcomes was *much* smaller than has previously been reported (Fishbein et al., 1988; Marchant-Haycox & Wilson, 1992; Steptoe & Fidler, 1987; van Kemenade et al., 1995). It is possible that previous figures have been inflated by task-related error variance, retrospective reporting, and imprecision in experimentation. A-State and attentional allocation both appear to be products of the interaction between A-Trait and context-/task-specific factors (Eysenck et al., 2007; Hainaut & Bolmont, 2006; Ruggiero, 2006). The fear that musicians have of their anxiety might therefore be unwarranted given the true size of the effect that anxiety has on musical performance outcomes. That is, it may not be A-State per se that produces the errors and impairment that so many musicians fear. Rather, a predisposition to anxiety might interact with extraneous factors in the performance arena (including the piece itself), resulting in performance impairment if working memory limits are overloaded and attentional flexibility severely reduced. This would likely correlate with increases in A-State, since both are moderated by A-Trait. Since A-State was not directly measured in the present research, further investigation is required before this conclusion can be accepted. Nevertheless, the present results support the eradication of the facilitative/debilitative anxiety dichotomy that has underpinned much musical performance anxiety research. That is, performance can be facilitated and debilitated, but not in a dichotomous manner.

Over-Estimation of Anxiety Effects

Most studies that have been cited as evidence for ACT have evaluated anxiety effects after arbitrarily creating high/low A-Trait groups (Ansari et al., 2008; Eldar et al., 2010; Harris & Cumming, 2003; Helfinstein et al., 2008). The problem with this is that arbitrary dichotomisation can produce false estimates of statistical and practical significance (Maxwell & Delaney, 1993). The present analysis was more sophisticated than the *t*-test comparison approach used in these past studies. Anxiety-related attentional bias was calculated *after* controlling for family-wise error and variation attributable to other fixed effects in the model, which cannot be achieved using *t*-tests (Keppel & Wickens, 2004). Nevertheless, secondary analyses were re-run after trichotomising A-Trait, in order to see whether this changed probability and effect size estimates. It was unfortunate that A-Trait needed to be categorised at all, since this increases the risk of Type I errors (Streiner, 2002). Nevertheless, the creation of three groups retained something of the continuous nature of A-Trait. Results produced using these three groups suggested trends as well as group differences. Interestingly, the interaction between A-Trait and distraction became seven times larger for completion time, doubled for reaction time, and moved from having no effect to having a moderate to large effect on the number of location errors. The interaction between A-Trait and distraction on sight reading performance effectiveness disappeared.

Novel results need to be interpreted tentatively. Given the sheer number of studies that have supported ACT predictions, it is unlikely that A-Trait has a null effect on efficiency and effectiveness. In fact, the present study at least partially supported many of the central predictions made within ACT. It is however plausible that the impact of A-Trait on attentional bias and consequent distractibility has been somewhat over-exaggerated in previous research. Neuroscientific evidence appears to support that high and low A-Trait performers experience different neural activity when performing in anxiety-provoking conditions (Berggren & Derakshan, 2012). Nevertheless, it may be useful to study the trajectory of these differences across changes in A-Trait. It is presumptuous to assume that this trajectory is linear without further investigation. As long as a large enough sample can be recruited, future studies can aim to treat A-Trait as a continuous variable and conduct post hoc comparisons within the context of the overall analysis. When such a sample cannot be obtained, it may be useful to create three or more A-Trait groups. Reliable evidence can then be compiled regarding the nature and trajectory of A-Trait effects.

The Controversy of Musical Measurement

Measurement of musical tasks has been a topic of considerable controversy (Wrigley, 2005). The present research produced evidence that aspects of a musical task *can* be manipulated and graded in quantifiable and meaningful ways. Participants in Study 1 identified technical requirements and note density as the two most important contributing factors in determining musical task difficulty. The sight reading pieces used in Study 2 were then manipulated by removing technical markings and reducing note density, which produced very large effects on completion time and performance effectiveness. These results provide evidence that: (i) technical components and note density are important components of task difficulty, and (ii) these factors can be validly measured.

Johnson (1997) and Mills (1991) proposed that qualitative judgements retain the substance of a performance in a way that is unattainable using quantification strategies. Observations made in the present research strongly oppose the absoluteness of this position. Nevertheless, task difficulty did not explain all of the variation observed in completion time and performance effectiveness in Study 2. Other task load factors were also identified in Study 1 (speed, stylistic complexity, emotional complexity, and repetition). It may be that including more factors would have increased the effect size, however to evaluate a combination of these factors using controlled experimentation, many more sight reading tasks would have been needed. Furthermore, it is difficult to conceive a method of quantifying the quality on one's performance of emotional and stylistic factors. In order to evaluate the effect that different combinations of these factors have on performance efficiency and effectiveness, future studies could employ a combination of subjective and objective rating procedures.

Error minimisation is very important to performing musicians (van Kemenade et al., 1995). Accurately capturing these errors and providing general recommendations for their reduction may only focus on a single element of the musical performance. Nevertheless it is a highly relevant element for many musicians who perceive themselves to be *making errors* as a result of their anxiety (Fishbein et al., 1988). Although the quantification method used in this study was not as comprehensive as Wrigley's (2005) rubric, it was entirely objective and sufficiently comprehensive to score all encountered performance phenomena in the present research. It lends itself to performance evaluation across a range of skill levels and is therefore well suited to research in the general musician population. Specifically, the set of grading criteria was used in the present research to score performances of musicians aged 12-52, with 3-40 years of playing experience, who had completed 0-9 graded examinations within at least one of three training background categories. No performance quality scoring procedure has been created using so heterogeneous a sample and also produced the sizeable task difficulty-related effects observed here.

Strengths and Limitations of the Research

Evaluation of Study 1

Study 1 was an important strength of the present research. Using a qualitative methodology, the researcher was able to categorically identify the component features of musical task difficulty. This approach relied on experts in the field to shape the nature of the construct, which is particularly useful when either no quantitative data is available or the relevant literature contains a large divergence in opinions (Flick, 2009). In this case both were true. No previous empirical data was available to draw upon. Furthermore, task difficulty has been primarily examined in the context of musical education research, within which personally defined grading criteria have most often been used to group pieces within descriptive difficulty categories (Ralston, 1999; Winston, 2003). Study 1 filled this gap in the literature by defining task difficulty in a way that lends itself to future testing and the manipulation of experimental musical tasks.

The validity of the three experimental musical tasks was evaluated in two ways: (i) face validity was assessed by collecting expert opinions and recommendations, and (ii) content validity was assessed by comparing modifications to the emergent factor structure of task difficulty. These assessments provided a rationale for using the tasks in Study 2 and ensured that the three pieces were designed with as much rigour as is possible in experimental musical research.

Evaluation of Study 2A

The pilot study further strengthened the present research. By ironing out inefficiencies, glitches, and behavioural anomalies prior to conducting the full-scale experiment, the researcher was able to minimise administration and experimenter sources of error. This was necessary given the onerous task load that experimental administration imposed on the researcher.

The pilot study was also used to develop an objective set of grading criteria for scoring musical performances. This increased the efficiency of the analysis and eliminated the need for inter-rater reliability estimates, which are notoriously low in musical performance research (Kageyama, 2007). Although previous marking rubrics have been developed (e.g., Wrigley, 2005), this is the first to both demonstrate objective accuracy and utilise positive and negative indicators of effectiveness. This objective grading procedure can be used as a basis for comparison in future musical performance research. Standardised scores and descriptive statistics that are derived using this procedure can be validly interpreted and contrasted across studies.

Evaluation of Study 2B

Study 2 required piano players to perform three novel sight reading tasks. Participants all had the same exposure to the experimental task, and practice and primacy effects were distributed randomly across the sample. Most previous musical performance studies have allowed participants to perform pre-prepared pieces, despite the fact that this complicates interpretability. Ecological validity comes with performing the pieces that one is learning as part of real-world musical participation. Nevertheless, differences between participants and performance tasks cannot be ruled out as the source of outcome variance in these studies. Due to the repeated measures design, the current study was not vulnerable to between-group threats to internal validity. All participants experienced a randomised set of the same nine conditions. Given the complexity of musical tasks and the current inability of researchers to equate factors between qualitatively different tasks, these sight reading tasks might offer the best compromise between ecological validity and preservation of experimental control.

By not allowing participants to select performance pieces in the present study, anxiety and distraction effects may have been underestimated. In his work on achievement motivation, Nicholls (1984) suggested that ego investment and consequent effort in task performance is determined by task difficulty, perceived ability, and perceived performance. Individuals typically self-select tasks that maximise the likelihood of demonstrating high ability whilst minimising the likelihood that they will demonstrate low ability. Subjective probability judgements of these likelihoods determine task effort, approach (mastery versus performance motivation), and quality outcomes (Eccles, 2005). In sport psychology literature Nicholls’ ego/task terminology is still widely applied (Elliot, 2005).

Participants may not have been as personally invested in performance of the sight reading task as they have been in previous studies, which have required them to perform personally chosen pieces. Greater personal investment may exist when musical pieces are self-selected. There may be more to lose if making errors on a piece over which one has a measure of personal ownership. Anxiety-inducing experimental conditions such as the distraction conditions used in the present research might have a greater effect under conditions of increased ecological validity. This direction of inquiry is worth pursuing in future research. If accurate, it is not a problem that can be easily rectified in music experimentation. Allowing self-selection of performance pieces re-introduces the uncontrollable variance that plagued earlier performance studies. The balance between ecology and internal validity is one that requires further consideration as the field continues to evolve.

Other measures could have been introduced in the present study to increase ego investment (and therefore performance anxiety). For example, LeBlanc et al.'s (1997) audience conditions might have been employed so that effects and interactions could be compared across different performance conditions. However the addition of a between-groups factor would have tripled the number of participants required for sufficient statistical power. Researchers who have access to large groups of musician participants can replicate the present study with audience conditions. This would increase the ecological validity of the study.

Ecological executive function tasks are those that accurately capture the cognitive demands of real-world environments (Manes, Villamil, Ameriso, Roca, & Torralva, 2009). Sight reading is a commonly examined component of musical skill in the real world, requiring both cognitive processing and motor execution (Wristen, 2005), however other musical performance skills may need to be independently evaluated. Perceptual processes and subsequent motor coordination have been shown to differ between the initial exposure and eventual recital of a piece (Halsband, Binkofski, & Camp, 1994). These motor differences may alter the executive processing requirements at either end of the learning process. Sight reading would therefore be a qualitatively different skill to performance of a prepared piece. The present study was a first attempt at measuring executive function variables within a musical performance context, and thus prioritised experimental control. Musical performance researchers can continue to refine the tasks used here by evaluating their capacity to predict subsequent performance in real-world examinations and recitals.

It may be that the salience of threatening cues in the external environment would increase in higher ecology performance settings. It was likely that the improved performance of moderate to high A-Trait musicians observed in the neutral distraction condition was due to the prioritised saliency of threatening stimuli in the piece; musical notes were direct threats (if performed incorrectly) to experimental instructions and the knowledge that one's performance would be examined at a later date. Thus, prioritisation of bottom-up perception would favour the stimuli in the primary task. True performance settings are far less contrived than an experimental laboratory. It seems likely that the same attentional rigidity that maintained the performance effectiveness of moderate-to-high A-Trait musicians in this study might easily impair performance when other salient task-irrelevant stimuli (such as those contributed by an observing audience) are present. If an attentional shift occurs during a performance, the musician needs to be flexible enough to shift back to the musical task.

It is important to consider alternative methods with which the hypothesised interaction between task difficulty and A-Trait might have been captured. It may have been useful to obtain subjectivity ratings from the participants to confirm the established difficulty of pieces. There is a possibility that A-Trait might have moderated the effect of subjectivity ratings more strongly than Piece ratings. Nevertheless, that task difficulty impacted efficiency in a manner consistent with both the research hypotheses and previous efficiency research (Berggren & Derakshan, 2012) means that it is unlikely that this variable was misperceived by the participants in the study. Instead, the non-significant A-Trait interactions with task difficulty are likely to reflect one of the following alternative explanations (all of which have been discussed in Chapter 7): (i) the relative irrelevance of A-Trait for predicting efficiency ratings in this particular sample; (ii) the inappropriateness of completion time as a measure of efficiency; or (iii) Type II Error, despite having sufficient power for observing this particular interaction.

Evaluation of the Dual Task Methodology

It is important to consider the extent to which primary task manipulations produced a theoretically and statistically independent impact on outcomes when equated alongside the effect of a dual task (Duncan et al., 1997). It can be difficult to accurately measure the separate influences of dual tasks on outcomes when modal similarity is too high (McLeod, 1977). Establishing independence in traditional dual task experiments is relatively straight forward. Widely used tasks with clearly defined presentation conditions (e.g., Stroop or saccade tasks) can be adopted by adapting those used in previous studies of cognition and performance. Music is a less straightforward domain. Peretz and Zatorre (2005) argued that sight reading is a primarily visuospatial task, however they also conceded that auditory feedback is relied upon to monitor task performance.

The effect of primary task difficulty on efficiency and effectiveness did not vary across the three auditory distraction conditions. Similarly, the effect of each distraction condition on secondary task reaction time and location errors did not vary across the three sight reading tasks. The present findings provide evidence for task independence since neither task moderated the influence of the other on measured outcomes. If this finding is replicated, researchers can confidently utilise these musical sight reading tasks in conjunction with auditory dual tasks in future experiments.

Measurement of Key Variables

Initially it was intended that this entire project be conducted without categorising A-Trait. Two considerations led to the decision to conduct secondary analyses using trichotomised A-Trait: (i) the importance of graphical representations of moderation relationships in the data, which could not be accomplished using a continuous variable; and (ii) recruitment difficulties. The former consideration did not impact analyses, since the overall GLMM for each outcome used the continuous A-Trait variable. However the latter consideration resulted in inadequate statistical power for some of the analyses; the secondary analyses were therefore included because they were not underpowered. By using three groupings of A-Trait, the researcher was able to maintain something of the continuous nature of the variable. This resulted in the observation of some curious similarities between moderate and high A-Trait performers. The validity of these findings relied almost entirely on the similarity of the groups to previous samples. Fortuitously, the high A-Trait group scored within the range of means observed across six clinical outcome studies (see Fisher & Durham, 1999), the moderate A-Trait group scored within the range of means produced by Spielberger et al.'s (1983) non-clinical normative samples, and the low A-Trait group performed more than one standard deviation below previous non-clinical samples (e.g., Crawford et al., 2011; Knight et al., 1983; Spielberger et al., 1983). Based on these results, it is likely that the three groups were aptly named and sufficiently different to draw accurate conclusions from trend data. This is an important issue for future studies to consider if comparisons will be made across more than two A-Trait groups.

The effect of A-Trait on distraction and subsequent processing efficiency is well-established when attentional load is high (Blankstein et al., 1990; Byrne & Eysenck, 1995; Eysenck & Calvo, 1992; Staal, 2004). In high load conditions, high A-Trait performers demonstrate inhibition and shifting impairments when distracted (Roberts, Hager, & Heron, 1994). This effect is magnified when distractors are threatening (Bar-Haim et al., 2007; Eldar et al., 2010; Hopko et al., 1998). This finding has been replicated in perceptuomotor research, albeit in a limited fashion (Smith et al., 2001; Williams et al., 2002). Such studies have typically used indirect measures of efficiency and failed to consider the possible impact of inhibition and shifting processes. There were two key improvements in the present perceptuomotor performance study: (i) A-Trait was treated as a continuous variable for primary analyses; and (ii) the distraction conditions imposed concrete differences in working memory demands, allowing general conclusions to be drawn regarding emergent inhibition and shifting effects.

Completion time was a problematic indicator of primary task efficiency. However primary task effectiveness outcomes were well suited for capturing variation produced by task load, A-Trait, and distraction. In previous studies that employed a time versus accuracy paradigm, efficiency and effectiveness were estimated across discrete presentations of a stimulus (e.g., Derakshan & Eysenck, 1998; MacLeod & Donnellan, 1993). Musical tasks require sustained attention, much like the tasks used in these previous studies, however they also require a time-based stream of sequential perceptuomotor output that closely resembles high-intensity competitive sports (Ganushchak & Schiller, 2008; Ruiz et al., 2011; Ullsperger & von Cramon, 2004). This means that outcomes also need to be measured continuously so that changes in efficiency and effectiveness can be accurately captured across an entire performance. In the present research, completion time was sensitive to task load effects but not to A-Trait or distraction effects and interactions. Future studies can measure neural correlates of efficiency in musical tasks, since these outcomes may be more resistant to extraneous factors than completion time. Conversely, composite was sensitive to continuous changes in performance quality, as evidenced by the strong correlations between the three component outcomes (Inverse_PC, No_Incorrect, and Chunks). This outcome was therefore a valid indicator of effectiveness.

The present research adopted the safest method for operationalising primary task efficiency and effectiveness by directly borrowing operational definitions from cognitive performance studies of ACT. In light of the finding that A-Trait moderated some indices of effectiveness after it had been converted into a categorical variable, future studies could alternatively operationalise primary task efficiency as completion time/Composite. The benefit of this approach is that it defines efficiency as speed *relative* to accuracy, which operationally accounts for any speed/accuracy trade-off that may have occurred to compensate for the high task load. In the context of musical performance, completion time might then need to be defined as optimal completion time minus actual completion time, since metric markings should ideally be adhered to by performing musicians. It is also possible that the resultant variable would have to be mathematically transformed if negative numbers are produced by those who play the piece faster than the optimal completion time. Future studies can adopt this measurement approach as an alternative to the standard application of cognitive performance literature utilised in the present research.

Secondary task reaction time and location errors have been frequently used in previous dual task studies that were interested in independently measuring efficiency and effectiveness outcomes (Cockburn & Smith, 1994; Harris & Cumming, 2003; Harris & Menzies, 1999). In the present research these outcomes were measured identically to the above studies. Therefore results between studies were directly comparable. As with these previous studies, the present results show that A-Trait has no independent influence on efficiency and effectiveness. Future ACT studies can maximise inter-study comparability by continuing to use reaction time and location errors as measures of speed and accuracy on performance tasks.

General Design Considerations

Spielberger’s (1983) State-Trait Anxiety Inventory (STAI) was used to measure A-Trait in this study. Social desirability bias can confound the measurement of anxiety factors, particularly when self-report scales have high face validity (Ganster, Hennessey, & Luthans, 1983). However, the A-Trait scale has demonstrated a much lower sensitivity to this source of bias than the A-State scale (Johnsen, Tracy, & Hohn, 1983). Anxiety-related effects and interactions were observed in accordance with the theoretical underpinnings of this study. Anxiety scores were also normally distributed. Therefore, the effect of social desirability bias is likely to have been minimised in the present research.

Significant sampling problems arose during recruitment for Study 2B. Contact was made with 3000 piano players in the Perth Metropolitan Area, each of whom indicated an interest in participating. Of these, only 29 both booked a time to do the experiment *and* showed up at that time (many cancelled on the day of their experiment). This severely impacted power in the study, particularly for detecting interactions on reaction time and error tally. Curiously, most previous musical performance studies have relied on similarly small samples, although none have specifically mentioned sampling difficulties (e.g., Appel, 1976: n = 30; Cheng et al., 2011: n = 25; Clark & Agras, 1991; n = 34; Kageyama, 2007: n = 18; Mentello, Coons, & Kantor, 1990: n = 17 [experiment 1] and 24 [experiment 2]; Nagel, Himle, & Papsdorf, 1989: n = 20; Niemann, Pratt, & Maughan, 1993: n = 18; Ruiz et al., 2011: n = 14; Zinn et al., 2000: n = 16). One way in which future musical performance researchers adopting an experimental design can increase sample size is by teaming up with, and running the experiment at, a range of musical institutions/campuses. However this introduces experimental control issues; each site running the experiment would need to do so in a standardised manner.

Convenience and snowball sampling resulted in high sample heterogeneity in the present study; that is, while participants were all piano players, there was a very diverse range of experience, age, and training represented. Sample heterogeneity is often undesirable because it can increase unmeasured bias and inflate outcome variation so that true effects are masked (Rosenbaum, 2005). In true experimental designs, the random allocation of groups or conditions can eliminate bias when a sufficient sample is collected (Rosenbaum, 2005). The present repeated measures design sampled 261 data points. This is a large sample for experimental purposes and random allocation of conditions is therefore likely to have sufficiently distributed unmeasured bias across the nine conditions. Mixed effects linear regression analysis further reduced the risk that results might be due to sampling error. This approach treats participants as ‘random effects’, which statistically accounts for within- and between-subject sources of variation and therefore allows inferences to be drawn regarding population effects (Penny & Holmes, 2003). Interestingly, a number of small to medium effects were observed despite sample variation. Therefore, these sample effects are more likely to have approximated true population effects than they otherwise might have using a narrower sample.

It is likely that some small and small to medium effects were masked in the present research, as evidenced by the approaching significance of some of the results. Indeed, a number of key reaction time and location error findings were uninterpretable because of low *p*-values. Furthermore, sample heterogeneity resulted in significant variation in the data. A larger sample with less variation would have improved the likelihood of capturing true effects and identifying illusory effects.

Convenience sampling also resulted in an unbalanced representation of age and gender. There was a positively skewed age distribution and 72% of the sample was female. Previous literature has identified a gender discrepancy in the frequency of anxiety-related performance impairment in musicians (McGinnis & Milling, 2005). Differences have also been observed across samples with child, adolescent, or adult age restrictions (Fishbein et al., 1988; Osborne et al., 2005; Ryan, 1998). No experimental groups were created in the present research, so the variability of these factors was able to be dealt with in the context of the linear effects regression model. None of the demographic factors were correlated with A-Trait scores either, which is desirable, because it means that they are unlikely to have contributed significant systematic bias to the calculation of anxiety-related effects. Future studies can improve on the current research by restricting the age range of the sample and evaluating emergent differences between specific age groups.

Recommendations for Musicians

The effect of task difficulty on completion time and subsequent performance outcomes was so sizeable that it is worthy of practical consideration. Density and value of notes in a given piece very strongly predicted musician processing speed and performance outcomes. The fact that such a large effect was produced *despite* substantial individual differences between performers indicates that the effect of processing load on performance is important irrespective of age, gender, experience, or training background. This suggests that denser pieces impose a more taxing processing load on a musician, which can manifest as observable performance impairment.

Salmon's (1990) review provided a benchmark that has strongly influenced the assessment of musician performance anxiety. In it, he suggested that anxiety causally impacts performance regardless of practice and preparation. It is critical to note that most studies that have supported this position have measured 'impairment' by collecting musicians' retrospective self-reports. This is in fact a measure of *perceived* impairment, rather than *objective* impairment, only the latter of which is visible to audiences. In the present study, aspects of the performance were objectively scored. Practice and priming effects were distributed randomly throughout the sample, yet task load was a significantly stronger predictor of objective performance impairment than anxiety. This indicates that there may be a discrepancy between a musician's subjective experience of performance quality and the sensory display experienced by onlookers. Since A-Trait moderates attentional control (seen in the Study 2B through shifting impairments) *and* A-State (Hainaut & Bolmont, 2006; Ruggiero, 2006), it is possible that the interaction between A-Trait and distraction is a more important predictor of impairment than A-State. Specifically, the present study supports that when task load is high, anxiety may overtax working memory, preventing attentional flexibility and the capacity to manage concurrent goals. In a real performance environment, distractors are not as controlled as they were in the present research. Performers also have to do more, which increases task load (e.g., pedalling, articulation, and so on). The combination of these factors might make it difficult to recover from or 'mask' errors once stimulus-driven attentional processes are prioritised. This is a relevant direction of inquiry for future MPA research.

So how can musicians improve their attentional flexibility? Sight reading skill has previously been shown to predict solo performance outcomes (McPherson, 1997; Saunders & Holahan, 1997). This is likely because the speed with which a performer can process novelty will partially determine response time and quality impairment when internal/external disruptions break the flow of implicit memory recall (muscle memory) during well-practiced performances. Inclusion of sight reading in one's practice routine may therefore improve working memory capabilities on musical tasks. Since task difficulty was seen in Study 1 to comprise a variety of piece-specific elements, it may be helpful to practice sight reading across a range of styles, composers, genres, speeds, and so on.

Solo real-world performances are rated as the most anxiety producing form of musical performance across musician samples (Cox & Kenardy, 1993). They also generate higher levels of anxiety than solo sport or academic performances (Simon & Martens, 1979). It therefore seems reasonable to assume that attentional flexibility needs to be deliberately practiced *within* the context of anxious-activation. This is consistent with Wan and Huon's (2005) discovery that beginner musicians who practiced with video monitoring improved their performances when placed in a high pressure examination environment. Many musicians experience a 'practice room' phenomenon, in which their performance in the practice room is superior to the recital performed on stage. Perhaps the best way to prepare for a performance is by inducing the same internal changes as might occur in the performance. Essentially this would involve: (i) practicing in an environment that activates one's predisposition toward anxiety (producing resultant inhibition and shifting impairments), and (ii) doing so in the presence of auditory and visual distractors (e.g., people watching, listening, or going about other activities whilst one practices). This is a relevant direction of inquiry for future MPA research.

The above recommendations are directly implicated by the present research. For a comprehensive overview of other musician performance anxiety treatments, readers are directed to literature reviews by Brugués (2011) and McGrath (2012).

Future Directions

In the present research, a musical experimentation paradigm was developed. In part, experimental control and scoring objectivity were possible because an electronic instrument was used, alongside software that accurately translates key presses into MIDI notation. This experimental paradigm may not be effective when evaluating non-electronic instrument performance (e.g., brass and woodwind). Nevertheless, the increasing availability of electronic instruments allows that the present experimental design can be replicated using any such instrument. Future studies can therefore evaluate the generalisability of the present results across instruments.

Musical performance researchers have observed many anxiety-related correlations, yet established few anxiety-related causal links. It is recommended that MPA researchers explore attentional processes and particularly the utility of ACT to explain variation in performance outcomes. The facilitative/debilitative dichotomy is a fallacy that oversimplifies the complexity of a real-world performance arena. Attentional Control Theory provides a useful method of conceptualising the complete spectrum of anxiety-related performance experiences *without* dividing these experiences into categories.

Despite the domination of attentional models within cognitive literature, there are a number of sport performance anxiety models that may warrant closer examination. The present study research evaluated the extent to which ACT hypotheses predict outcomes in musical performances. This focus was selected based on the rationale that musical performance is a cognitive endeavour simultaneous to being a perceptuomotor endeavour. Next, it may be worth researching the comparative explanatory power of competing models *across* literature domains. For example, future researchers might evaluate the goodness of fit of musician performance data to ACT concurrently to Beilock and Carr's (2001) explicit monitoring theory or Masters, Polman, and Hammond's (1993) reinvestment hypothesis.

Shifting impairments were particularly noticeable in the present research, however inhibition effects could not be determined. The threat-based saliency of the musical task masked the ability to detect an anxiety-related attentional bias to threatening distractors. Future studies may need to develop alternative methods of evaluating inhibition effects during musical performance. Importantly, the modality of distractor presentation may be directly related to the magnitude of impairment. For example, it is possible that the perceptual dominance of visual stimuli favours a musical task when distraction is solely auditory. Researchers can evaluate the effect of visual distraction on musical performance, bearing in mind that visual secondary tasks are more likely to disrupt the primary task by virtue of the similar presentation modality. Another possible approach is to evaluate ecological distractors such as different types of audience, different positions of the audience in relation to the performer, and so on. The goal of these types of research would be to further delineate the interaction of A-Trait and distraction on musical performance outcomes.

Musical performance outcomes were not impaired in the present study. Nevertheless, the rigidity and prioritisation of bottom-up processing that emerged in secondary task location errors might easily translate to performance impairments in non-laboratory settings in which threatening environmental cues are less controlled and therefore more salient. It would therefore be useful to replicate the present study *within* a real-world performance setting. This would allow the above extrapolations to be explicitly measured. The management of ecology/internal validity is directly relevant here. Although there is no currently available method for ensuring internal validity in real-world musical performance research, the present contribution offers a basis for comparison so that changes in effect size estimates can be interpreted.

Another way to pursue this direction of inquiry would be to manipulate performer motivation. Incentive manipulations have successfully affected task prioritisation in cognitive tasks (Eysenck et al., 2007). The benefit of this replication approach is that experimental control could be maintained in much the same way it was in the present study. Variation across anxiety levels would therefore be directly attributable to experimental manipulations. This cannot be conclusively established in non-standardised experimental settings. Unfortunately, a much larger sample would be required to maintain adequate statistical power if a between-subjects factor was included (Keppel & Wickens, 2004).

A number of design recommendations emerge from the present contribution. It is suggested that A-Trait be treated as a continuous variable. Previous studies may have overestimated effect sizes when a median-split or alternative method of dichotomisation was employed. In order to avoid this and more accurately approximate population effects, the variability produced by continuous measurement needs to be preserved. The present study provided evidence that both statistical significance and effect size can markedly improve when A-Trait is categorised. Indeed, this approach may be useful when researchers want to establish the existence of group differences between two poles of a continuous factor (e.g., weight, height, mood, and so on). Attentional control literature has produced significant evidence that group differences exist between high and low A-Trait performers. In order to understand the complexities and trajectory of this relationship, it seems useful to now explore the nature and rate of change of this relationship across changes in A-Trait. It is ideal to treat A-Trait as a continuous variable. However, if sample size is inadequate for this, researchers may instead create three, four, or five A-Trait groups, so that trends in group differences can be meaningfully interpreted.

A-State was not measured in the present study, since the researcher aimed to specifically evaluate ACT predictions regarding A-Trait effects. A questionnaire measure of A-State was undesirable since questionnaires are static measures, whereas A-State is transient. Therefore, there would be no way to link continuous changes in outcomes to continuous changes in A-State. Although physiological arousal is a single component of anxiety, it may be useful for future researchers to evaluate changes in arousal measures alongside experimental outcomes such as those measured here. This is one way in which a continuous (albeit partial) measure of A-State could be incorporated into a replication of the present research. Researchers who are interested in measuring the relationship between A-Trait and A-State concurrently in the context of the present experiment are encouraged to either do so separately to their evaluation of ACT hypotheses so as to avoid having to interpret a four-way interaction (A-Trait x A-State x efficiency x effectiveness).

Finally, the sizeable importance of task difficulty in determining outcomes critically departed from previous MPA research. Not only does this finding necessitate the consideration of task difficulty in future MPA research, but it also implies that practice could be a relevant and useful strategy for musicians to minimise the impact of anxiety on processing and consequent performance outcomes. Indeed, all performance outcomes improved across the duration of the present experiment. A recommendation was therefore made to deliberately practice processing novelty by sight reading a variety of pieces. This would provide exposure across the range of factors identified in Study 1. Additionally, practicing in anxiety-provoking settings in the presence of potential distractors might be a way to minimise the 'practice room effect' in the lead up to a performance. The above recommendations were consistent with the findings of the present study and ACT. They can be effectively evaluated within the context of a longitudinal design and may produce valuable insights for many musicians who continue to demonise the experience of anxiety.

Summary

The research that has been outlined in this dissertation made four key contributions to the field. These included: (i) an exploration of task difficulty; (ii) the creation of three musical piece variations that can be used as experimental sight reading tasks in future studies; (iii) the development of the first objective scoring criteria for musical tasks; and (iv) the first evaluation of Attentional Control Theory predictions in musical performance research.

Task difficulty has been notoriously overlooked in MPA research. The present dissertation explored the component features of this construct. In line with transactional models of stress, it was seen that task load and performer factors both interact to produce the experience of musical task difficulty. These findings provide future researchers with a starting point from which task difficulty can be further examined, manipulated, and evaluated. The present research has demonstrated that it is critical that task difficulty considerations be incorporated into future musical performance studies.

Using the most important of the emergent task load factors, a musical piece was manipulated to produce three task variations. The three musical tasks demonstrated face and content validity and produced very large differences in efficiency and effectiveness measures. Indeed, these effects were so large that they can be reliably expected to re-emerge in future studies and across pianist samples. These pieces provide researchers in the field with the first validated musical performance tasks to adopt for experimental purposes.

The objective grading criteria developed in this contribution are the first of their kind. Specifically, they were used to grade piano performances across a range of experience levels. These provide the most effective and unbiased basis for comparison currently available in the field. It is recommended that future studies utilise these criteria so that the need for multiple subjective ratings and consideration of examiner-related error variance is eliminated entirely. This will also assist in building a literature of comparable findings.

The relevance of attentional processes to musical performance is one that is easily overlooked when encountering the anticipation and emotional intensity of the stage. Nevertheless, Attentional Control Theory provides explanatory power for a range of anxiety-related musician experiences. Importantly, it does so without oversimplifying or categorising human factors. The present research supports future applications of Attentional Control Theory to the musical performance domain. A-Trait reduced attentional flexibility when performing musical tasks. Shifting impairments were particularly implicated in this. Although musical performance outcomes were not impaired, the observed shifting impairments might easily manifest as performance impairments in ecological musical performance settings. These findings support the continued examination of ACT predictions in musical and broader perceptuomotor performance literature.

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Appendix A

Interview Protocol for Study 1, Phase Two, Music First

"We're going to move into the next phase of the interview now. I'm going to play you three pieces of music"

[Play pre-recorded pieces]

"If you were choosing one of these to start a student off on, which would be the easiest? Why?"

Explore

"Which would be the second-easiest? Why?"

Explore

"What makes the [number] piece the hardest of the three?"

Explore

"This is the sheet music for the first piece [place on table], the second piece [place on table], and the third piece [place on table] that you just heard. Are there any other features that you notice that may contribute to how difficult each of these pieces seems to be?"

Explore

"That's the end of the interview. Is there anything you think I have missed or would like to add at this stage?"

Appendix B

Interview Protocol for Study 1, Phase Two, Scores First

"We're going to move into the next phase of the interview now. I'm going to show you three pieces of sheet music. This is the first [place on table], this is the second [place on table], and this is the third [place on table]. If you were choosing one of these to start a student off on, which would be the easiest? Why?"

Explore

"Which would be the second-easiest? Why?"

Explore

"What makes this last piece [point] the hardest of the three?"

Explore

"I'm now going to play you each of the pieces of music that you have been looking at."

[Play pre-recorded pieces]

"Are there any other features that you notice that may contribute to how difficult each of these pieces seems to be?"

Explore

"That's the end of the interview. Is there anything you think I have missed or would like to add at this stage?"

Appendix C

Three Variations of Telemann's *A Graceful Dance*

"Original" (Difficult) Variation

"Some Notes Removed" (Intermediate) Variation

"Many Notes Removed" (Easy) Variation

Appendix D

Study 1 Information Sheet

Division of Health Sciences

School of Psychology

Dear Participant,

As a PhD student and an experienced musician, I am investigating the relationship between anxiety and performance. For my first study I am interested in discovering what factors comprise a difficult musical task by interviewing a number of musicians regarding their personal opinions and beliefs on this subject.

Participation is voluntary, and interviews will likely take about 30-60 minutes of your time. Your participation will remain completely anonymous and you may withdraw at any time during the proceedings. All names and information from which you might be identified will be removed from the interview transcripts. Your attendance and interaction will be considered consent for your information to be used in this study. I am interested in your own opinions and would very much appreciate your assistance.

The information you provide will be recorded on a digital recorder and transcribed into a word document. Once a transcript is completed, the original recording will be wiped clean. Interview transcripts will be stored on an encrypted hard drive and used to complete my thesis, and possibly, future publications. After completing my thesis, the transcripts will be stored on an encrypted hard drive for five years, after which they will be destroyed.

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number HR 146/2007). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

To indicate a desire to participate in this study, access further information about the study, or withdraw from the study, please feel free to contact me (*phone number*) or my supervisor Leigh Smith (*phone number*).

Thank you for your willingness and enthusiasm to take part in this study.

Sincerely,

Matthew Ruggiero

Appendix E

Revised Intermediate Condition

Appendix F

No Distractor DMDX .rtf Document

```
<ep><fd 1><azk><cr><d 119><vm 1280, 1024, 1024, 32, 60><id keyboard><nfb><dbc
210210210><dfs 36><eop>


! No Distraction task (No distractor condition);
! Plays set of instructions and then ends;

0 “Instructions”;
<d 1800>
0 <wav 2> “C:\...\Next page.wav”;
<d 119>
0 “Begin playing” / <wav 2> “C:\...Begin playing.wav”;

0 “The End”;
```

Note: filename extensions have been shortened to “…” for dissertation only.

Appendix G

Neutral Distractor DMDX .rtf Document

<ep><n 80><s 80><fd 1><azk><cr><d 119><t 4000><vm 1280, 1024, 1024, 32, 60><id digitalVOX><id RecordVocal 0, 2000><id keyboard><nfb><dbc 210210210><dfs 36><eop>

$
! Verbal Distraction task (Neutral condition);
! Presents 64 threatening words and 16 target word (random order);
! Target word = "**tick**";
! Audio files (.wav) for all 80 words are 1000ms in length (1ms accuracy);
! 2000ms silence follows each audio file;
! Presentation of target + response time = 4000ms (total)
! Each word is printed on the screen for the researcher as it is presented in auditory format to the participant

0 "Instructions";
<d 1800>
0 <wav 2> "C:\...\Next page.wav";
<d 119>
0 "Begin playing" / <wav 2> "C:\...\Begin playing.wav";
$

001 "**ankle**" / <wav 2> "C:\...\Audio files - Neutral distractors\ankle.wav";
002 "**appliance**" / <wav 2> "C:\...\Audio files - Neutral distractors\appliance.wav";
003 "**barrel**" / <wav 2> "C:\...\Audio files - Neutral distractors\barrel.wav";
004 "**blase**" / <wav 2> "C:\...\Audio files - Neutral distractors\blase.wav";
005 "**board**" / <wav 2> "C:\...\Audio files - Neutral distractors\board.wav";
006 "**bowl**" / <wav 2> "C:\...\Audio files - Neutral distractors\bowl.wav";
007 "**building**" / <wav 2> "C:\...\Audio files - Neutral distractors\building.wav";
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011 "**chin**" / <wav 2> "C:\...\Audio files - Neutral distractors\chin.wav";
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028 "**hammer**" / <wav 2> "C:\...\Audio files - Neutral distractors\hammer.wav";
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033 "**iron**" / <wav 2> "C:\...\Audio files - Neutral distractors\iron.wav";
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037 “**kettle**” / <wav 2> “C:\...\Audio files - Neutral distractors\kettle.wav”;
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049 “**part**” / <wav 2> “C:\...\Audio files - Neutral distractors\part.wav”;
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+084 * “**tick**” / <wav 2> “C:\...\tick.wav”;
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+090 * “**tick**” / <wav 2> “C:\...\tick.wav”;
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+099 * “**tick**” / <wav 2> “C:\...\tick.wav”;

$0 “**The End**”;$

Note: filename extensions have been shortened to “…” for dissertation only.

Appendix H

Social Threat Distractor DMDX .rtf Document

<ep><n 80><s 80><fd 1><azk><cr><d 119><t 4000><vm 1280, 1024, 1024, 32, 60><id digitalVOX><id RecordVocal 0, 2000><id keyboard><nfb><dbc 210210210><dfs 36><eop>

$
! Verbal Distraction task (Threat condition);
! Presents 64 threatening words and 16 target word (random order);
! Target word = “**tick**”;
! Audio files (.wav) for all 80 words are 1000ms in length (1ms accuracy);
! 2000ms silence follows each audio file;
! Presentation of target + response time = 4000ms (total)
! Each word is printed on the screen for the researcher as it is presented in auditory format to the participant

0 “Instructions”;
<d 1800>
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<d 119>
0 “Begin playing” / <wav 2> “C:\...\Begin playing.wav”;
$

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051 “**scrutiny**” / <wav 2> “C:\...\Audio files - Threat distractors\scrutiny.wav”;
052 “**shameful**” / <wav 2> “C:\...\Audio files - Threat distractors\shameful.wav”;
053 “**shy**” / <wav 2> “C:\...\Audio files - Threat distractors\shy.wav”;
054 “**silence**” / <wav 2> “C:\...\Audio files - Threat distractors\silence.wav”;
055 “**snubbed**” / <wav 2> “C:\...\Audio files - Threat distractors\snubbed.wav”;
056 “**speech**” / <wav 2> “C:\...\Audio files - Threat distractors\speech.wav”;
057 “**stare**” / <wav 2> “C:\...\Audio files - Threat distractors\stare.wav”;
058 “**stranger**” / <wav 2> “C:\...\Audio files - Threat distractors\stranger.wav”;
059 “**stupid**” / <wav 2> “C:\...\Audio files - Threat distractors\stupid.wav”;
060 “**tense**” / <wav 2> “C:\...\Audio files - Threat distractors\tense.wav”;
061 “**uninvolved**” / <wav 2> “C:\...\Audio files - Threat distractors\uninvolved.wav”;
062 “**unwelcome**” / <wav 2> “C:\...\Audio files - Threat distractors\unwelcome.wav”;
063 “**unworthy**” / <wav 2> “C:\...\Audio files - Threat distractors\unworthy.wav”;
064 “**useless**” / <wav 2> “C:\...\Audio files - Threat distractors\useless.wav”;

+084 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+085 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+086 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+087 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+088 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+089 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+090 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+091 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+092 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+093 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+094 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+095 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+096 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+097 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+098 * “**tick**” / <wav 2> “C:\...\tick.wav”;
+099 * “**tick**” / <wav 2> “C:\...\tick.wav”;

$0 “**The End**”;$

Note: filename extensions have been shortened to “…” for dissertation only.

Appendix I

Pre-recorded Experiment Instructions for Participants

Researcher: “Please sit on the piano stool, put on the headphones, and open to the instructions on the first page of the file.”

[Audio “Instructions PART 1.wav”]
“Today you are going to be sight reading nine pieces of music. Your performance is going to be recorded as you play, and evaluated by a panel of examiners at a later date. Before playing each piece you will be given 30 seconds to analyse the sheet music. Try to play the piece as closely to the way it’s written as possible. Remember it will be examined for accuracy. Playing the piece accurately is the most important thing for you to focus on in this experiment.”

“Whilst playing the piece you will have one additional, less important task to perform. Through the headset you will hear a list of words being spoken while you play. Whenever you hear the word “tick” spoken, you must respond by saying ‘tock’ as quickly as possible. When you hear “tick”, you must say ‘tock’. On the count of three give this a try. One…two…three…tick.”
END AUDIO
Participant: “tock”

IF participant responds incorrectly
THEN execute **[audio “tick tock re-test.wav”]**

> “Try again, on the count of three I will say ‘tick’ and you must respond with ‘tock’. One…two…three…tick.”
> **END AUDIO**
> Participant: “tock”

REPEAT UNTIL CORRECT

[Audio “Instructions PART 2.wav”]
“Good. So when you hear the word ‘tick’, you must say ‘tock’ as quickly as possible.”

“In a moment the experiment will begin. Simply follow the instructions you are given through the headset. There are only two things you need to do. The first is to play each piece as accurately as possible, and the second is to say the word ‘tock’ as quickly as possible every time you hear the word ‘tick’. Remember that your performance of the piece is the most important part of this experiment though. Do not allow the words to affect the quality of your performance.”

“Alright, let’s begin.”
END AUDIO

IF neutral condition
THEN run DMDX **[Neutral condition.rtf]**

> “Please turn to the next page of the file in front of you. You now have 30 seconds to analyse the piece.”
> **[Time 30 seconds]**
> “Your 30 second preparation time is over. Please begin playing the piece.”

[Wordlist begins]
WHEN piece is finished
[Researcher to mute presentation of remaining words]
END CONDITION

IF social threat condition
THEN run DMDX **[Threat condition.rtf]**
"Please turn to the next page of the file in front of you. You now have 30 seconds to analyse the piece."
[Time 30 seconds]
"Your 30 second preparation time is over. Please begin playing the piece."
[Wordlist begins]
WHEN piece is finished
[Researcher to mute presentation of remaining words]
END CONDITION

IF no distractor condition
THEN run DMDX **[No distractor.rtf]**
"Please turn to the next page of the file in front of you. You now have 30 seconds to analyse the piece."
[Time 30 seconds]
"Your 30 second preparation time is over. Please begin playing the piece."
END CONDITION

Continue to repeat specific conditions until all nine presentations are completed

[Audio "Instructions PART 3.wav"]
"You've now completed all nine of the pieces. Thank you for your participation in this experiment."
END AUDIO

Appendix J

Two Distractor Wordlists Used in the Target-Response Probe Task

Neutral Distractors		Social threat distractors	
Ankle	Iron	Ashamed	Joke
Appliance	Item	Blamed	Judged
Barrel	Journal	Blushing	Loathed
Blasé	Jug	Boring	Lonely
Board	Kettle	Class	Loser
Bowl	Lawn	Clumsy	Manipulate
Building	Lock	Conversation	Mistake
Cabinet	Machine	Criticised	Naïve
Cannon	Mantel	Dance	Neglected
Chair	Material	Date	Offended
Chin	Metal	Despised	Party
Clock	Month	Disgraced	Pathetic
Column	News	Dull	Piteous
Contents	Nun	Embarrassed	Presentation
Context	Office	Failure	Rejected
Cord	Paper	Festivity	Ridicule
Cork	Part	Flawed	Scorned
Corridor	Passage	Foolish	Scrutiny
Curtains	Pencil	Game	Shameful
Door	Rain	Handshake	Shy
Egg	Rattle	Hated	Silence
Elbow	Seat	Hostile	Snub
Engine	Statue	Humiliated	Speech
Fabric	Stove	Ignorant	Stare
Finger	Street	Inadequate	Stranger
Foot	Table	Incompetent	Stupid
Fork	Taxi	Inept	Tense
Hammer	Theory	Inferior	Uninvolved
May	Time	Inhibited	Unwelcome
History	Tool	Insult	Unworthy
Hydrant	Trunk	Intimidated	Useless
Ink	Umbrella	Invitation	Worthless

Appendix K

Experiment Administration Sheet

Participant code:

No. re-tests:

Condition	False +ve tally	Reaction times (ms)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Conditions:

0 = no dist.   E = easy task

1 = neutral dist.   I = intermediate task

2 = threat dist.   D = difficult task

Appendix L

Study 2 Participant Information Sheet

Division of Health Sciences

School of Psychology

Dear Participant,

As a PhD student and experienced musician, I am investigating the relationship between anxiety and performance across a variety of musical tasks. For this study I am exploring the connection between musician competency, task difficulty, and performance quality. Participation will involve sight-reading nine short pieces of piano music. Recordings will be made while you play and the quality of your performance will be rated by examiners at a later date. In order to qualify for participation, you must be able to sight read Grade 1 AMEB equivalent piano music, playing both hands together.

Participation is voluntary, and will likely take about 40 minutes. You will receive $20 as a reimbursement for your time and travel. Your participation will remain completely anonymous and you may withdraw at any time during the proceedings. If you choose to withdraw you will still receive the $20 reimbursement. As a precaution against being identified, your name will not be collected. However, for this reason you will only be able to withdraw from the study prior to completing the experiment. Your attendance and interaction will be considered consent for your data to be used in this study.

Record sheets and musical recordings will be used to complete my thesis, and possibly, future publications. Record sheets will be stored in a locked filing cabinet and recordings on an encrypted hard drive during the study and for five years subsequently, after which they will be destroyed.

If you would like further information about this study, please feel free to contact me (*phone number*) or my supervisor Jenny Thornton (*phone number*). Additionally, if you feel distressed as a result of this study, you may contact [*name of counselling service*] (*phone number*).

Thank you for your willingness and enthusiasm to take part in this study.

Sincerely,
Matthew Ruggiero

Note: This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number HR 146/2007). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 92662784 or by emailing hrec@curtin.edu.au

Appendix M

State-Trait Anxiety Inventory (Form Y-2)

Directions:
A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel.

1 = Almost never
2 = Sometimes
3 = Often
4 = Almost always

1.	I feel pleasant	**1**	**2**	**3**	**4**
2.	I feel nervous	**1**	**2**	**3**	**4**
3.	I feel satisfied with myself	**1**	**2**	**3**	**4**
4.	I wish I could be as happy as others seem to be	**1**	**2**	**3**	**4**
5.	I feel like a failure	**1**	**2**	**3**	**4**
6.	I feel rested	**1**	**2**	**3**	**4**
7.	I am “calm, cool, and collected”	**1**	**2**	**3**	**4**
8.	I feel that difficulties are piling up so that I cannot overcome them . . .	**1**	**2**	**3**	**4**
9.	I worry too much over something that really doesn’t matter	**1**	**2**	**3**	**4**
10.	I am happy	**1**	**2**	**3**	**4**
11.	I have disturbing thoughts	**1**	**2**	**3**	**4**
12.	I lack self-confidence	**1**	**2**	**3**	**4**
13.	I feel secure	**1**	**2**	**3**	**4**
14.	I make decisions easily	**1**	**2**	**3**	**4**
15.	I feel inadequate	**1**	**2**	**3**	**4**
16.	I am content	**1**	**2**	**3**	**4**
17.	Some unimportant thought runs through my mind and bothers me	**1**	**2**	**3**	**4**
18.	I take disappointments so keenly that I can’t put them out of my mind	**1**	**2**	**3**	**4**
19.	I am a steady person	**1**	**2**	**3**	**4**
20.	I get in a state of tension or turmoil as I think over my recent concerns and interests	**1**	**2**	**3**	**4**

Appendix N

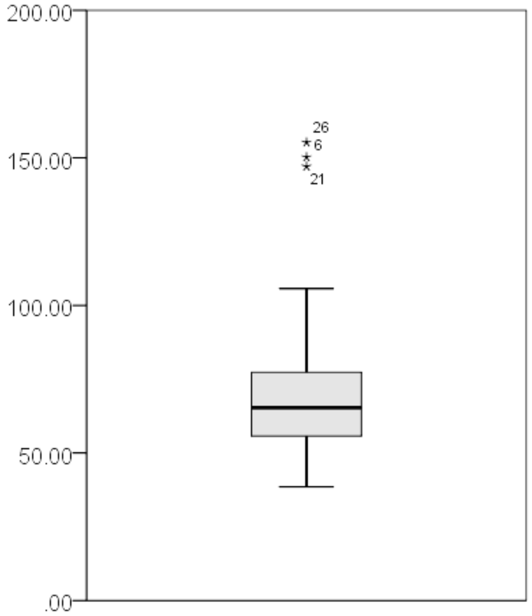
Piece x Distraction x A-Trait Interactions on Completion Time, Composite, Reaction Time (RT) and Error Tally

Outcome	*F*	*df*1	*df*2	*p*	η_p^2
Completion Time	0.24	4	243	.915	.02
Composite	1.37	4	243	.245	.03
RT	0.82	2	161	.441	.11
Error Tally	0.54	2	162	.582	.14

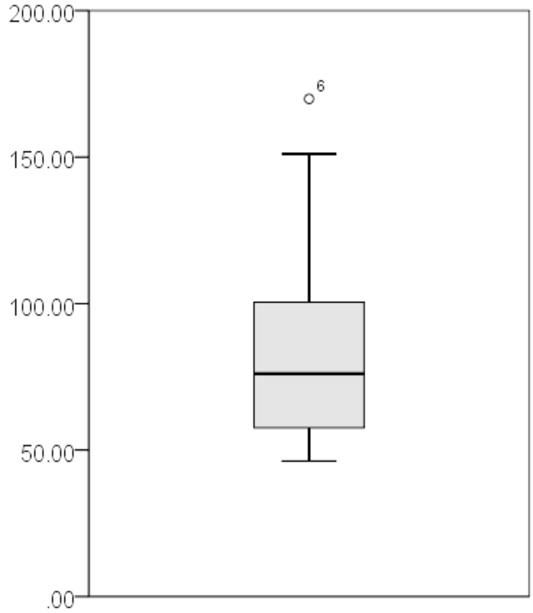
Appendix O

Boxplots for Completion Time, Composite, Reaction Time (RT), and Error Tally

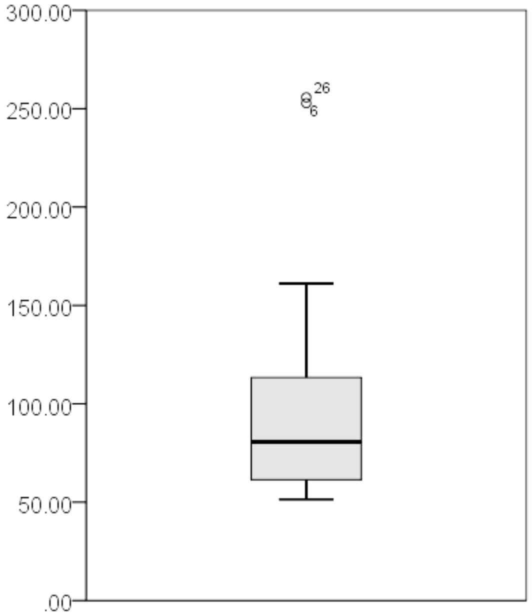
Completion Time:



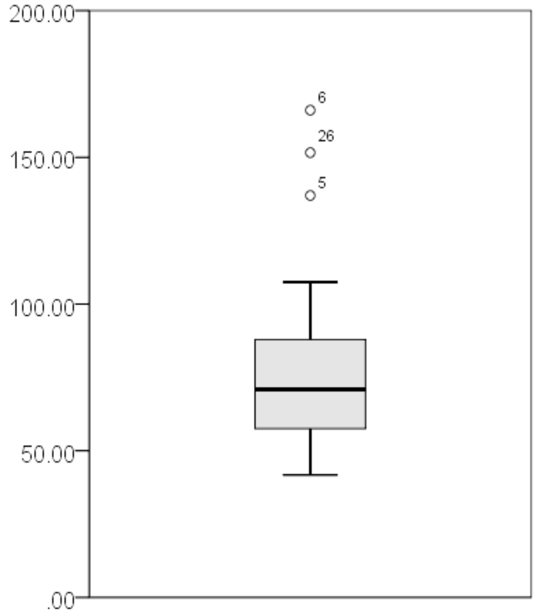
No Distraction, Easy Piece



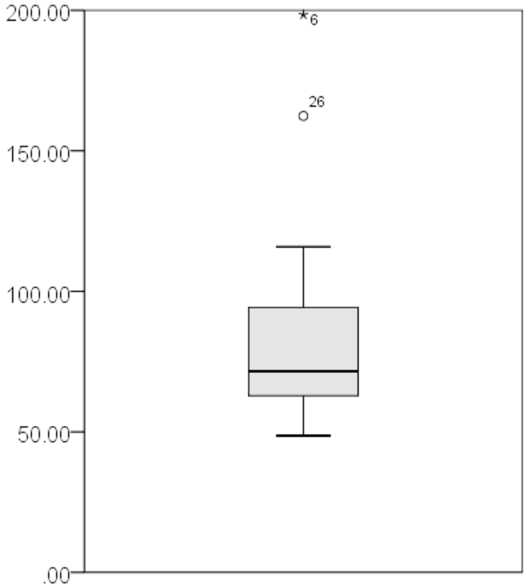
No Distraction, Intermediate Piece



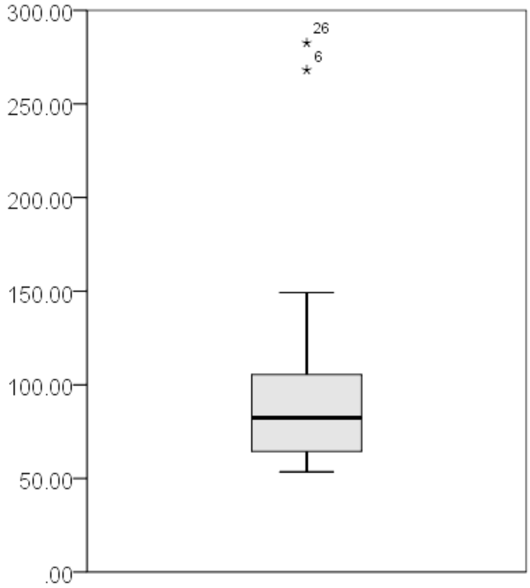
No Distraction, Difficult Piece



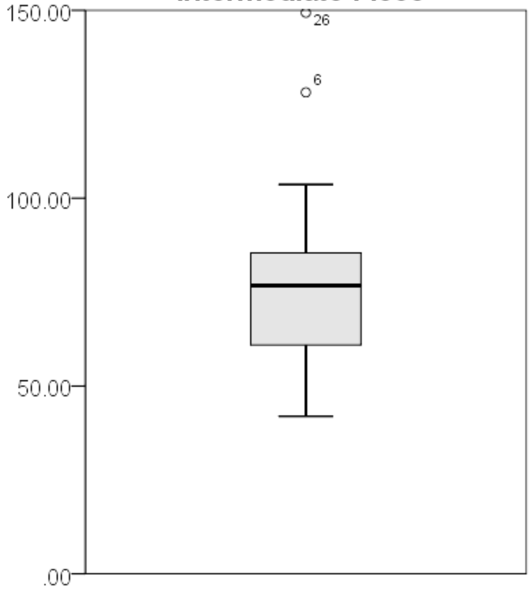
Neutral Distraction, Easy Piece



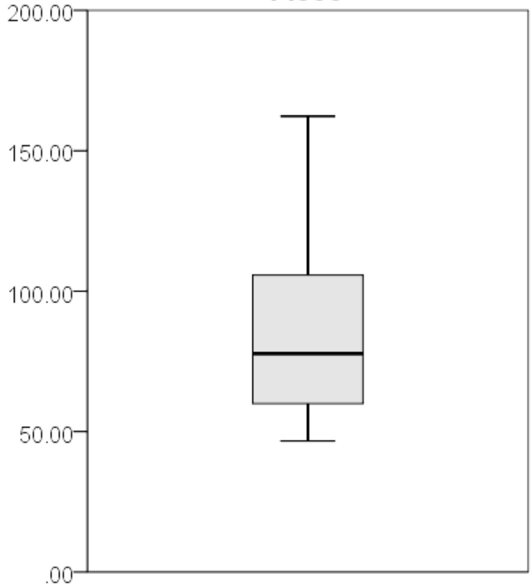
Neutral Distraction, Intermediate Piece



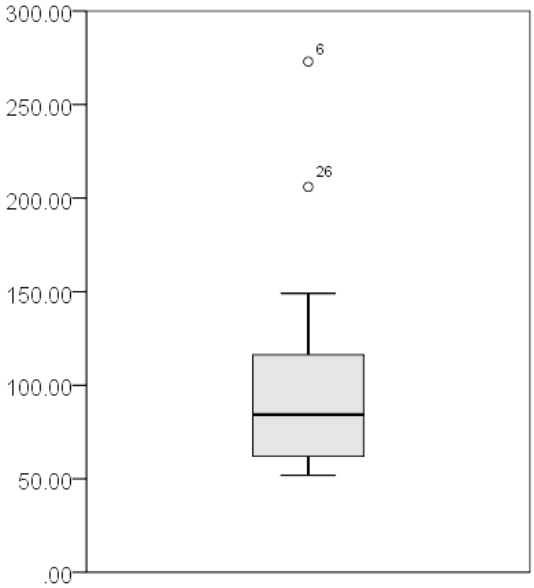
Neutral Distraction, Difficult Piece



Social Threat Distraction, Easy Piece

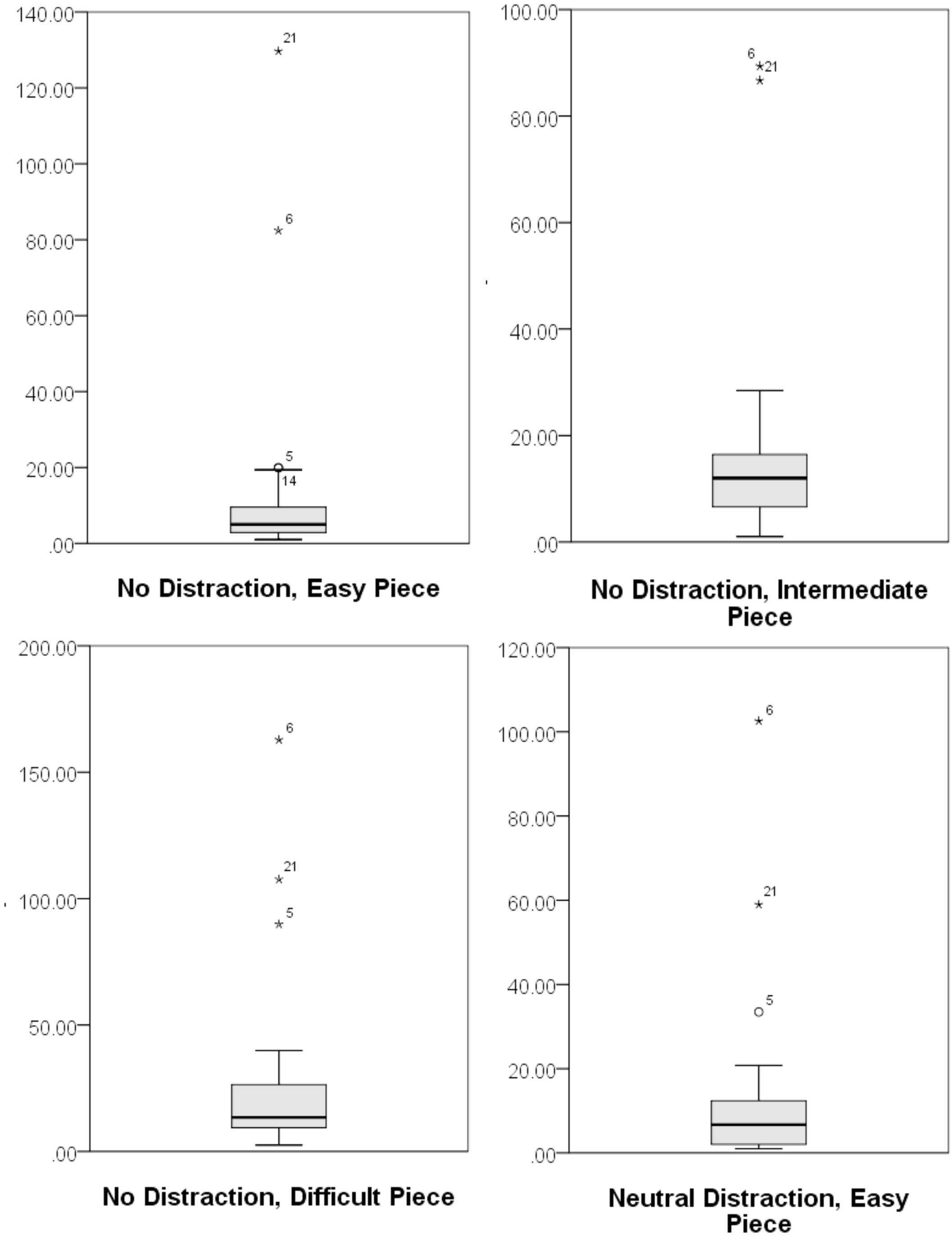


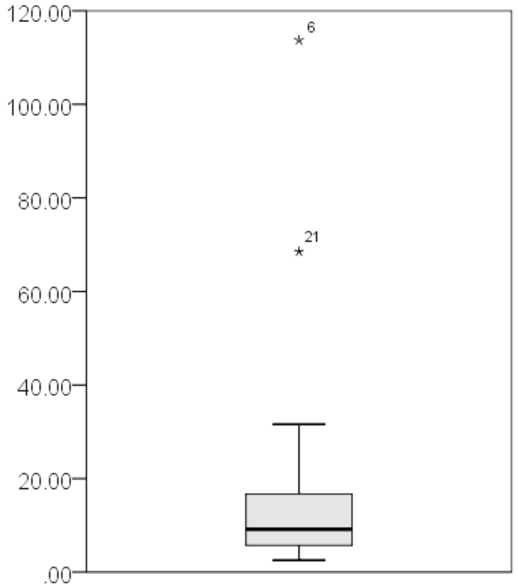
Social Threat Distraction, Intermediate Piece



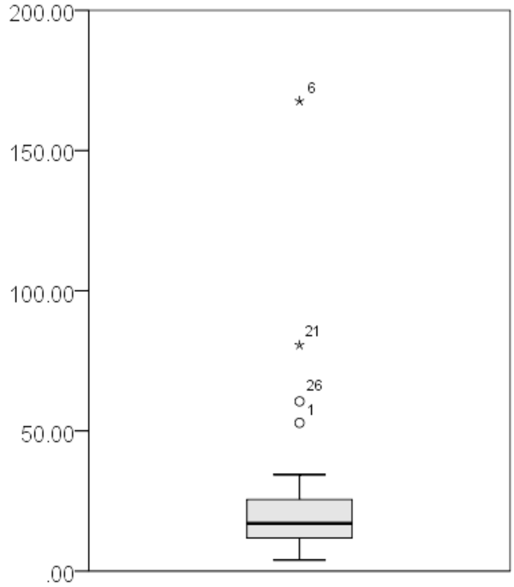
Social Threat Distraction, Difficult Piece

Composite:

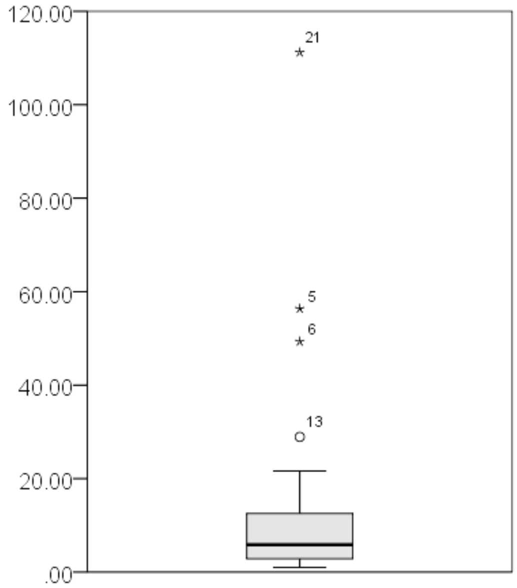

140.00
120.00
100.00
80.00
60.00
40.00
20.00
.00
21
6
5
14
No Distraction, Easy Piece
100.00
80.00
60.00
40.00
20.00
.00
6
21
No Distraction, Intermediate Piece
200.00
150.00
100.00
50.00
.00
6
21
5
No Distraction, Difficult Piece
120.00
100.00
80.00
60.00
40.00
20.00
.00
6
21
5
Neutral Distraction, Easy Piece



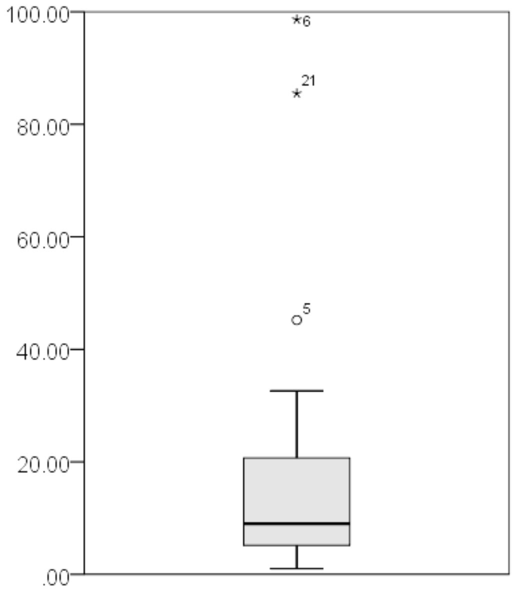
Neutral Distraction, Intermediate Piece



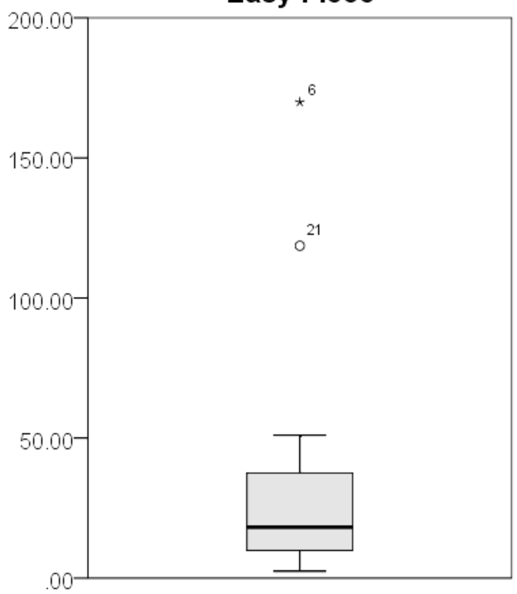
Neutral Distraction, Difficult Piece



Social Threat Distraction, Easy Piece

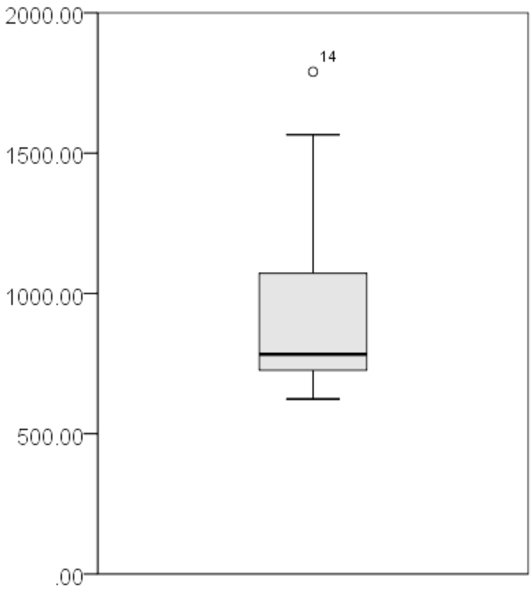


Social Threat Distraction, Intermediate Piece

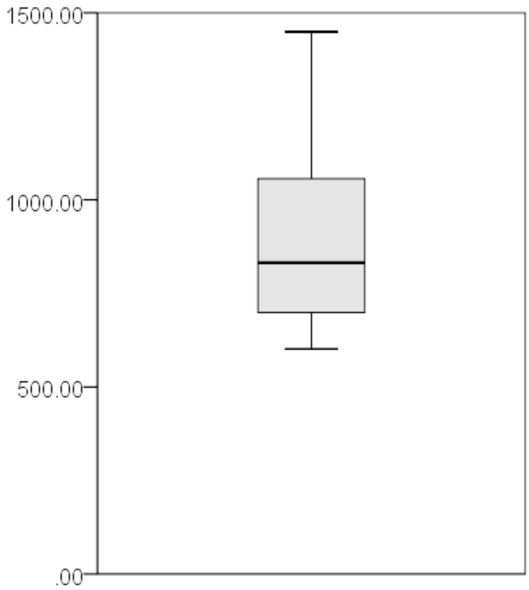


Social Threat Distraction, Difficult Piece

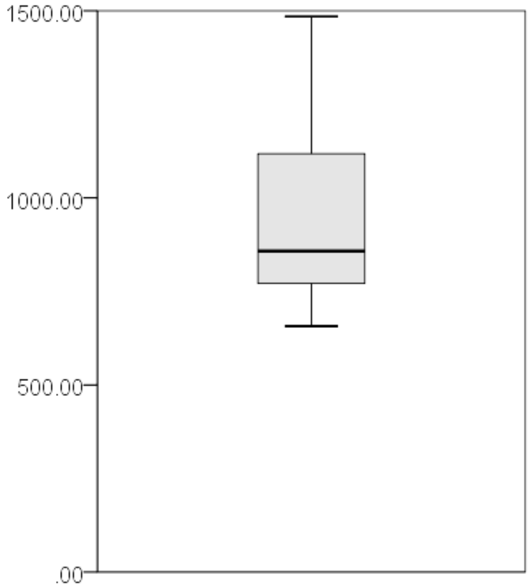
Reaction Time (RT):



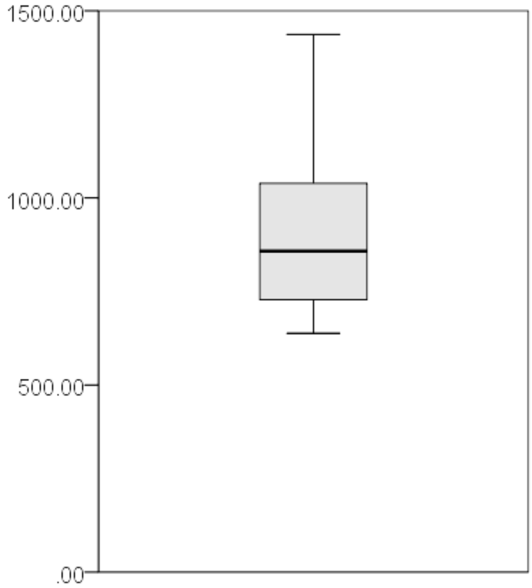
Neutral Distraction, Easy Piece



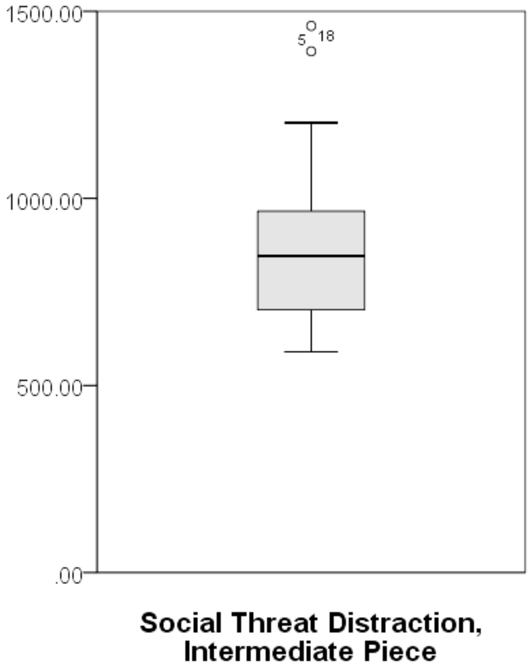
Neutral Distraction, Intermediate Piece

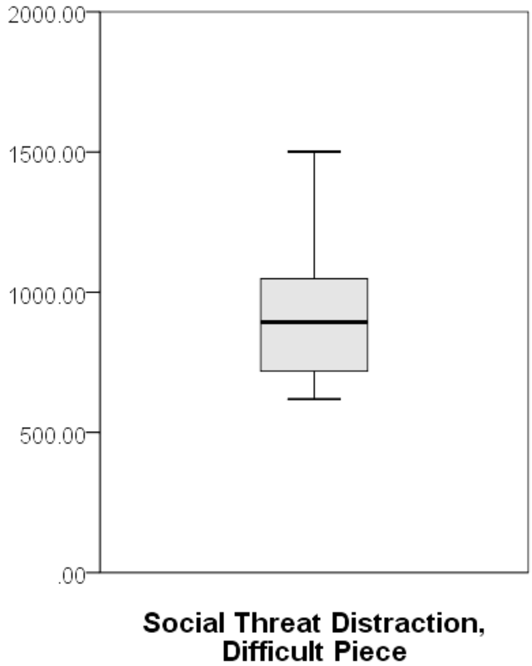


Neutral Distraction, Difficult Piece

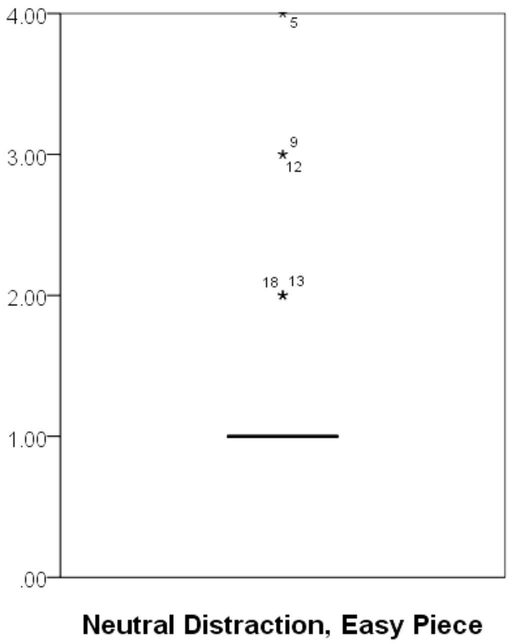


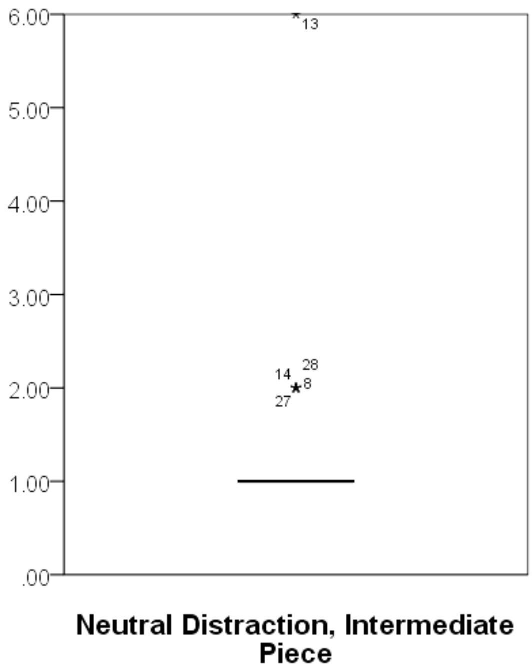
Social Threat Distraction, Easy Piece

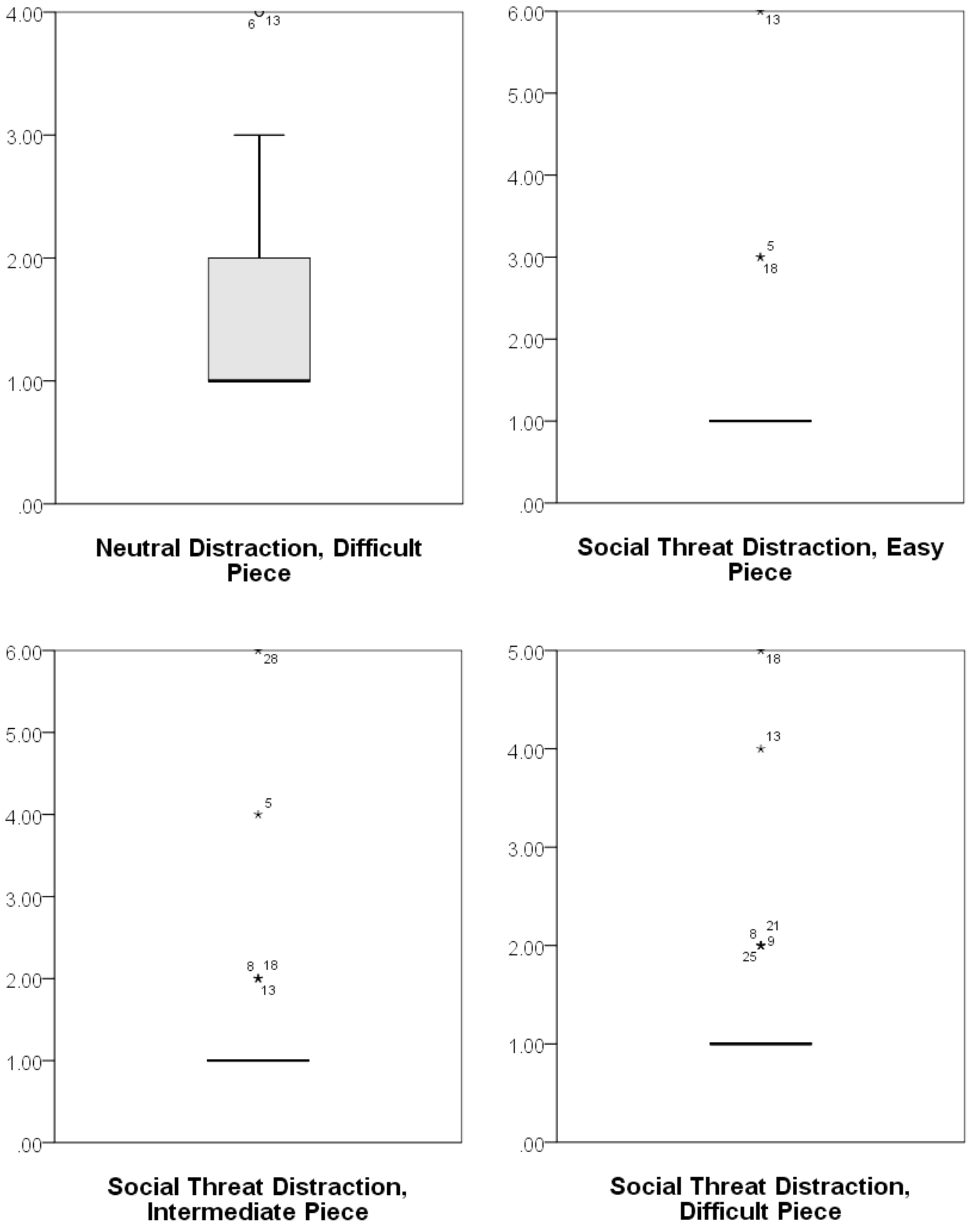

1500.00
1000.00
500.00
.00
5
18
Social Threat Distraction,
Intermediate Piece


2000.00
1500.00
1000.00
500.00
.00
Social Threat Distraction,
Difficult Piece

Error Tally:


4.00
3.00
2.00
1.00
.00
5
9
12
18
13
Neutral Distraction, Easy Piece


6.00
5.00
4.00
3.00
2.00
1.00
.00
13
14
28
8
27
Neutral Distraction, Intermediate
Piece


4.00
3.00
2.00
1.00
.00
Neutral Distraction, Difficult Piece
6.00
5.00
4.00
3.00
2.00
1.00
.00
Social Threat Distraction, Easy Piece
6.00
5.00
4.00
3.00
2.00
1.00
.00
Social Threat Distraction, Intermediate Piece
5.00
4.00
3.00
2.00
1.00
.00
Social Threat Distraction, Difficult Piece

Appendix P

Assumption Testing

Table P1

Skewness and Kurtosis Statistics and Significance (Two-Tailed) for Completion Time, Composite, RT, and Error Tally in each of the Nine Experimental Conditions

Distraction condition	Piece condition	Outcome	Skewness statistic	Sig. (*p* < .025)	Kurtosis statistic	Sig. (*p* < .025)
No Distraction	Easy	Completion Time	1.77	Yes	2.63	Yes
		Composite	3.66	Yes	13.73	Yes
	Intermediate	Completion Time	1.32	Yes	1.43	No
		Composite	2.98	Yes	8.79	Yes
	Difficult	Completion Time	2.01	Yes	4.19	Yes
		Composite	2.82	Yes	8.25	Yes
Neutral	Easy	Completion Time	1.51	Yes	2.11	No
		Composite	3.31	Yes	12.21	Yes
		RT	1.00	Yes	-0.22	No
		Error Tally	2.34	Yes	4.96	Yes
	Intermediate	Completion Time	2.14	Yes	5.57	Yes
		Composite	3.42	Yes	12.79	Yes
		RT	1.95	Yes	4.30	Yes
		Error Tally	4.21	Yes	19.83	Yes
	Difficult	Completion Time	2.47	Yes	6.35	Yes
		Composite	3.41	Yes	13.57	Yes
		RT	1.40	Yes	0.99	No
		Error Tally	2.10	Yes	3.76	Yes

Table P1

Skewness and Kurtosis Statistics and Significance (Two-Tailed) for Completion Time, Composite, RT, and Error Tally in each of the Nine Experimental Conditions (Continued)

Distraction condition	Piece condition	Outcome	Skewness statistic	Sig. ($p <$ .025)	Kurtosis statistic	Sig. ($p <$ .025)
Social Threat	Easy	Completion Time	1.23	Yes	2.32	Yes
		Composite	3.18	Yes	11.41	Yes
		RT	2.47	Yes	5.89	Yes
		Error Tally	3.84	Yes	15.67	Yes
	Intermediate	Completion Time	0.86	No	0.09	No
		Composite	2.63	Yes	6.99	Yes
		RT	2.23	Yes	4.65	Yes
		Error Tally	3.51	Yes	12.88	Yes
	Difficult	Completion Time	2.11	Yes	5.50	Yes
		Composite	2.83	Yes	9.02	Yes
		RT	3.71	Yes	15.98	Yes
		Error Tally	2.99	Yes	9.04	Yes

Note. RT and Error Tally statistics have not provided for the three No Distraction conditions, since these were control conditions in which participants were not exposed to the target-response task. Significant statistics (labelled "yes" in the table) represent violations of normality.

Table P2

Sphericity Violations for Completion Time and Composite within each of the Fixed Effects

Within-subject effect	Outcome	Approximate χ^2	p
Distraction	Composite	9.72	.008
Piece	Completion Time	40.24	< .001
	Composite	22.96	< .001
Distraction x Piece	Completion Time	21.83	.010