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Do Anxiety Level and Anxiety-Related Content Affect Accuracy and Endorsement Rate on Syllogistic Reasoning by Increasing Reliance on Belief-Biased Heuristic Processing?

A dual process account of the relationships between anxiety, working memory, and reasoning

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Abstract

This study used an adaptation of the belief bias paradigm and correlational analyses to investigate the effects of validity, believability, content, and anxiety level on syllogistic reasoning in a sample comprised of undergraduate students and volunteers from the general population within a dual process framework. All the variables were found to affect reasoning accuracy, but content did not affect endorsement rate. These patterns of responding were not due solely to working memory differences, and accuracy decreases in high-anxious participants were found not to be due to a reliance on belief-biased processing resulting from working memory depletion, thus suggesting that what determines the engagement of the analytic and heuristic processes in the dual process theory of reasoning is not cognitive load.

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Ethics Statement

The research carried out in this study was conducted in accordance with the ethical guidelines published by the British Psychological Society (2003a; 2003b) and those published by the University of Plymouth. Prior to conducting the research, an outline was approved by the University of Plymouth's Ethics Committee.

Informed consent was obtained by providing the participants with a full brief and opportunity to ask questions prior to completing the study. The brief was presented as part of the web-based experiment, and included a paragraph stating that clicking 'continue' would be accepted as the individuals giving their informed consent. Participants that completed the study in laboratory conditions under supervision were also given a paper consent form to sign if they gave their consent. A similar click-to-confirm format was used to confirm that all participants were over sixteen years of age.

Within the brief prior to beginning, and instructions during the experiment, it was made clear to participants that they had the right to withdraw at any time throughout the study without incurring any penalty by clicking the 'withdraw' button that was included on each web-page of the study. Each participant's right to withdraw was emphasised to protect individuals from harm or undue stress in the experimental procedure by providing a way for them to avoid any stressful situation. At the beginning of the experiment, participants were also given participant numbers to input in order to identify their data sets and provide anonymity.

Within the brief and debrief, contact details for the experimenter and supervisor were given, and details of external support networks such as the student counselling services were provided should any individual feel they were suffering from the effects

of anxiety, or wish to obtain further details of the study, it's results, or a copy of it upon completion.

A full debrief was presented on screen to all participants as part of the web-based experiment, and an opportunity to ask any further questions was provide. Furthermore, the debrief notified participants that they could withdraw their data at any point by contacting the experimenter with their participant identification number.

Data Collection Statement

The data for this study was collected as a group effort between Daniel Zahra, Jodi Carter, and Rachael Robinson. Each collected roughly a third of the total data set. Exactly which individual collected which data set is indicated in the raw data by the initials prefixing the participant identification numbers.

Acknowledgements

Many thanks to all those who participated in this study; the willingness of those who volunteered greatly helped in overcoming recruitment limitations.

Thanks also to Dr. Shira Elqayam, for her interest in my ideas early on, and her sustained support and encouragement, Professor Simon Handley for his comments and expertise with regards the thinking and reasoning literature, and to Dr. Simone Schnall for inspiring an interest in the emotion and cognition literature.

Many thanks also to Neil Jones for hosting the study on his webpage for free, and to Jodi Carter to taking care of the programming of the experiment

Introduction

The construct of working memory, originally proposed by Baddeley (1986, Baddeley & Hitch, 1974), has been a useful tool for the explanation of experimental results for over thirty years. The original multifactor construct, developed to replace the 'short term memory' aspect of Atkinson and Shiffrin's (1968) 'Multi-store Model of Memory', consisting of the visuo-spatial sketch-pad, primary acoustic store and a phonological loop, all of which are controlled by a central executive, has proven a durable and empirically supported model. This model of working memory has recently been reworked by Repovš and Baddeley (2006) to incorporate the voluminous research that has been conducted on the construct over the years, but it remains essentially the same structurally.

The different components of working memory have been shown to differentially affect a variety of cognitive tasks (see Matlin, 2003, for an overview). For example, the visuo-spatial sketch-pad has been implicated in spatial tasks and object recognition (Brandimonte, Hitch, & Bishop, 1992), and the phonological loop and primary acoustic store have played a great explanatory role in the field of psycholinguistics (for example, Garman, 1990). A number of what could be termed 'meta-components' of working memory have also been discussed in the literature. These aspects cover concepts such as working memory span, memory used to create a sense of time, and a verbal versus non-verbal distinctions between tasks performed by the components of working memory (Barkley, 2006). Within the thinking and reasoning literature, working memory has also played a major role in research on reasoning ability, that is, the ability to derive logical conclusions from premises or effectively perform tasks such as those that require the manipulation and combination of information. The general pattern of association between working memory and reasoning ability is one of a

positive correlation, regardless of what measures of working memory are used and what reasoning tasks are utilised (Dutke & Stöber, 2001; Newstead, Handley, Harley, Wright, & Farrelly, 2004).

Similarly to working memory research generally, a number of studies have demonstrated differential involvement of working memory components across different types of reasoning tasks (Phillips, Wynn, Gilhooy, Della Sala, & Logie, 1999; Ford, 1995; Handley, Capon, Beveridge, Dennis, & Evans, 2004). For example, Handley, Capon, Copp, and Harper (2002) found correlations between the spatial reasoning 'Tower of Hanoi' task and spatial memory capacity, but no correlation between these and verbal working memory measures. To complete the dissociation in their study they also showed a positive correlation between performance on conditional reasoning tasks and verbal working memory. Although this and other experiments seem to show unitary functioning of the components of working memory, researchers such as Lehto (1996) claim to provide evidence from correlational analyses of a range of working memory measures that there is not one, single pool of resources that can be allocated to the components by the central executive. However, what is meant by 'resources' in this critique is not entirely clear, and, as pointed out by Handley *et al.* (2002) the sample size, being one of only thirty-five, was small in comparison to the majority of individual differences research, and therefore may have been insufficient to detect meaningful differences. Whether there is one pool or separate allowances for verbal and spatial tasks, the differences in unitary functioning, and effects of cognitive load on central executive functioning have still been widely found and remain within the working memory model’s power of explanation (Repovš & Baddeley, 2006).

In the emotion and cognition literature, anxiety, defined as autonomic central nervous system arousal, has been shown to affect performance on working memory

tasks. Although numerous different theories with vastly differing specifics have been proposed as to the structure and taxonomy of emotion (Strongman, 2003; Feldman-Barrett, & Russell, 1999; Kunda, 1994) and how increased anxiety leads to poorer performance on complex cognitive tasks (Derakshan, & Eysenck, 1998; Hopko, Ashcraft, Ruggiero, & Lewis, 1998; McNally, 1998; Tohill & Holyoak, 2000; Luk, 1998; Goldstein & Blackman, 1978), there seems to be an underlying agreement that anxiety is caused by, or based on, task-irrelevant thoughts, which use the finite resources of working memory (Elliman, Green, Rogers, & Finch, 1997), and so, leave less resources available for the completion of the tasks (Dusek, 1980). 'Resources' across the literature is a term that has been widely and variously defined. In this study it is taken to refer to attentional span and control, memory span, and the ability to complete concurrent tasks. Such a failing of attentional processes might be accounted for by problems with the metacognitive ability of inhibitory control thought to be determined by the central executive, which has been posited as deficient in anxious individuals (Van Boxtel, Van der Molen, Jennings, & Brunia, 2001).

An interesting study by Dutke and Stöber (2001) presents data that suggests the link between working memory and task relevant and irrelevant demands isn't quite as straight forward. Despite performing worse on average across tasks, high test-anxious individuals perform relatively better on tasks with high sequential demands than they do on tasks with low sequential demands. That is, the more a task requires an individual to monitor and update task-relevant information, the less of an impact test-anxiety has. The explanation for this proposed by Dutke and Stöber (2001) is that tasks low in sequential demands allow the individual time to dwell on task-irrelevant, anxious, thoughts, and this allocation of resources away from the task is detrimental to performance. However, in the high-sequential-demand tasks, intrinsic task prompts

result in sustained attention and allocation of resources to task relevant information, countering the misallocation of resources due to anxiety.

However, other researchers such as Eysenck and Calvo (1992) in their processing efficiency theory have shown that increasing cognitive load can increase the impact of anxiety. This suggests that it is not working memory capacity itself that determines the impact of anxiety on task performance, but is more likely to be the allocation of those resources that determines the impact. Given that the central executive is widely accepted as controlling allocation of working memory resources (Baddeley & Della Sala, 1996), it seems possible that a more efficient central executive would better allocate resources and thus lead to reduced anxiety (Zahra, 2006). In the case of Dutke and Stöber's (2001) findings, the higher sequential demands could be seen as cueing the central executive to allocate more resources to the task-relevant information, thus improving performance. However, the poorer performance of test-anxious individuals generally across tasks suggests that anxiety affects the efficiency of resource allocation, or vice versa. It follows then that those higher in central executive functioning would suffer less as a result of higher task demands, and be less affected by anxiety. Better reasoners would show less impact or signs of anxiety because their central executive's more effectively allocate resources to task relevant information. Given that individuals higher in working memory central executive (WMCE) control are supposedly better able to allocate resources effectively to relevant tasks, and perform better at reasoning tasks (Gilhooly, Logie & Wynn, 1999; DeNeys, 2006a) any investigation of the link between WMCE and reasoning might be expected to find a positive correlation between WMCE and reasoning ability (for example, Süβ, Oberaurer, Wittmann, Wilhelm, & Schulze, 2002).

This leads then to the question of whether anxiety can be linked to reasoning ability through the systems of working memory, and whether such a model could be accommodated within an existing theory of cognitive functioning. One study conducted by Oaksford, Morris, Grainger, & Williams (1996) investigated the effects of mood on reasoning performance using the Wason selection task (Matlin, 2003). They reported that both positive and negative mood induction suppresses normative reasoning strategies. By way of explanation, Oaksford *et al* (1996) refer to a reliance on default responses under high cognitive load conditions. They also adopt the tripartite working memory model of Baddeley (1986; 1997; Repovš & Baddeley, 2006), which places the central executive as the system that would control resource allocation, as a mechanism underling their explanation. Furthermore, although Oaksford *et al.* (1996) make use of the idea of an 'optimal hypothesis testing strategy' (p491) to explain their results, the dual process theory (DPT) of Evans (2004; 2006) would provide a similar and more parsimonious account, that emotions reduce resources which render analytic processes unable to operate. Additionally, the dual process theory of reasoning can incorporate other models of cognitive resource management, such as processing efficiency theory (Eysenck & Calvo, 1992) and other theories such as that of Blanchette and Richards (2004) which posit working memory as the mechanism through which emotions affect cognition. The specifics of this dual process model and how it can incorporate working memory and emotion are discussed below.

This hypothesis, that anxiety disrupts the central executive component of working memory, (Dutke & Stöber, 2001; Eysenck, Payne, & Derakshan, 2005) and so would disrupt its allocation of resources to the different components of working memory, is also in-line with the suggestion of a differential allocation hypothesis (Oaksford *et al.* 1996) that suggests it is the *allocation* of resources rather than the

availability of resources that causes the observed deterioration in cognitive functioning. Although such a hypothesis has not previously been incorporated in the DPT as an explanation of when the different systems are used, it has been applied to reading span and other higher cognitive functions by Turley-Ames and Whitfield (2003), whose theoretical model is compatible with the DPT and provides a mechanism similar to that proposed by Blanchette and Richards (2006) by which central executive loading would determine heuristic and analytic responding through resource allocation.

The DPT of reasoning (Evans, 2003, 2006; Evans & Over, 1996a) therefore seems to provide a framework within which the link between anxiety and reasoning ability can be explored, and working memory considered as a common factor. Although a wide variety of other descriptive and prescriptive theories can be found in the literature, for example, logicism (Oaksford & Chater, 1998) or the mental models theory (Garnham & Oakhill, 1997; Manktelow, 2000), that could provide a framework for such a combination, DPT seems to have already pulled together under one theoretical explanation a variety of empirical data, by providing a way of combining emotion-as-load and deficits in reasoning, thus lending itself to tentative explanations of findings from the combined areas of cognition and emotion and thinking and reasoning. In the dual-process theory of Evans (2003; Evans & Coventry, 2003) reasoning tasks are seen as being processed by one of two systems which utilise different methods. Normatively logical reasoning is associated with the analytic system and heuristic, pragmatic reasoning is attributed to the automatic responding of the heuristic system (De Neys, 2006a). It then follows that working memory, through its association with reasoning ability, could be considered a component necessary for analytic system functioning. Such a link between working memory and the analytic

system has been put forward by researchers such as Engle, Tuholski, Laughlin, and Conway (1999) and Kyllonen and Christal (1990), and is discussed in detail by De Neys, (2006b). This conceptualisation of the heuristic processes as irrational, or, to sidestep the rationality debate, 'non-normative' (Evans, Venn, Feeney, 2002; Stanovich & West, 1999; Evans, Newstead, & Byrne, 1993), has been proposed as an explanation of a variety of empirical demonstrations of the belief bias effect (Stanovich, 1999; Manktelow, 2000). As summarised by Evans (2004), the belief bias effect is the tendency to endorse believable conclusions more often than unbelievable ones, regardless of logical accuracy, or as outlined by Evans and Over (1996a), deductive inferences being biased by the believability of the conclusions.

In the standard belief bias paradigm, as presented by Evans, Barston, and Pollard (1983), validity and believability of syllogism conclusions are varied within a two-by-two analysis of variance. Participants score one point for each endorsement they make, that is, for each time they respond ‘valid’, regardless of the syllogism’s logical accuracy. This method allows for an investigation of the main effects of both validity and believability, as well as any interactions between the two. The findings of these experiments typically find that believable conclusions are endorsed more often than unbelievable ones, such that a main and interaction effect for believability and validity are found. This is generally accepted as allowing the measurement of belief based and logical responding through comparing responses to different validity and believability levels of syllogism. Although the belief bias effect had been studied prior to the Evans *et al.* (1983) study, as discussed by Evans himself (Evans, 2004), the methodology and framework within the investigations were lacking rigour and control.

In order to link emotion and cognition research with thinking and reasoning, the belief-bias paradigm can be expanded to include factors measuring content effects

and anxiety effects. As little research has been conducted on the effects of syllogism content, specifically emotive content, and as research that has investigated the effects of anxiety on reasoning in non-clinical populations is scarce (Blanchette & Richards, 2004), the addition of content and anxiety-level factors to the belief bias paradigm would allow a combination of the two fields in such a way as to address a gap in our knowledge of how anxiety, content, validity and believability interact in the general population. Furthermore, scoring responses by both endorsement and logical accuracy whilst investigating both content and anxiety level allows an expansion of Oaksford *et* al's (1996) results that found any emotional content to suppress logical responding, by investigating how existing anxiety-level interacts with problem content.

In such a paradigm, syllogisms with anxiety-related content might be expected to increase belief bias by increasing the salience of anxious, task-irrelevant thoughts, which would then redirect or occupy working memory resources. Such a situation might be considered as forcing the individual to resort to their 'default' heuristic processing system, and so, would be expected to increase belief bias. Furthermore, if such systems result in processes such as matching bias (Manktelow, 2000), and other non-normative approaches to reasoning tasks (Stanovich & West, 1998a; 1998b), then accuracy would also be expected to be reduced. Such hypotheses are supported in part by early research by Eysenck, MacLeod, and Mathews (1987), and later findings in a similar vein (Eysenck, Payne, & Derakshan, 2005; Perowne & Mansell, 2002) that report a greater degree of attention allocation to stimuli perceived as threatening (Wenzlaff, Rude, & West, 1996; Yovel & Mineka, 2005); such as exam-related content might be by assessment anxious individuals. The link here between DPT and working memory is made through perceiving the central executive as an attentional system (Baddeley, 1997), selecting stimuli and allocating resources to one

of the two reasoning systems in order to decide on a response. Different allocation strategies would lead to focus on different aspects of the problem and therefore different types of response (Ansburg & Hill, 2003); belief based ones with the heuristic system, logically valid ones with the analytic system. In this way, by manipulating not only the validity and believability of conclusions, but also the content of the syllogisms, it is hoped that the relatively recent linking of anxiety to reasoning tasks (for example, Capon, Handley, & Dennis, 2003) might be continued and extended using a modified version of the belief bias paradigm. Based on the literature that suggests deficits in cognitive processes due to anxiety (Yovel & Mineka, 2005; Krikorian, Zimmerman, & Fleck, 2004), it would be expected that high-anxious individuals would show a main effect for syllogism content, and, more specifically, reduced accuracy on anxiety-related content. This follows from the findings that anxiety-prone individuals show selective attention for threat related stimuli and processing of these stimuli would reduce the resources available to process anxiety-related syllogisms. This is contrary to the findings by Johnson-Laird, Mancini, and Gangemi (2006) that individuals reason more accurately on material related to personal psychological problems, however, their hyper-emotion theory predictions are based on a clinical population. This study intends to look at anxiety in the general population, and as such, individuals would be expected to have less expertise regarding their worries and related content.

Alongside the belief bias paradigm as a tool for investigating the link between anxiety and reasoning ability, correlational analyses would allow replications of previous research. As such, measures of WMCE would be expected to correlate positively with reasoning accuracy, based on the dual-process theory's idea of two systems competing for resources, and the central executive being the most likely construct to be in control of this allocation. Furthermore, correlations between anxiety

and reasoning ability, as measured by accuracy, as well as anxiety and working memory, would be expected to show a negative relationship. A negative relationship between WMCE and reasoning ability, as well as negative correlations between anxiety and reasoning ability are predicted, based on the assumption that anxious states require maintenance which require cognitive resources (Gilhooly, Logie, Wetherick, & Wynn, 1993) that would otherwise be used to process material analytically. This pattern of correlations would provide replications of prior studies that show anxiety to impair reasoning accuracy. A negative correlation between WMCE functioning and anxiety level might be taken to suggest that those individuals with less control over resource allocation suffer more from anxiety (Mathews & MacLeod, 2002), or that anxiety reduces the amount of cognitive resources dedicated to the working memory tasks; as no task has yet been devised to measure clearly the central executive's ability to control resource allocation (Oaksford *et al*, 1996). Utilising the belief bias paradigm alongside correlational analyses would allow for any observed interaction effects to shed light on the directionality of the correlations.

In summary, adding content and anxiety level factors to the belief bias paradigm of Evans *et al.* (1983), alongside a measure of working memory, allows for the incorporation of the predictions of models such as the processing efficiency theory and a variety of other emotion based theories of reasoning, and allows the following predictions to be tested by using measures of endorsement and accuracy; Main effects will be found for validity and believability on endorsement and accuracy rates as found in previous studies. Furthermore, high anxiety levels and anxiety content are expected to reduce reasoning accuracy by depleting working memory resources, such that individuals will have to rely on heuristic responses such as believability.

Method

Participants

Participants in this study were volunteers and undergraduate psychology students at the University of Plymouth participating as part of a course requirement (N=77, 11 male, 66 female). However, due to technical difficulties, not all data sets were received for all measures, resulting in slightly different sample sizes for each analysis.

Design

In order to answer the research questions of interest, the first part of the experimental design is a correlational one to allow an investigation of the direction and strength of any relationships between working memory central executive functioning, assessment anxiety, and reasoning ability. Any significant trends found will be subject to regression analyses in order to assess effect sizes and the relative impact of each factor on the other, as well as construct regression equations to evaluate the predictive value of each variable.

In order to assess belief bias and any interaction between validity, believability, content, and anxiety level, a partial-within quasi-experimental analysis of variance (ANOVA) design; 2 Validity (Valid, Invalid) x 2 Believability (Believable, Unbelievable) x 2 Content (Anxiety related, Neutral) with 2 Anxiety level (High, Low) as a between-subject variable will be used.

Following this, WMCE will be added as a between-subjects covaried factor under an ANCOVA design to control for individual differences in working memory capacity, and to test the robustness of any effects found in the ANOVA.

The above mentioned ANOVA and ANCOVA designs will first be run using reasoning accuracy as a dependent variable to assess logical accuracy, and then re-

ran with endorsement rate as the dependent variable to assess belief biased responding, and allow for an investigation of the relationships between the two.

Furthermore, recording of endorsement as well as accuracy data allows for the construction of a range of indices to separate different aspects of the design in such a way as to allow for further correlational analyses in order to clarify any relationships found by the initial correlations or the ANOVA.

These were computed as follows; Logic Index Anxiety Content = (AVB+AVU) endorsements – (AIB+AIU) endorsements, Logic Index Neutral Content = (NVB+NVU) endorsements – (NIB+NIU) endorsements, Belief Index = (VB+IB) endorsements – (VU+IU) endorsements, Conflict Index = (VU+IB) accuracy, and the Non-Conflict Index = (VB+IU) accuracy.

Calculating a logic index provides a measure of performance on the syllogisms that is measured by normatively rational responding, irrespective of content or believability. This is split by content to avoid the possibility of opposite patterns negating each other. The belief index allows for an assessment of endorsement rate irrespective of validity or content, and the conflict and non-conflict indices create an opportunity to evaluate individuals' accuracy as a function of belief-logic conflict. Partial correlations will be conducted if any significant correlations are found in order to control for working memory and reasoning ability to assess the robustness of any relationships. Furthermore, regression analyses will be conducted to further examine the relationships between any significant correlations.

Higher scores on these indices reflect a higher reliance on beliefs in responding, more normatively logical responding on anxiety related syllogisms, more normatively logical responding on neutral syllogisms, and higher logical responding on conflict and non-conflict items respectively.

Materials: Working Memory Measures

In order to provide a measure of working memory central executive (WMCE) functioning, an adaptation of the program 'Sentences', developed by Capon (Capon, Handley, & Dennis, 2003) was used. The adaptations were made to allow it to be run from a web-based server in order to avoid room restrictions and time constraints. This section of the experimental program presents participants with groups of sentences, to which they have to respond true or false. After each set of sentences, which range from one sentence to seven sentences long, participants have to recall the last word of each sentence in the set, similar to the sentence validation tasks used by Daneman and Carpenter (1983).

True-False indications were made by clicking true or false buttons on screen with the computer mouse. Word recall responses were collected through keyboard input into a text box in the program between true-false verification sections. Participants controlled the speed of progression themselves as they were required to click on each sentence after verification to display the next sentence. Recall sections were indicated by the word 'RECALL' appearing on-screen after the last sentence in each set was verified.

WMCE scores were calculated as the mean number of words recalled over the seven trial blocks based on weighted averages of each block to correct for the variation in the number of sentences that had to be verified between each recall cue.

A working memory span task was also created using strings of ten randomly generated numbers. This task required participants to view a string of ten numbers for ten seconds, and then recall as many as they could. However, following a small scale pilot (N=4, 1 male, 3 female) of this and the other working memory measures, the span task was excluded due to running-time restrictions.

Materials: Assessment Anxiety Scales

The Assessment Anxiety Scale consists of both an adapted version of the Test Anxiety Inventory (TAI) (Sarason, 1978; Spielberger, Gonzalez, Taylor, Algaze, & Anton 1978; UIOWA, 2006), and the revised Anxious Thoughts and Tendencies Scale (ATT; Uhlenhuth, McCarty, Paine & Warner, 1999).

The TAI used consists of thirty-five of the original fifty items. The fifteen items that were not used comprised the subscales for 'concerns about not being prepared for a test' and 'concerns over future security', as well as items that were rephrasings of other items.

The TAI items remaining can be summed together to give an overall test-anxiety score (AAtot), or can be grouped into subscales from two broad groups; *Sources of Test Anxiety* and *Main Expressions of Test Anxiety*. Within the *Sources of Test Anxiety* there are subscales measuring ‘Concerns about how others will view you if you do poorly’ and ‘Concerns about self-image’. Within the *Main Expressions of Test Anxiety* there are subscales measuring ‘Bodily Reactions’ (see also Thompson, 1988, for details of physiological mechanisms involved bodily responses to anxiety), ‘Thought Disruptions’, and ‘General Test-Anxiety’

The ATT consists of fifteen items, looking at the tendency to adopt an anxious cognitive style. These items were embedded as a subscale of the overall anxiety measure. All of the items in this combined scale were responded to on a five point Likert scale, the sums of which provide an assessment anxiety total, equivalent to the sum of the ATT and TAI totals, and separate scores for each of the subscales of the TAI. Given that each of the scales and subscales provided output that was an index of anxiety, with higher values being indicative of higher anxiety, summing the totals of each was deemed justified. This is further justified by the average item-total

correlation for the combine scale being relatively high, *r*=.584, supporting the idea that each item, subscale, and scale, is measuring the same construct.

A small scale pre-test using volunteers drawn from the student population (N=14, 2 male, 12 female) showed the internal-reliability of the combined ATT and TAI scale to be α=.96. Individual Cronbach's Alpha test-retest reliability coefficients were found to be α=.95 and α=.94 for the ATT and TAI items respectively, above acceptable levels for the purpose of this study. The split half reliability coefficient for the combined scale after correction with the Spearman-Brown correction formula for using a divided sample to create two halves was *r* = .992. These measures indicate that both the TAI and ATT measure similar constructs, and support the decision to sum the totals to provide a single measure.

Materials: Syllogisms

The syllogisms for the reasoning measure were adapted from examples published by Bacon, Handley, and Newstead (2003), Capon *et al.* (2003), Garnham and Oakhill (1997), Manktelow (2000), and Newstead, Handley, Harley, Wright, and Farrelly, (2004). In line with the standard belief bias paradigm (Evans *et al.*, 1983), there were four sets of syllogisms, based on the status of their conclusions. These were valid believable, valid unbelievable, invalid believable and invalid unbelievable.

A pre-test of the syllogisms was conducted as a manipulation check in order to ascertain whether there were significant differences in believability between conclusions from each of the categories. A small sample of volunteers (N=14, 2 male, 12 female) were emailed a list of the conclusions taken from the syllogisms intended to be used in the belief bias measure, and asked to rate each of the conclusions on a nine-point Likert scale ranging from ‘totally unbelievable’ to ‘totally believable’.

The results of this belief ratings pre-test showed that there was good inter-rater reliability, and when the results were split by believability, to investigate whether the difference in ratings of believability between the two levels (believable, unbelievable) was statistically significant, a within subjects t-test was conducted. The results of the *t*-test showed the believable items (M=7.46, SD=.72) to be rated as significantly more believable than the unbelievable items (M=4.02, SD=.83), $t(13)=11.74$ $p<0.01$.

In order to investigate the effects of content related to assessment anxiety, a further set of loaded syllogisms were created by replacing the neutral words in the thematic syllogisms with assessment anxiety related words such as ‘test’ and ‘exam’ (See Appendix A). Within this loaded set, the four groups were still present; valid believable, valid unbelievable, invalid believable, and invalid unbelievable.

As this was part of a larger study, two further sets of syllogisms were created with eating-disorder related content, giving a total of 48 syllogisms. However, due to extremely significant correlations between the anxiety measures used, and the eating disorder inventory, second edition, (EDI2; Garner, 1991) scores, $r=+.674$, $n=68$, $p<.001$, two-tailed, the three loaded sets of syllogisms were collapsed into one group by averaging totals within each category.

The result of this is to provide eight categories of syllogism; Neutral-Valid-Believable (NVB), Neutral-Valid-Unbelievable (NVU), Neutral-Invalid-Believable (NIB), Neutral-Invalid-Unbelievable (NIU), and Anxiety-related-Valid-Believable (AVB), Anxiety-related-Valid-Unbelievable (AVU), Anxiety-related-Invalid-Believable (AIB), Anxiety-related -Invalid-Unbelievable (AIU).

This number of categories allows an investigation of main effects for validity, believability, and content, as well as allowing an analysis of any interactions between

factors. These were randomly ordered within the reasoning section of the experiment to avoid order effects between validity, believability, or loading.

Procedure: Administration of Measures

Each of the experimental measures was written into a self-administering web-based program by one of the experimenters, and the results were emailed automatically to the experimenters for each section completed by each participant. Anonymity was assured through the use of participant identification numbers that were issued for each participant to input at the start of each section of the program. Informed consent was obtained from laboratory and geographically distant participants by including a brief at the start of the program, and a detailed consent form. Participants were told that by clicking to continue they were giving their informed consent and that they were over eighteen year of age. Debriefing was achieved by the inclusion of a detailed brief that was presented by the program upon completion of the study. Contact details of the experimenters and supervisors were provided on the same screen as the brief, with a paragraph informing participants that they could email for further information or to have their data withdrawn. Individuals' right to withdraw was ensured through the inclusion of a 'withdraw' button on each screen, and a paragraph in the brief drawing attention to their right to withdraw and explaining that they could do so at any time without incurring any penalty. (For technical details of the experiment, please contact the author)

Procedure

Participants who were geographically distant were emailed a web-link to the study along with a participant identification number, where they were asked to follow the onscreen instructions. This group of participants were asked to complete the study in a quiet room, and were asked to sign into an instant messaging service so that the experimenter could provide real-time support and assistance if necessary. Participants who were able to attend laboratory sessions were seated in front of desktop computers that had been connected to the internet and were set up to show the study website in the browser window. Both groups then followed the onscreen instructions which guided them through the different sections of the study.

The first screen was a consent and confirmation of age page. Laboratory participants also signed a paper consent form at this stage. This was followed by the brief and instructions. The working memory section was presented after this. Following completion of the WMCE measure, instructions for the syllogistic reasoning section were presented, along with an example. The 48 syllogisms followed. Next in the sequence, participants were presented with instructions on how to complete the assessment anxiety measure, which were followed by the TAI and ATT items in a random order. Upon completion of the assessment anxiety combined scale, instructions were presented on how to complete the EDI2 section. The EDI2 items then followed, succeeded by a debrief page.

Upon completion of each section, participants were directed to click a submit button, which emailed the results for that section to the experimenters.

Results

Correlations

Significant correlations were found between both the ATT and TAI, r=+.703, n=63, p<.001, two-tailed. Furthermore, significant positive correlations were found between the TAI total and its subscales. Given the high degree of inter-scale correlations, theses measures were summed to give an anxiety total (AAtot). Table B1.0 in Appendix B shows a complete correlation matrix. Yellow cells highlight AAtot, ATT, and TAI correlations. Orange cells highlight inter-subscale correlations.

The correlations between anxiety scales and WMCE (blue cells in table B1.0) show a general trend of negative correlation, although only that with the 'views of others' subscale reaches significance. Overall, as anxiety increases, WMCE performance decreases.

Reasoning ability shows a positive, although non-significant, relationship with WMCE, and a general pattern of negative correlations with measures of anxiety. This negative relationship reaches significance for the subscales; TAI total, r=-.244, n=73, p=.038, Self Image, r=-.237, n=73, p=.044, and General Anxiety, r=-.290, n=73, p=.013, all two-tailed.

Accuracy ANOVA

Syllogism responses were first scored for accuracy. Due to technical problems during compilation of the data sets, not all participants' submitted a complete data-set, and so, the sub-sample for the following analyses of reasoning accuracy comprises data from 64 of the 77 who took part in the study (9 male, 55 female).

In order to investigate the effects of content, and the validity and believability of the conclusions on syllogistic reasoning ability, a 2 Content (Anxiety, Neutral) x 2

Validity (Valid, Invalid) x 2 Believability (Believable, Unbelievable) x 2 Anxiety (High, Low) analysis of variance was conducted.

Content, Validity, and Believability were entered as within-subjects variables. Anxiety-Group factor levels were defined as above- and below-median based on the AAtot and was included as a between subjects variable. The descriptive statistics are shown in Table 1.0 (see Table B1.1 in Appendix B for the full ANOVA table).

Table 1.0 *Descriptive Statistics for the Syllogism Groups based on Accuracy Scores*

Syllogism Category	Anxiety Group (Median Split)	Mean	Std. Deviation	N
AVB	Low Anxiety	2.6576	.38049	34
	High Anxiety	2.7340	.33240	30
AVU	Low Anxiety	2.1556	.36916	34
	High Anxiety	2.1120	.60854	30
AIB	Low Anxiety	1.9215	.59321	34
	High Anxiety	1.6343	.73999	30
AIU	Low Anxiety	1.8344	.60389	34
	High Anxiety	1.8227	.71517	30
NVB	Low Anxiety	2.6765	.53488	34
	High Anxiety	2.8333	.37905	30
NVU	Low Anxiety	2.8235	.57580	34
	High Anxiety	2.7000	.83666	30
NIB	Low Anxiety	2.4706	.70648	34
	High Anxiety	1.7667	.89763	30
NIU	Low Anxiety	2.0000	.85280	34
	High Anxiety	1.9667	.80872	30

The ANOVA based on accuracy rates found a significant main effects for content, $F(1,62)= 39.347$, $p<.001$, $eta^2=.388$,validity, $F(1,62)= 92.339$, $p<.001$, $eta^2=.598$, and believability $F(1,62)= 9.066$, $p=.004$, $eta^2=.128$, as well as a main effect for anxiety group, $F(1,62)= .145$, $p=.034$, $eta^2=2.176$. Comparing the means of content groups shows that reasoning is less accurate on syllogisms with anxiety-related content (M=2.109) than neutral content (M=2.405). Reasoning is also more accurate on valid (M=2.587) than invalid syllogisms (M=1.927). Accuracy was also higher on believable (M=2.337) than unbelievable syllogisms (M=2.177). Furthermore, low-anxious

individuals (M=2.317) were more accurate on average than high-anxious individuals (M=2.196). As an aside, although difference in mean score may seem small, the scores could only range from zero to three.

Significant two-way interaction effects were found between validity and anxiety group, $F(1,62)= 4.031$, $p=.049$, $eta^2=.061$, and between content and believability, $F(1,62)= 5.670$, $p=.020$, $eta^2=.084$. Plots of these interaction effects are shown in figures 1.1a and 1.1b respectively.

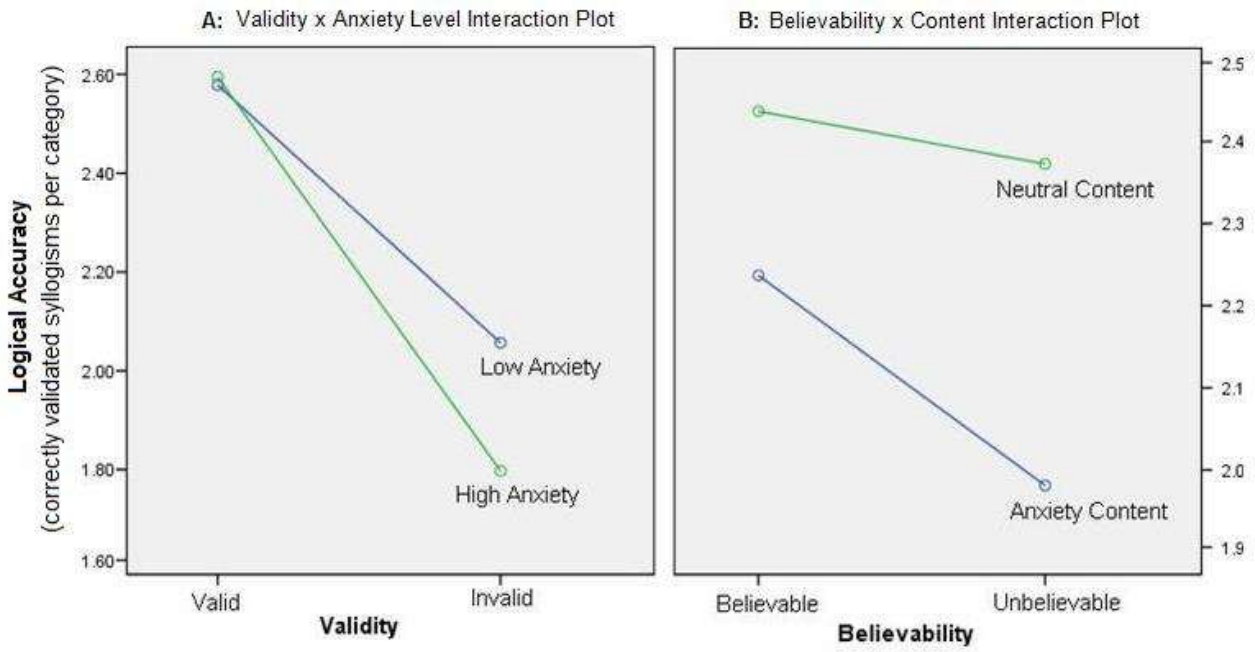

Figure 1.1 Interaction plots based on accuracy data for Validity, Believability, Content, and Anxiety Group

Individuals perform less accurately overall when conclusions are invalid, and high-anxious individuals are less accurate than low-anxious individuals when conclusions are invalid.

Reasoning accuracy is generally lower on syllogisms with unbelievable conclusions, but this also interacts with syllogism content, resulting in lower general performance for anxiety-related content, with the lowest accuracy being found for syllogisms with anxiety-related content and unbelievable conclusions.

There were also significant three-way interactions between validity, believability, and anxiety group, $F(1,62)= 7.387$, $p=.009$, $eta^2=.106$, and content, validity, and believability, $F(1,62)= 15.615$, $p<.001$, $eta^2=.201$. The plots for these interactions are shown in figures 1.2 and 1.3. From the results shown in figure 1.2, it can be seen that anxiety related content exacerbates the effects of both believability and validity by reducing reasoning accuracy. It can also be seen that there is a large effect of content on valid unbelievable syllogisms, with anxiety related content decreasing accuracy by nearly a third.

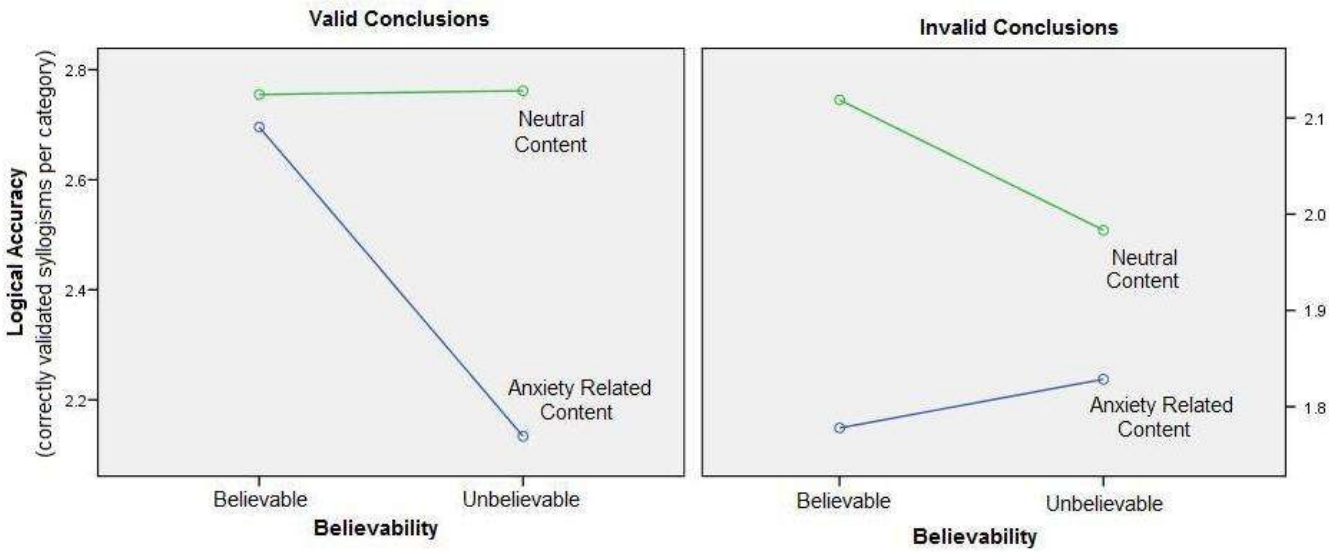

Figure 1.2 Interaction plots, based on accuracy data, of Believability x Content interactions, split by Validity

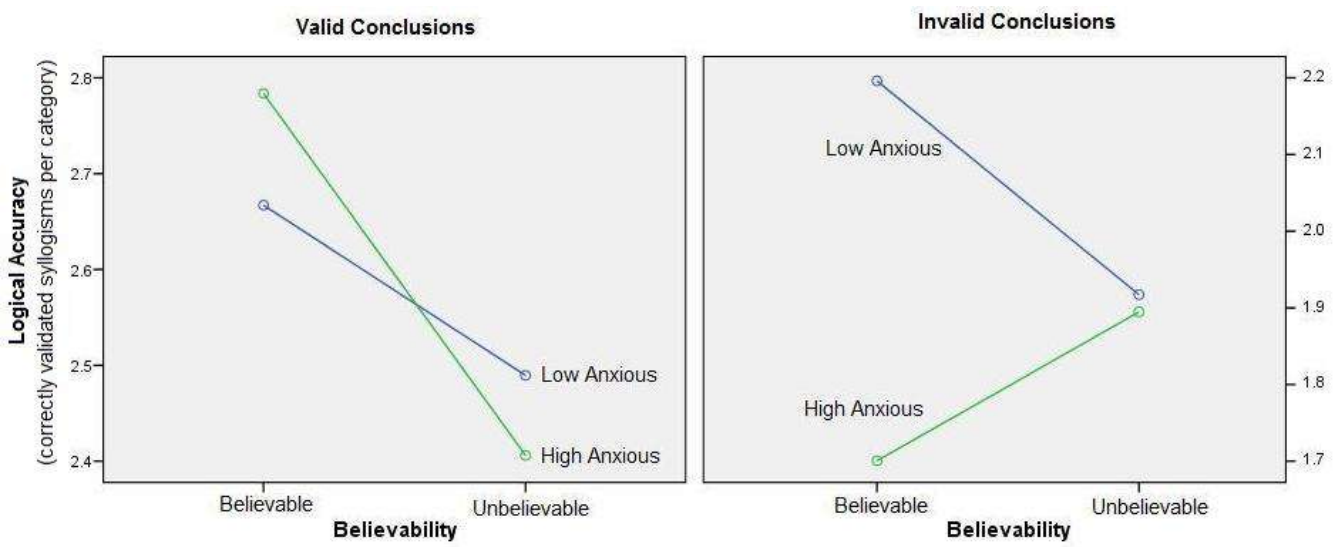

Figure 1.3 Interaction plots, based on accuracy data, of Believability x Anxiety Group interactions, split by Validity

From the plots shown in figure 1.3, it can be seen that although similar patterns of responding is seen between high and low anxious groups on valid conclusions across believability levels, when the conclusions are invalid, there is a different pattern of interaction between believability and anxiety group. Low-anxious individuals show a relatively standard pattern of interaction between validity and believability, responding less accurately moving from valid-believable, to valid-unbelievable, to invalid-believable, to invalid-unbelievable. However, high-anxious individuals respond lower overall, but show an increase in accuracy between invalid-believable and invalid-unbelievable. This suggests that anxiety reduces, or even reverses the effect of believability on syllogistic reasoning.

There were minor deviations from homogeneity of variance for the anxiety content, valid, and unbelievable syllogism groups (Levene's test significant at p=.014), and the neutral, valid, believable syllogism group (Levene's test significant at p=.008). Given the minority deviation (two out of eight groups), and that square-root, logarithmic, and reciprocal transformations confound the problem and exaggerate the deviation, the data were used in their untransformed state. The statistical robustness of an ANOVA design allows for slight deviations from homogeneity without excessive distortion of the results, and so, the use of untransformed data was considered acceptable.

Accuracy ANCOVA

Following the analysis of variance above, working memory central executive scores were included in an analysis of covariance in order to statistically control for differences between participants' working memory ability (table B1.2; full table in Appendix B). Covarying WMCE mediated but did not eliminate the effects found in the

ANOVA for accuracy, leaving only the main effects for WMCE score and Anxiety Group, $F(1,58)= .207$, $p=.027$, $eta^2=1.628$, and , $F(1,58)= .252$, $p=.023$, $eta^2=1.337$, respectively, as well as a three-way interaction between validity, believability, and anxiety group, $F(1,58)= 5.740$, $p=.020$, $eta^2=.090$ as statistically significant. The patterns of these interactions are the same as those found prior to covarying WMCE.

Endorsement ANOVA

In order to further investigate the relationships found with accuracy scores, the syllogism responses were re-scored based on endorsement rate rather than accuracy. That is, the number of syllogisms to which participants' responded 'valid', regardless of the logical status of the conclusions. Descriptive statistics are shown in table 2.0 (full ANOVA table is shown in Appendix B, table B2.0)

Table 2.0 *Descriptive Statistics based on Endorsement Rate*

Syllogism Category	Anxiety Group (Median Split)	Mean	Std. Deviation	N
AVB	Low Anxiety	2.6576	.38049	34
	High Anxiety	2.7340	.33240	30
	Total	2.6934	.35800	64
AVU	Low Anxiety	2.1556	.36916	34
	High Anxiety	2.1120	.60854	30
	Total	2.1352	.49227	64
AIB	Low Anxiety	1.0785	.59321	34
	High Anxiety	1.3657	.73999	30
	Total	1.2131	.67620	64
AIU	Low Anxiety	1.1656	.60389	34
	High Anxiety	1.1773	.71517	30
	Total	1.1711	.65307	64
NVB	Low Anxiety	2.6765	.53488	34
	High Anxiety	2.8333	.37905	30
	Total	2.7500	.47140	64
NVU	Low Anxiety	2.8235	.57580	34
	High Anxiety	2.7000	.83666	30
	Total	2.7656	.70693	64
NIB	Low Anxiety	.5294	.70648	34
	High Anxiety	1.2333	.89763	30
	Total	.8594	.87045	64
NIU	Low Anxiety	1.0000	.85280	34
	High Anxiety	1.0333	.80872	30
	Total	1.0156	.82601	64

A significant main effect for validity was found, $F(1,62)= 339.034$, $p<.001$, $eta^2=.845$, as well as a significant main effect for anxiety group, $F(1,62)= 4.031$, $p=.049$, $eta^2=.061$. Comparisons of the means of the levels shows that invalid conclusions (M=1.073) were endorsed less than valid conclusions (M=2.587), and that high low-anxious individuals endorsed more conclusions overall (M=1.899) than low-anxious individuals (M=1.761).

Furthermore, interaction effects were found between believability and anxiety group, $F(1,62)= 7.387$, $p=.009$, $eta^2=.106$, content and validity, $F(1,62)= 39.347$, $p<.001$, $eta^2=.388$, content and believability, $F(1,62)= 15.615$, $p<.001$, $eta^2=.201$, and validity and believability, $F(1,62)= 9.066$, $p=.004$, $eta^2=.128$. As well as these interactions, a three way interaction was found between content, validity, and believability, $F(1,62)= 5.670$, $p=.020$, $eta^2=.084$.

The patterns within the two-way interaction show that invalid conclusions are endorsed less than valid conclusions, and that this is exaggerated by believability, but primarily for valid conclusions, reducing the endorsement rate for valid-unbelievable conclusions to below that of valid-believable conclusions, but having little impact on the endorsement rates for invalid conclusions (fig.1.4a). The pattern of interaction between content and believability is less clear cut. (fig.1.4b). Unbelievable-Anxious syllogisms are endorsed less than Believable-Anxious ones, where ‘Anxious’ and ‘Neutral’ refer to anxiety related content and neutral content respectively. However, with neutral syllogisms, the endorsement rate is higher for Unbelievable than Believable conclusions.

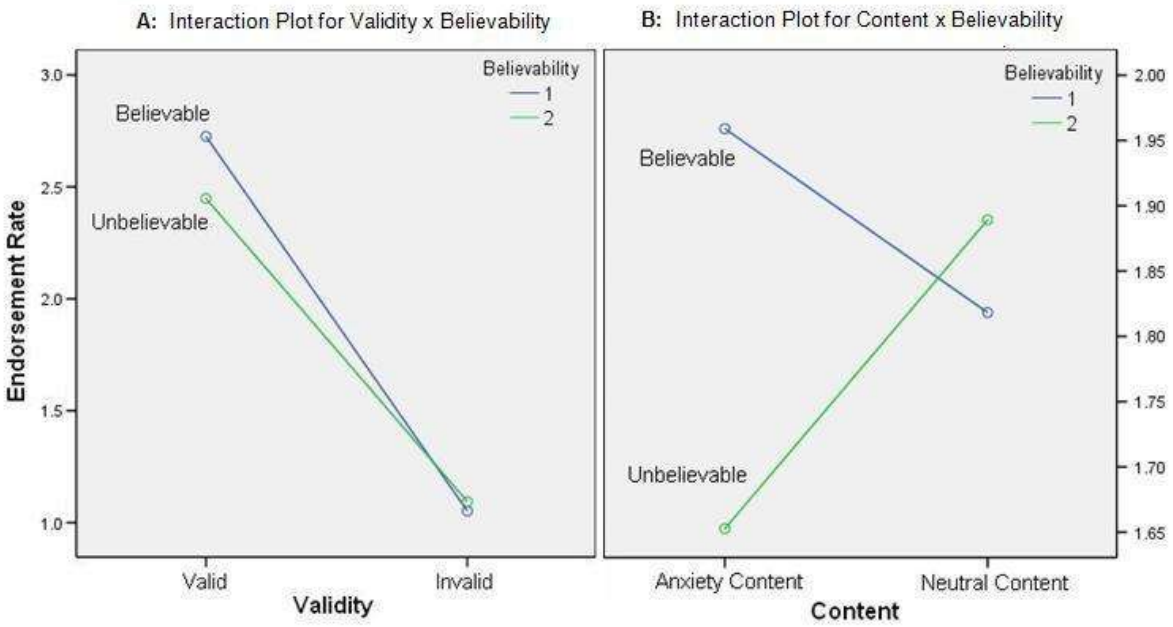

Figure 1.4 Interaction plots based on endorsement rate data for validity, believability, and content

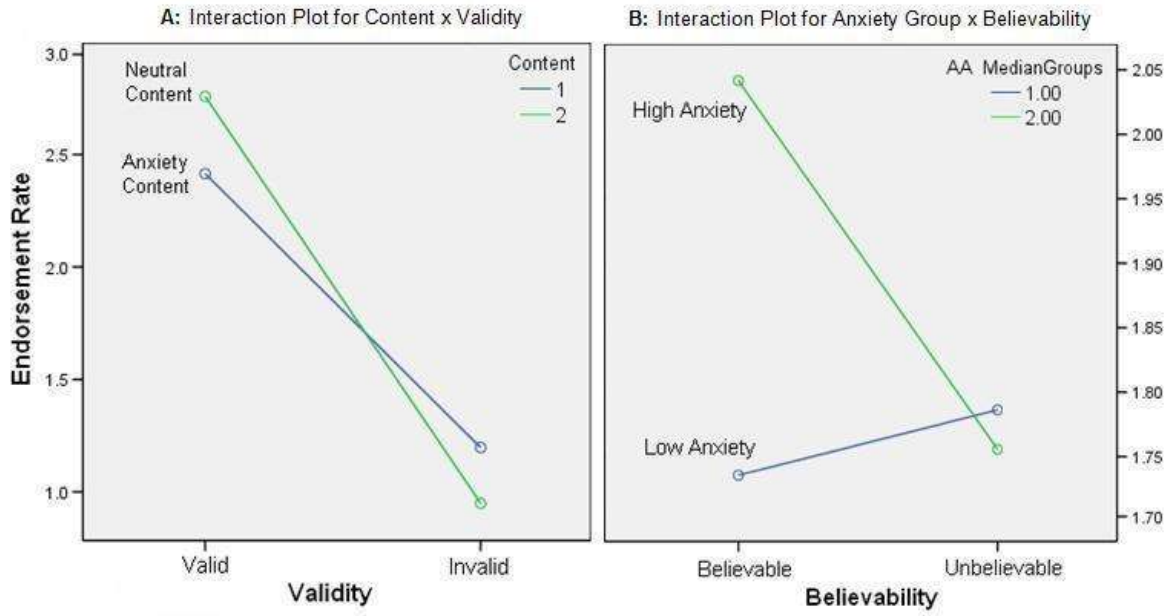

Figure 1.5 Interaction plots based on endorsement data for validity, believability, anxiety and content

Similarly, the interaction between Validity and Content (fig.1.5a) suggests that content can reverse the effects of validity, with neutral-valid conclusions being endorsed more than anxious-valid ones, but neutral-invalid being endorsed less than anxious-invalid ones. The interaction between Believability and Anxiety Group (fig. 1.5b) shows no

significant difference between endorsements of unbelievable syllogisms, but that low anxious individuals endorse less believable conclusions.

The plots for the three way interaction found between content, validity, and believability (fig.1.6) suggests that the interaction between validity and believability is only present with anxiety-related content, and that anxious content reduces the endorsement rate of valid-unbelievable conclusions.

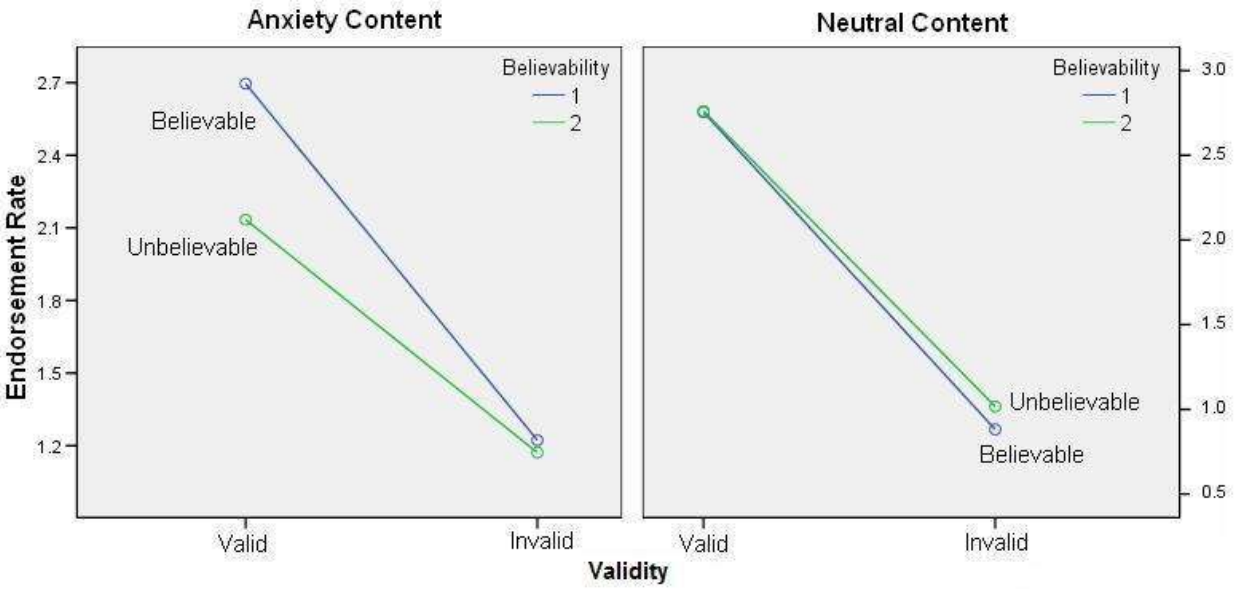

Figure 1.6 Interaction plots for validity x believability, splt by content

ANCOVA

Following the analysis of variance above, working memory central executive scores were included in an analysis of covariance in order to statistically control for differences between participants' working memory ability (results shown in Table B2.1 in Appendix B). Covarying WMCE reduced the size of the effects, leaving only the main effect for validity, $F(1,58)= 9.860$, $p=.003$, $eta^2=.145$, and the believability x anxiety-group interaction, $F(1,58)= 5.740$, $p=.020$, $eta^2=.090$, at statistically significant levels. However, the patterns still remained, albeit at sub-significant levels. The patterns shown by these effects are identical to those shown prior to covarying WMCE

score; invalid conclusions are endorsed less than valid ones, and the interaction plot resembles that shown in figure 1.5b above.

Logic, Belief, Conflict, and Non-Conflict Indices

Table 3.0 below shows the pattern for correlations between the indices calculated and reasoning ability, WMCE, AAtot and eating disorder proneness. Correlations of these measures and all of their subscales are shown in Table B3.0 of Appendix B.

Table 3.0 *Table of Correlation Coefficients and Alpha-levels for relationships between Indices, working memory, assessment anxiety, reasoning ability and eating disorder measures (N=64)*

Measures		Reasoning Ability	Indices				
			Belief	Logic Anx-related	Logic Neutral	Conflict	Non-Conflict
WMCE Score	Pearson	.162	.175	.140	.158	-.042	.138
	Sig	.211	.176	.282	.225	.748	.289
EDI2 total	Pearson	-.168	-.288(*)	-.117	-.220	.288(*)	.022
	Sig	.208	.028	.380	.097	.028	.869
AAtot	Pearson	-.222	-.366(**)	-.202	-.209	.206	-.164
	Sig	.082	.003	.115	.103	.109	.203
Reasoning Ability	Pearson	-	.177	.956(**)	.762(**)	-.321(**)	-.176
	Sig	-	.162	.000	.000	.010	.163
Belief	Pearson	.177	-	.203	.034	-.605(**)	.397(**)
	Sig	.162	-	.108	.792	.000	.001
Logic ACon[1]	Pearson	.956(**)	.203	-	.540(**)	-.347(**)	-.178
	Sig	.000	.108	-	.000	.005	.160
Logic NCon[2]	Pearson	.762(**)	.034	.540(**)	-	-.143	-.128
	Sig	.000	.792	.000	-	.259	.313
Conflict	Pearson	-.321(**)	-.605(**)	-.347(**)	-.143	-	.490(**)
	Sig	.010	.000	.005	.259	-	.000

* significant at $p<.05$, ** significant at $p<.01$
1- Logic Index based on performance on syllogisms with anxiety related content
2- Logic Index based on performance on syllogisms with neutral content

A significant positive correlation was found between reasoning ability and the logic index for both anxiety related and neutral content. Reasoning ability and both the conflict and non-conflict indices were negatively correlated, although only the former reached significance.

Anxiety, as measured by AAtot, showed patterns of negative, although non-significant, correlations with working memory, r=-.204, n=64, p=.121, reasoning ability, and with logical accuracy on both anxiety-related and neutral content syllogisms. AAtot was also negatively correlated with accuracy on non-conflict items, but not conflict items. AAtot showed a significant negative correlation with belief biased responding.

There was no significant correlational patterns between the belief and logic indices. Both assessment anxiety and eating disorder proneness increases decreased logical and belief biased responding.

These patterns of correlation were still observed, although at lower significance levels, after partialling out working memory and reasoning ability together, and working memory and reasoning ability separately. (Appendix B, Table B4.0).

A backwards regression analysis indicated that accuracy on neutral and anxiety-related content, reasoning ability, working memory, anxiety caused by concern over the views of others, bodily symptoms of anxiety, anxious thoughts, anxiety over self-image, general anxiety symptoms, and ATT total all provided significant predictors of belief biased responding, p<.05 (Table B5.0 of Appendix B). However, the most statistically significant model that can be derived from these variables is that based on reasoning ability and assessment anxiety together, resulting in a regression equation of *Belief Index Score = 2.159 - 1.88 Views of Others + 0.142 reasoning ability***,** predicting 20% of the variance, significant at p<.05. (Tables 4.0 below for beta values, and B5.1 of Appendix B for model summaries)

Table 4.0 *Regression coefficients for model 9(RA and AA views of others subscale) with Belief Biased Responding as the DV*

Model		Unstandardised Coefficients		Standardized Coefficients	t	Sig.	Adjusted R^2
		Beta	Std. Error	Beta			
9	(Constant)	2.159	3.084	-	.700	.487	
	AA Views Of Others	-.188	.057	-.391	-3.315	.002	.199
	Reasoning Ability	.142	.069	.243	2.065	.044	

Discussion

This study looked at the effects of believability and validity as well as content and anxiety level on syllogistic reasoning by assessing response accuracy and endorsement rates. Furthermore, this study looked at the relationships between working memory, anxiety, accuracy and reasoning ability, with consideration given to difference s between heuristic belief based responding and analytic, normatively logical responding.

The accuracy data shows that people perform less accurately when syllogism conclusions are invalid and when conclusions are unbelievable. The interaction effect between these two factors seems reasonable in the light of previous belief bias research (Evans *et al.* 1983) and the emotion and cognition literature in general (Barlow, 1991), with accuracy decreasing from valid-believable, to valid-unbelievable, to invalid-believable and being worst for invalid unbelievable syllogisms. In addition to these effects, anxiety related content was found to reduce accuracy in comparison to neutral content, and high anxious individuals performed less accurately than low anxious individuals. Furthermore, both of these factors interacted with validity and believability, acting to exaggerate the effects of both separately and together. However, content and anxiety level appear to reduce accuracy through separate mechanisms, based on the fact that although both interact with the other factors, they do not show an interaction with each other, which is suggestive of separate causal

mechanisms. This pattern of results could be explained by content reducing available resources by drawing attention to the semantics of the thematic content (Derryberry & Reed, 1998) and away from the structure, which is required for logical responding, and increasing reliance on believability and validity as cues. In addition, anxiety level might impact memory as opposed to attention by occupying systems such as the phonological loop and short-term memory, components cited as necessary for syllogistic reasoning with task-irrelevant anxious thoughts. Adopting a methodology focusing on what individual participants are thinking, possibly from a discursive standpoint (Augostinos, Walker, & Donaghue, 2006; Hutchby & Wooffitt, 2004), whilst controlling for factors such as cognitive style and motivation (Cacioppo, Petty, Feinstein, Blair, & Jarvis, 1996; Dusek, 1980) might allow clarification of how these two aspects alter what people do when reasoning.

The patterns found within the endorsement data are interesting in that they do not closely fit the profile of the original belief bias study (Evans *et al.*, 1983, p289). The data does show an effect for validity and anxiety group matching those found for the accuracy data, but the effect for belief is minimal, possibly due to the instructions to accept premises as true reducing reliance on belief cues. The interaction effects found with endorsement rates are similar to those found for accuracy data, but to a lesser degree. Content did not show an effect independently, but did show an interesting pattern of interaction, increasing endorsement rate in believable, but decreasing endorsement rates in unbelievable syllogisms. This seems to show that anxiety increases attention to the believability of conclusions, elevating the endorsement rates when believable, decreasing them when unbelievable, relative to endorsement rates for neutral content syllogisms. This again could be explained by the focusing effect of

content and anxiety, given that anxiety level increased the endorsement of believable conclusions.

The general unusual pattern of endorsement could possibly be explained by the psychology students within the sample having completed various courses in logic with a focus on syllogistic reasoning. A general grasp of formal logic will cue individuals to ignore the content, but they may not have the level of understanding to perform normatively. This consideration could also explain why a different pattern was found between accuracy and endorsement data, with endorsement being affected more by ignoring content than accuracy, which still relies on an assessment of the structure.

That covarying working memory dramatically reduced the effect sizes found for content, validity an believability as measured by both accuracy and endorsement rate suggests that a large part of these effects are moderated by working memory, primarily verbal working memory given the nature of the measures used. However, that anxiety level main affects appear to remain significant after controlling for working memory suggests the possibility that assessment anxiety level does not just impact the resources of working memory, and may operate through a variety of mechanisms.

This is supported by the correlational data, especially the logic and belief indices. Although working memory and reasoning ability showed a general positive trend, reasoning ability and anxiety showed a negative trend, and working memory and anxiety showed a negative trend, all of which would seem to support the idea that increased cognitive load due to anxiety reduces reasoning ability by depleting working memory resources and forcing a reliance on the heuristic system, closer inspection of logic and belief indices show a different pattern.

Although increasing anxiety reduces logical responding, it also reduces belief biased responding. This supports the general tenet that anxiety reduces reasoning

accuracy, but if the mechanism for this proposed by the DPT were correct, it would be expected that increased anxiety would reduce logical, but increase belief based responding. As such, anxiety does seem to decrease reasoning accuracy, but not by increasing reliance on the believability heuristic.

These results could be explained in a number of ways. Belief bias is not the only form of heuristic responding. High anxiety has been associated with reduced impulsivity (Schweizer, 2002) and increased caution (APA, 1994), and as such, individuals may be more cautious when reasoning, and be able to recognise and avoid using belief as a cue, however, this may not leave enough cognitive capacity to then respond logically. As such, anxiety may help individuals avoid one heuristic, but then rely on another, such as the matching, atmosphere, or the MIN heuristic approaches (Manktelow, 2000). One mechanism through which this might occur is based on the suggestions of authors such as Schwarz and Clore (2003; 1983) in the emotion and cognition literature who have proposed that mood is used unconsciously as a cue to likes and dislikes, as well as error and correctness (Berridge & Winkielman, 2003). As such, high anxious individuals might interpret their mood as evidence that their initial response, likely to be that cued by belief, is incorrect, and thus utilise different strategies engaging different heuristics. That this would leave high anxious individuals more likely to reconsider their initial responses than low anxious individuals would account for the reduction in belief bias as anxiety increases, but still allow for the overall decrease in reasoning ability with increasing anxiety.

Alternatively, as the patterns for decreased logical and belief based reasoning remain after partialling out working memory and reasoning ability, it seems reasonable that factors besides limited working memory are responsible for the reduction in logical

responding, and these factors my not force a reliance on the heuristic system, thus creating the apparent dissociation of the heuristic and analytic systems.

Although the idea that reduced working memory leads to worse logical performance (Elqayam, 2006) is supported by the results, and anxiety can reduce working memory, anxiety may also impact the analytic system in a selective way, reducing logical responding but not necessarily forcing a reliance on heuristics, instead striking a balance between the two to compensate for limitations. As such, the two systems do not appear to exist in an either-or state, rather they seem to be in a dynamic equilibrium and processing can involve aspects of both. Furthermore, which aspects of the systems are utilised does not seem to be solely governed by cognitive load. In addition to this it does not seem that differential allocation of resources to either system or to anxiety maintenance determines which system is used, given that the working memory central executive measure was shown not to predict heuristic responding, which then raises the question of what determines which aspects of each system are used.

It could possibly be a combination of availability of resources, allocation of those resources, and some additional factor that this study did not investigate. Possible candidates that could provide further insight if they were included in future studies are strategy use (Turley-Ames & Whitfield, 2003), and purely attentional systems, as well as measures of inhibitory control as separate aspects of the central executive. Such an approach could combine the belief bias paradigm, which has proven to be a useful and flexible tool in this study with the emerging conceptualisation of the central executive as a clustered construct of different control systems rather than a single entity (Phillips *et al*, 1997).

In response to Johnson-Laird *et al's* (2006) hyper emotion theory's predictions that individual's reason better on materials related to conditions they are suffering from, this study suggests otherwise. It would be expected under the hyper emotion theory that anxious individuals would show better reasoning on anxiety related content. However, anxiety was shown to decrease reasoning accuracy on both types of content. This might be due to differences between the samples. Whereas Johnson-Laird *et al.* (2006) investigated individuals with clinical levels of various emotional disorders, this study looked at a sample from the general population. As such, although assessment anxiety in its more extreme forms might constitute a social phobia under DSM-IV (APA, 1994), with the scales used to measure anxiety, even high scorers would be grouped as the sub-clinical non-pathological anxiety category. Including measures of response latencies and time spent on both anxiety related and neutral content syllogisms in future studies would allow a more detailed look at reasoning differences between high and low anxious individuals by giving a clearer picture of attention and resource allocation. Furthermore, not controlling for time spent on each syllogism in the current study might have mediated belief bias effects on endorsement rate by allowing individuals longer on more difficult syllogisms enabling them to overcome belief based responses. Given that chronometric variables such as reducing time allowance have been shown to increase heuristic responding (Evans & Curtis-Holmes, 2005; De Neys, 2006), investigating heuristic and analytic responding between high and low anxious individuals under time-limited conditions within this paradigm is one possible avenue for future research. If using a general population sample, better discrimination between anxiety and depression (Barlow, 1991), and the effects of each if these conditions and their components (Alloy, 1991; McNally, 1998; Greco & Roger, 2001) on reasoning given the relatively high prevalence and

comorbidity of both in the student population and adolescent population generally (Garber, & Hilsman, 1992; Parker, & Roy, 2001; Chambel, & Curral, 2005; Cox, Fuentes, Borger, & Taylor, 2001; Wisdom & Green, 2004) might clarify the results of this study and possibly reconcile them with the hyper emotion theory by allowing the two conditions and their respective effects to be controlled for.

In relation to research that has found anxiety to effect primarily spatial working memory (Shackman, Sarinopoulos, Maxwell, Pizzagalli, Lavric, & Davidson, 2006), this study suggests otherwise, finding anxiety to be negatively correlated with a measure of verbal and central executive functioning. However, if the effect of anxiety is to impair the central executive's allocation of resources, then all working memory tasks would be expected to show impairments. In addition to this, the discrepant findings may be accounted for by the fact that this study measured a combination of state and trait anxiety in relation to assessments, whereas Shackman *et al.* (2006) looked at induced acute state anxiety.

Another interesting finding, although not the main focus of this study, is that the relationships between anxiety, logic and belief bias are very similar to the relationships between eating disorder proneness, logic, and belief bias. This suggests that either reasoning is affected in a similar way in the two conditions, or that anxiety is a common component of eating disorders. That the 'views of others' subscale scores provided one of the most predictive variables of belief biased responding in the regression analyses seems reasonable given the large component of evaluation apprehension seen in anxiety disorders such as social phobia and eating disorders such as anorexia nervosa (APA, 1994). The affect of these different aspects of anxiety on belief based responding further supports the suggestion that different types of anxiety may affect cognitive functions differently, and opens a line of investigation

aimed at comparing reasoning abilities within and between similar clinical conditions using the adapted belief bias paradigm

This experiment, although providing support for the use of the belief bias paradigm in such an investigation, can only suggest correlational relationships due to the quasi-experimental nature of the groups used in the analyses (Evans, 2005). As such, future research might aim to create groups experimentally by manipulating anxiety or mood in order to provide evidence of causal links between anxiety, working memory and reasoning ability.

Controlling for strategy use might also allow further clarification of these results. A number of studies claim that syllogistic reasoning is based on verbal strategies. However, there is evidence that strategy use is not homogenous in the general population (Ford, 1995; Cybinski & Selvanathan, 2005). As such, verbal and spatial reasoning strategies might have been affected differentially by anxiety, leading to different patterns within the two groups, adding noise to the data.

Although anxiety is shown to decrease logical responding, the patterns of correlations with conflict and non-conflict indices show no clear pattern. This may be due to the indices being computed across different content types. However, it can be seen that as anxiety level increases, accuracy on conflict items increases, whereas on non-conflict items accuracy decreases. This could be taken as further evidence of caution in anxious individuals being cued by the conflict between belief and logic, leading to more careful reasoning on conflict items.

Given that some researchers have reported sex differences in both levels and effects of anxiety (Watson, 1991), future research might look at sex differences in the effects of anxiety on reasoning, something that was impracticable in the current study. Furthermore, given the questionable generalisability of findings based on student

samples (Yuille & Cutshell, 1986), a replication of the methods used with a larger sample might give greater ecological validity to these findings. Alternatively, utilising a specialist sample could shed light on the relationships between anxiety, working memory, and reasoning, as well as analytic and heuristic processing in a clinical population, for example, adapting the design of this study to investigate the effects of anxiolytic medication (Feldman, & Quenzer, 1984) on reasoning performance.

Including a variety of other measures to control for variables such as time of day could possibly clarify the contentious findings, and improve the methodology. Despite there being mixed evidence for effects of circadian rhythms on reasoning (Natale, Alzani, & Ccogna, 2003), it might prove worthwhile ruling it out as a confounding variable, given that circadian type, like reasoning style and strategy, is not homogenous in the general population and has been shown to affect performance on cognitive tasks (Natale *et al*, 2003). Furthermore, the adapted belief bias paradigm could be used in conjunction with neuroimaging techniques to investigated the biological substrates of anxiety (Gazzaniga, Ivry, & Mangun, 2002; LeDoux, 1994; 1998); and the prefrontal cortex in relation to heuristic and analytic reasoning; assumed to be the seat of the central executive (Baddeley & Della Sala, 1996). Such a combination might allow for further investigation of the anatomical basis of the central executive as well as the heuristic and analytic reasoning systems.

The unusual endorsement data may have been due to a lack of control for structure in the construction of the materials, resulting in differing difficulty levels between syllogism categories. Greater control in the construction of materials in the future would rule out this possibility in future studies. However, despite this, the patterns of effect were mainly highly statistically significant, so it is reasonable to assume the effects would withstand tighter methodological controls.

In relation to possible applications that can be developed from this research, the mood-as-information explanation of anxiety effects allows the possibility that individuals could be made conscious of their reliance on erroneous emotional cues, and thus evaluate situations more objectively (Caputo & Dunning, 2005). This might serve to improve reasoning by reducing unnecessary caution and thus unnecessary cognitive demands. In addition to this, having individuals develop positive future outcomes of test situations might reduce anxiety by alleviating negative irrelevant thoughts, again, increasing the availability of cognitive resources after the creation of these alternative positive outcomes (Broda-Bahm, 2000; Branscombe & Nario-Redmond, 1996). Such methods might not operate as expected, that is, they might not improve reasoning by providing the resources necessary to use analytic processes rather than heuristic ones, but they might serve to shift the weight individuals give to the outputs of each system. Better understanding of the effects of anxiety and other emotions on cognitive systems has been suggested as a way of improving coping abilities in a number of life situations (Argyle, 1994; Goleman, 2004a, 2004b, 2004c), and it seems such an understanding might be beneficial to situations such as assessment anxiety by allowing greater control of cognitive resources and how individuals go about solving reasoning problems, thus improving general performance.

In summary, the adapted belief bias paradigm seems methodologically suited to investigating the effects of content and anxiety on heuristic and analytic processes under a dual process framework, although a few refinements and adjustments of the additional factors would be beneficial in future research. The overall effects of anxiety level and anxiety related content was to reduce performance on syllogistic reasoning and working memory tasks, as expected. However, although a dual process framework allows for the combination of a number of other theoretical models and

ideas, such as Oksford *et al.*'s (1996) optimal hypothesis testing and Eysenck and Calvo's (1992) processing efficiency model under a single account, the mechanism through which anxiety has these effects is not solely based in the working memory system. Furthermore, although anxiety reduces reasoning accuracy, it does not appear to do this by forcing reliance on heuristic processes such as belief biased responding. Additional research is needed to identify more clearly how these effects are mediated and refine the dual process theory of reasoning, but the current study provides some interesting preliminary findings.

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Appendix A: Syllogism Pool

Assessment Anxiety (AA) Loaded Syllogisms; numbers 01-12, Eating Disorders (01) Loaded Syllogisms; numbers 13-24, Eating Disorder Loaded (ED1 and ED2) Syllogisms; numbers 25-36, Neutral Syllogisms (NS); numbers 37-48

AA Valid Believable

01 All exams are difficult
All difficult tasks are stressful
Therefore, all exams are stressful

02 All essays are difficult
Some exams are essay based.
Therefore, some exams are difficult

03 No students are anxious.
Some lecturers are students.
Therefore, Some lecturers are not anxious.

AA Valid Unbelievable

04 All presentations are relaxing
Some exams are presentations
Therefore, some exams are relaxing

05 Some students are anxious
All anxious people are millionaires
Therefore, some students are millionaires

06 No exams can be passed.
All essays are exams
Therefore, no essay based coursework can be passed

AA Invalid Believable

07 All students are in their twenties
Some anxious people are not in their twenties
Some of the students are anxious

08 All exams cause heart-rate increases
No difficult coursework is part of exams
Some difficult coursework causes heart-rate increases

09 All of the students are nervous
Some hyper-tension sufferers are not nervous
Some of the students are hyper-tension sufferers

AA Invalid Unbelievable

10 No exams are essay based
Some essays are hard
Therefore no exams are hard

11 Some Students are Anxious
All Anxious people suffer panic attacks
Therefore, all Students suffer panic attacks

12 Some nervous people are not lecturers
All nervous people are successful
Some of the lecturers are not successful people

ED1 Valid Believable

13 No bulimics are unhappy
Some women are unhappy
Therefore some women are not bulimic

14 No anorexics are perfect
Some girls are perfect
Therefore some girls are not anorexic

15 No dieter is happy
Some girls are happy
Therefore some girls are not dieters

ED1 Valid Unbelievable

16 No healthy foods are fattening
Some lettuces are fattening
Therefore, some lettuces are not healthy

17 All high calorie foods are delicious
Some low calorie foods are delicious
Therefore, some low calorie foods are high calorie foods

18 No low fat foods are fattening
Some chocolate bars are fattening
Therefore some chocolate bars are not low fat foods.

ED1 Invalid Believable

19 Some dieting methods are harmful
Some exercises are harmful
Therefore some dieting methods are exercises

20 Some thin people are miserable
Some eating disorder sufferers are miserable
Therefore some thin people are eating disorder sufferers

21 No ways to lose weight are easy
Some diets are easy
Therefore some ways to lose weight are not diets

ED1 Invalid Unbelievable

22 No anorexics are underweight
Some eating disorder sufferers are underweight
Therefore, some anorexics are not eating disorder sufferers

23 No people on diets are happy
Some girls are happy
Therefore, people on diets are not girls

24 No anorexics are chocolate eaters
Some girls are chocolate eaters
Therefore, all anorexics are not girls

ED2 Valid Believable

25 All of the gymnasts have toned legs
All people with toned legs are slim
Therefore, all gymnasts are slim

26 All supermodels have flat stomachs
All people with flat stomachs are slender
Therefore, all supermodels are slender

27 No individual who eats lots of chips is healthy
Some larger people eat lots of chips
Therefore, some larger people are not healthy

ED2 Valid Unbelievable

28 All the thin people are beautiful
All the beautiful people are happy
Therefore, all thin people are happy.

29 No person who eats too much has slim legs
Some thin people eat too much
Therefore, some thin people do not have slim legs

30 All people who are overweight like to eat celery
People who like celery are intent on eating healthy
Therefore, all overweight people are intent on eating healthily

ED2 Invalid Believable

31 Some oversized people hate their legs
All oversized people eat too much chocolate
Therefore some oversized people do not have thin legs

32 Some thin people think they have big buttocks
All people who think they have big buttocks exercise regularly
Therefore some thin people do not exercise regularly

33 No objects that can help you lose weight are inexpensive
Some herbal diet pills are inexpensive
Therefore herbal diet pills help you lose weight

ED2 Invalid Unbelievable

34 All overweight people have big buttocks in relation to their body shape
Some size six people have big buttocks in relation to their body shape
Therefore some overweight people are a size six

35 Some overweight people do not exercise excessively
All overweight people have large abdomens
Therefore, some people with large abdomens exercise excessively

36 Some people with oversized thighs do not watch what they eat
No thin people watch what they eat
Therefore, some thin people have oversized thighs

NS Valid Believable

37 All nurses are hospital workers
All hospital workers are required to work night shifts
Therefore, all nurses are required to work night shifts

38 All swans are white.
Some birds are swans.
Therefore, some birds are white.

39 No geese are felines.
Some birds are geese.
Therefore, Some birds are not felines.

NS Valid Unbelievable

40 All fungi are not edible
Mushrooms are fungi
Therefore, mushrooms are not edible

41 Some monkeys are aliens
All aliens are blue
Therefore, some monkeys are blue

42 No birds can fly.
All sparrows are birds.
Therefore, no sparrows can fly

NS Invalid Believable

43 All of the cats are rabid
Some of the animals are not rabid
Some of the cats are animals

44 All of the librarians are doctors
Some of the sculptors are librarians
None of the sculptors are doctors

45 All of the parents are teachers
Some of the drivers are not teachers
Some of the parents are drivers

NS Invalid Unbelievable

46 No doctors are kind
Some kind people are in the medical profession
Therefore no doctors are professionals

47 Some Dogs are Chefs
All Chefs are Yellow
Therefore, all Dogs are Yellow

48 Some of the doctors are not clowns
All of the doctors are intellectuals
Some of the clowns are not intellectuals

Appendix B: Tables

Table B1.0 *Correlation coefficients between working memory, ED, AA, AA-subscales, and RA measures for N=76*

					Anxiety Measures		Anxiety Subscales					
		WMCE Score	ED Total	AA Total	TAI Total	ATT Total	Views Of Others	Self Image	Thoughts	Bodily	General	Reasoning Ability
WMCE Score	Pearson	1	-.319(*)	-.194	-.181	-.177	-.268(*)	-.227	.011	-.174	-.111	.183
	Sig.		.013	.128	.155	.166	.034	.073	.930	.172	.385	.148
ED Total	Pearson	-.319(*)	1	.674(**)	.570(**)	.717(**)	.544(**)	.620(**)	.388(**)	.510(**)	.310(*)	-.053
	Sig.	.013		.000	.000	.000	.000	.000	.001	.000	.010	.668
AA Total	Pearson	-.194	.674(**)	1	.960(**)	.874(**)	.776(**)	.884(**)	.825(**)	.827(**)	.718(**)	-.210
	Sig.	.128	.000		.000	.000	.000	.000	.000	.000	.000	.074
TAI Total	Pearson	-.181	.570(**)	.960(**)	1	.703(**)	.754(**)	.893(**)	.891(**)	.848(**)	.819(**)	-.244(*)
	Sig.	.155	.000	.000		.000	.000	.000	.000	.000	.000	.038
ATT Total	Pearson	-.177	.717(**)	.874(**)	.703(**)	1	.661(**)	.696(**)	.549(**)	.630(**)	.404(**)	-.112
	Sig.	.166	.000	.000	.000		.000	.000	.000	.000	.000	.346
Views Of Others	Pearson	-.268(*)	.544(**)	.776(**)	.754(**)	.661(**)	1	.699(**)	.544(**)	.494(**)	.411(**)	-.094
	Sig.	.034	.000	.000	.000	.000		.000	.000	.000	.000	.428
Self Image	Pearson	-.227	.620(**)	.884(**)	.893(**)	.696(**)	.699(**)	1	.707(**)	.682(**)	.694(**)	-.237(*)
	Sig.	.073	.000	.000	.000	.000	.000		.000	.000	.000	.044
Thoughts	Pearson	.011	.388(**)	.825(**)	.891(**)	.549(**)	.544(**)	.707(**)	1	.731(**)	.750(**)	-.218
	Sig.	.930	.001	.000	.000	.000	.000	.000		.000	.000	.063
Bodily	Pearson	-.174	.510(**)	.827(**)	.848(**)	.630(**)	.494(**)	.682(**)	.731(**)	1	.635(**)	-.202
	Sig.	.172	.000	.000	.000	.000	.000	.000	.000		.000	.086
General	Pearson	-.111	.310(*)	.718(**)	.819(**)	.404(**)	.411(**)	.694(**)	.750(**)	.635(**)	1	-.290(*)
	Sig.	.385	.010	.000	.000	.000	.000	.000	.000	.000		.013
Reasoning Ability	Pearson	.183	-.053	-.210	-.244(*)	-.112	-.094	-.237(*)	-.218	-.202	-.290(*)	1
	Sig.	.148	.668	.074	.038	.346	.428	.044	.063	.086	.013	

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table B1.1 *ANOVA Table for 2 Content (Anxiety, Neutral) x 2 Validity (Valid, Invalid) x 2 Believability (Believable, Unbelievable) x 2 Anxiety (High, Low) based on Accuracy scores*

Within-Subjects Factors	df	Mean^2	Eta^2	F	Sig.
Content	1	11.144	.388	39.347	.000
Content * AA_MedianGroups	1	.382	.021	1.348	.250
Error(Content)	62	.283			
Validity	1	55.450	.598	92.339	.000
Validity * AA_MedianGroups	1	2.420	.061	4.031	.049
Error(Validity)	62	.601			
Believability	1	3.262	.128	9.066	.004
Believability * AA_MedianGroups	1	.593	.026	1.648	.204
Error(Believability)	62	.360			
Content * Validity	1	.292	.021	1.333	.253
Content * Validity * AA_MedianGroups	1	.384	.027	1.751	.191
Error(Content*Validity)	62	.219			
Content * Believability	1	1.169	.084	5.670	.020
Content * Believability * AA_MedianGroups	1	.110	.009	.533	.468
Error(Content*Believability)	62	.206			
Validity * Believability	1	1.764	.055	3.609	.062
Validity * Believability * AA_MedianGroups	1	3.611	.106	7.387	.009
Error(Validity*Believability)	62	.489			
Content * Validity * Believability	1	4.540	.201	15.615	.000
Content * Validity * Believability * AA_MedianGroups	1	.615	.033	2.115	.151
Error(Content*Validity*Believability)	62	.291			
Between-Subjects Factors	df	Mean^2	Eta^2	F	Sig.
AA_MedianGroups	1	1.875	2.176	.145	.034

Table B1.2 *ANCOVA Table for 2 Content (Anxiety, Neutral) x 2 Validity (Valid, Invalid) x 2 Believability (Believable, Unbelievable) x 2 Anxiety (High, Low) with WMCE score covaried*

Within-Subjects Factors	df	Mean^2	Eta^2	F	Sig.
Content	1	.290	.018	1.066	.306
Content * WMCE_Score	1	.055	.003	.201	.655
Content * AA_MedianGroups	1	.107	.007	.393	.533
Error(Content)	58	.273			
Validity	1	1.859	.049	2.979	.090
Validity * WMCE_Score	1	.155	.004	.249	.620
Validity * AA_MedianGroups	1	2.303	.060	3.690	.060
Error(Validity)	58	.624			
Believability	1	.005	.000	.014	.906
Believability * WMCE_Score	1	.213	.011	.633	.430
Believability * AA_MedianGroups	1	.995	.049	2.959	.091
Error(Believability)	58	.336			
Content * Validity	1	.254	.019	1.147	.289
Content * Validity * WMCE_Score	1	.407	.031	1.840	.180
Content * Validity * AA_MedianGroups	1	.409	.031	1.849	.179
Error(Content*Validity)	58	.221			
Content * Believability	1	.199	.019	1.100	.299
Content * Believability * WMCE_Score	1	.041	.004	.228	.635
Content * Believability * AA_MedianGroups	1	.229	.021	1.264	.265
Error(Content*Believability)	58	.181			
Validity * Believability	1	.022	.001	.046	.832
Validity * Believability * WMCE_Score	1	.016	.001	.032	.858
Validity * Believability * AA_MedianGroups	1	2.781	.090	5.740	.020
Error(Validity*Believability)	58	.485			
Content * Validity * Believability	1	1.057	.058	3.564	.064
Content * Validity * Believability * WMCE_Score	1	.276	.016	.930	.339
Content * Validity * Believability * AA_MedianGroups	1	.563	.032	1.898	.174
Error(Content*Validity*Believability)	58	.296			
Between-Subjects Factors	df	Mean^2	Eta^2	F	Sig.
WMCE_Score	1	1.339	1.628	.207	.027
AA_MedianGroups	1	1.100	1.337	.252	.023

Table B2.0 *ANOVA Table for 2 Content (Anxiety, Neutral) x 2 Validity (Valid, Invalid) x 2 Believability (Believable, Unbelievable) x 2 Anxiety (High, Low)based on Endorsement Rate*

Within-Subjects Effects	df	Mean^2	Eta^2	F	Sig.
Content	1	.292	.021	1.333	.253
Content * AA_MedianGroups	1	.384	.027	1.751	.191
Error(Content)	62	.219			
Validity	1	292.128	.845	339.034	.000
Validity * AA_MedianGroups	1	1.875	.034	2.176	.145
Error(Validity)	62	.862			
Believability	1	1.764	.055	3.609	.062
Believability * AA_MedianGroups	1	3.611	.106	7.387	.009
Error(Believability)	62	.489			
Content * Validity	1	11.144	.388	39.347	.000
Content * Validity * AA_MedianGroups	1	.382	.033	1.348	.250
Error(Content*Validity)	62	.283			
Content * Believability	1	4.540	.201	15.615	.000
Content * Believability * AA_MedianGroups	1	.615	.033	2.115	.151
Error(Content*Believability)	62	.291			
Validity * Believability	1	3.262	.128	9.066	.004
Validity * Believability * AA_MedianGroups	1	.593	.026	1.648	.204
Error(Validity*Believability)	62	.360			
Content * Validity * Believability	1	1.169	.084	5.670	.020
Content * Validity * Believability * AA_MedianGroups	1	.110	.009	.533	.468
Error(Content*Validity*Believability)	62	.206			
Between-Subjects Effects	df	Mean^2	Eta^2	F	Sig.
AA_MedianGroups	1	2.420	.061	4.031	.049

Table B2.1 *ANCOVA Table for 2 Content (Anxiety, Neutral) x 2 Validity (Valid, Invalid) x 2 Believability (Believable, Unbelievable) x 2 Anxiety (High, Low) based on endorsement data with WMCE score covaried*

Within-Subjects Effects	df	$Mean^2$	Eta^2	F	Sig.
Content	1	.254	.019	1.147	.289
Content * AA_MedianGroups	1	.409	.031	1.849	.179
Error(Content)	58	.221			
Validity	1	8.111	.145	9.860	.003
Validity * AA_MedianGroups	1	1.100	.023	1.337	.252
Error(Validity)	58	.823			
Believability	1	.022	.001	.046	.832
Believability * AA_MedianGroups	1	2.781	.090	5.740	.020
Error(Believability)	58	.485			
Content * Validity	1	.290	.018	1.066	.306
Content * Validity * AA_MedianGroups	1	.107	.007	.393	.533
Error(Content*Validity)	58	.273			
Content * Believability	1	1.057	.058	3.564	.064
Content * Believability * AA_MedianGroups	1	.563	.032	1.898	.174
Error(Content*Believability)	58	.296			
Validity * Believability	1	.005	.000	.014	.906
Validity * Believability * AA_MedianGroups	1	.995	.049	2.959	.091
Error(Validity*Believability)	58	.336			
Content * Validity * Believability	1	.199	.019	1.100	.299
Content * Validity * Believability * AA_MedianGroups	1	.229	.021	1.264	.265
Error(Content*Validity*Believability)	58	.181			
Between-Subjects Effects	df	$Mean^2$	Eta^2	F	Sig.
WMCE_Score	1	.155	.004	.249	.620
AA_MedianGroups	1	2.303	.060	3.690	.060

Table B3.0 *Table of Correlation Coefficients and Alpha-levels for relationships between working memory, AA, AA-subscales, and RA measures(N=64)*

		WMCE Score	ED total	Anxiety Scales			Anxiety Subscales					Reasoning Ability
				AA total	TAI total	ATT total	Views Of Others	Self Image	Thoughts	Bodily	General	
WMCE Score	Pearson	1	-.341(**)	-.204	-.191	-.187	-.241	-.247	-.004	-.207	-.116	.162
	Sig.		*.009*	*.121*	*.148*	*.156*	*.065*	*.059*	*.975*	*.116*	*.380*	*.211*
ED total	Pearson	-.341(**)	1	.695(**)	.596(**)	.725(**)	.554(**)	.647(**)	.419(**)	.503(**)	.382(**)	-.168
	Sig.	*.009*		*.000*	*.000*	*.000*	*.000*	*.000*	*.001*	*.000*	*.003*	*.208*
AA total	Pearson	-.204	.695(**)	1	.960(**)	.876(**)	.779(**)	.897(**)	.826(**)	.821(**)	.723(**)	-.222
	Sig.	*.121*	*.000*		*.000*	*.000*	*.000*	*.000*	*.000*	*.000*	*.000*	*.082*
TAI total	Pearson	-.191	.596(**)	.960(**)	1	.705(**)	.757(**)	.898(**)	.893(**)	.853(**)	.819(**)	-.248
	Sig.	*.148*	*.000*	*.000*		*.000*	*.000*	*.000*	*.000*	*.000*	*.000*	*.052*
ATT total	Pearson	-.187	.725(**)	.876(**)	.705(**)	1	.667(**)	.721(**)	.550(**)	.608(**)	.419(**)	-.135
	Sig.	*.156*	*.000*	*.000*	*.000*		*.000*	*.000*	*.000*	*.000*	*.001*	*.295*
Views Of Others	Pearson	-.241	.554(**)	.779(**)	.757(**)	.667(**)	1	.724(**)	.554(**)	.488(**)	.406(**)	-.094
	Sig.	*.065*	*.000*	*.000*	*.000*	*.000*		*.000*	*.000*	*.000*	*.001*	*.469*
Self Image	Pearson	-.247	.647(**)	.897(**)	.898(**)	.721(**)	.724(**)	1	.709(**)	.690(**)	.693(**)	-.249
	Sig.	*.059*	*.000*	*.000*	*.000*	*.000*	*.000*		*.000*	*.000*	*.000*	*.051*
Thoughts	Pearson	-.004	.419(**)	.826(**)	.893(**)	.550(**)	.554(**)	.709(**)	1	.741(**)	.747(**)	-.233
	Sig.	*.975*	*.001*	*.000*	*.000*	*.000*	*.000*	*.000*		*.000*	*.000*	*.068*
Bodily	Pearson	-.207	.503(**)	.821(**)	.853(**)	.608(**)	.488(**)	.690(**)	.741(**)	1	.661(**)	-.212
	Sig.	*.116*	*.000*	*.000*	*.000*	*.000*	*.000*	*.000*	*.000*		*.000*	*.097*
General	Pearson	-.116	.382(**)	.723(**)	.819(**)	.419(**)	.406(**)	.693(**)	.747(**)	.661(**)	1	-.274(*)
	Sig.	*.380*	*.003*	*.000*	*.000*	*.001*	*.001*	*.000*	*.000*	*.000*		*.031*
Reasoning Ability	Pearson	.162	-.168	-.222	-.248	-.135	-.094	-.249	-.233	-.212	-.274(*)	1
	Sig.	*.211*	*.208*	*.082*	*.052*	*.295*	*.469*	*.051*	*.068*	*.097*	*.031*	

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table B4.0 *Partial Correlations between Indices of Logic, Belief, Conflict and Non-Conflict, and Anxiety, showing partialling out of WMCE and RA, WMCE alone, and RA alone.*

Control	Indices		AA	Belief	Logic ACon	Logic NCon	Conflict	Non Conflict
			Indices					
WMCE Score and Reasoning Ability	AA total	Corr	1.000	-.407(**)	-.035	.036	.208	-.204
		Sig	.	*.002*	*.802*	*.793*	*.128*	*.136*
	Belief	Corr	-.407	1.000	.163	-.163	-.584(**)	.417(**)
		Sig	*.002*	.	*.233*	*.234*	*.000*	*.002*
	Logic ACon	Corr	-.035	.163	1.000	-1.000	-.190	-.038
		Sig	*.802*	*.233*	.	*.000*	*.164*	*.781*
	Logic NCon	Corr	.036	-.163	-1.000	1.000	.190	.038
		Sig	*.793*	*.234*	*.000*	.	*.164*	*.780*
	Conflict	Corr	.208	-.584(**)	-.190	.190	1.000	.495(**)
		Sig	*.128*	*.000*	*.164*	*.164*	.	*.000*
WMCE	AA total	Corr	1.000	-.433(**)	-.170	-.109	.256	-.165
		Sig	.	*.001*	*.211*	*.425*	*.057*	*.225*
	Belief	Corr	-.433(**)	1.000	.316(**)	.125	-.627(**)	.337(**)
		Sig	*.001*	.	*.018*	*.359*	*.000*	*.011*
	Logic ACon	Corr	-.170	.316(**)	1.000	.578(**)	-.449(**)	-.197
		Sig	*.211*	*.018*	.	*.000*	*.001*	*.145*
	Logic NCon	Corr	-.109	.125	.578(**)	1.000	-.220	-.129
		Sig	*.425*	*.359*	*.000*	.	*.103*	*.343*
	Conflict	Corr	.256	-.627(**)	-.449(**)	-.220	1.000	.522(**)
		Sig	*.057*	*.000*	*.001*	*.103*	.	*.000*
Reasoning Ability	AA total	Corr	1.000	-.363(**)	-.007	-.001	.165	-.221
		Sig	.	*.006*	*.957*	*.993*	*.221*	*.099*
	Belief	Corr	-.363(**)	1.000	.201	-.236	-.622(**)	.415(**)
		Sig	*.006*	.	*.134*	*.077*	*.000*	*.001*
	Logic ACon	Corr	-.007	.201	1.000	-.993(**)	-.232	-.041
		Sig	*.957*	*.134*	.	*.000*	*.083*	*.762*
	Logic NCon	Corr	-.001	-.236	-.993(**)	1.000	.262(*)	.035
		Sig	*.993*	*.077*	*.000*	.	*.049*	*.794*
	Conflict	Corr	.165	-.622(**)	-.232	.262(*)	1.000	.454(**)
		Sig	*.221*	*.000*	*.083*	*.049*	.	*.000*

* significant at $p<.05$, ** significant at $p<.01$

Table B5.0 *Regression Models with Belief Index score as the DV*

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	144.387	10	14.439	2.087	.044
	Residual	332.156	48	6.920		
	Total	476.542	58			
2	Regression	144.386	9	16.043	2.367	.026
	Residual	332.156	49	6.779		
	Total	476.542	58			
3	Regression	143.164	8	17.896	2.684	.015
	Residual	333.378	50	6.668		
	Total	476.542	58			
4	Regression	141.262	7	20.180	3.070	.009
	Residual	335.280	51	6.574		
	Total	476.542	58			
5	Regression	137.861	6	22.977	3.528	.005
	Residual	338.681	52	6.513		
	Total	476.542	58			
6	Regression	132.587	5	26.517	4.086	.003
	Residual	343.955	53	6.490		
	Total	476.542	58			
7	Regression	123.624	4	30.906	4.729	.002
	Residual	352.918	54	6.536		
	Total	476.542	58			
8	Regression	117.798	3	39.266	6.020	.001
	Residual	358.745	55	6.523		
	Total	476.542	58			
9	Regression	108.151	2	54.075	8.220	.001
	Residual	368.392	56	6.578		
	Total	476.542	58			

Predictor variables of models:

1	NContentRAacc, AA_Bodily, Reasoning_Ability, WMCE_Score, AA_ViewsOfOthers, AnxContRAacc, AA_General, ATT_total, AA_Thoughts, AA_SelfImage
2	NContentRAacc, AA_Bodily, Reasoning_Ability, WMCE_Score, AA_ViewsOfOthers, AnxContRAacc, AA_General, ATT_total, AA_Thoughts
3	NContentRAacc, Reasoning_Ability, WMCE_Score, AA_ViewsOfOthers, AnxContRAacc, AA_General, ATT_total, AA_Thoughts
4	NContentRAacc, Reasoning_Ability, AA_ViewsOfOthers, AnxContRAacc, AA_General, ATT_total, AA_Thoughts
5	NContentRAacc, Reasoning_Ability, AA_ViewsOfOthers, AnxContRAacc, ATT_total, AA_Thoughts
6	NContentRAacc, Reasoning_Ability, AA_ViewsOfOthers, AnxContRAacc, ATT_total
7	Reasoning_Ability, AA_ViewsOfOthers, AnxContRAacc, ATT_total
8	Reasoning_Ability, AA_ViewsOfOthers, ATT_total
9	Reasoning_Ability, AA_ViewsOfOthers

Table B5.1 *Regression model summaries*

Model	R	R^2	Adjusted R^2	Std. Error
1	.550	.303	.158	2.631
2	.550	.303	.175	2.604
3	.548	.300	.188	2.582
4	.544	.296	.200	2.564
5	.538	.289	.207	2.552
6	.527	.278	.210	2.547
7	.509	.259	.205	2.556
8	.497	.247	.206	2.554
9	.476	.227	.199	2.564