DOES A RESTRICTION IN WORKING MEMORY CAPACITY MEDIATE THE RELATIONSHIP BETWEEN WORRY AND INTERPRETIVE BIASES IN GENERALIZED ANXIETY DISORDER?

by

Kathleen Tallon

Bachelor of Arts Honours, McGill University, 2012

A thesis

presented to Ryerson University

in partial fulfillment of the

requirements for the degree of

Master of Arts

in the Program of

Psychology

Toronto, Ontario, Canada, 2014

AUTHOR'S DECLARATION FOR ELECTRONIC SUBMISSION OF A THESIS

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I authorize Ryerson University to lend this thesis to other institutions or individuals for the purpose of scholarly research

I further authorize Ryerson University to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

I understand that my thesis may be made electronically available to the public.

Does a Restriction in Working Memory Capacity Mediate the Relationship Between Worry and Interpretive Biases in Generalized Anxiety Disorder?

Kathleen Tallon

Master of Arts, 2014

Psychology

Ryerson University

ABSTRACT

Generalized Anxiety Disorder (GAD) is characterized by excessive, uncontrollable worry and is associated with specific cognitive and emotional difficulties including a threat interpretation bias (IB). Worry, especially in a verbal mode, has been shown to cause a temporary restriction in working memory (WM) capacity. This study examined whether the effects of worry on WM account for threat interpretation biases in GAD. Participants ($N = 36$) with GAD completed questionnaires assessing worry and related processes. Lower baseline WM was related to higher state anxiety, emotion dysregulation, intolerance of uncertainty, thought suppression, negative problem orientation, and lower attentional control, and was not associated with trait worry. Participants were trained to worry in verbal or imagery form, per Leigh and Hirsch (2011), and then completed a WM task and an IB task a second time. Induced worry, regardless of its form, did not significantly affect WM or IB. Theoretical implications and methodological considerations are discussed.

Acknowledgements

I would like to express my sincere gratitude to my supervisor, Dr. Naomi Koerner, for her time and dedication over the last 2 years. Your encouragement and direction have helped me develop as a researcher and have motivated me to work towards my full potential. I am grateful to my supervisory committee member Dr. Lixia Yang for her support and guidance throughout the development of my thesis. Thank you also to Dr. Martin Antony who kindly agreed to serve on my examining committee. I am grateful to my fellow members of the Cognition and Psychopathology Lab for always being generous with your assistance, advice, and moral support. It is a privilege and a pleasure to work alongside you. Thank you to my family for their continued love and support. Finally, I am grateful to the Canadian Institutes of Health Research for providing funding during my Master's education.

Table of Contents

List of Tables

List of Figures

List of Appendices

Does a Restriction in Working Memory Capacity Mediate the Relationship Between Worry and Interpretive Biases in Generalized Anxiety Disorder?

Worry is a thought process that is “negatively affect-laden,” future-oriented, and typically concerns a problem whose outcome is uncertain (Borkovec, Robinson, Pruzinsky, & DePree, 1983). Most people engage in worry to some degree (Tallis, Davey, & Capuzzo, 1994). For some individuals however, this normative process can become pathological in the form of Generalized Anxiety Disorder (GAD). Individuals with GAD experience their worry as excessive, pervasive, and uncontrollable (Brown, 1997). According to the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* by the American Psychiatric Association (DSM-5; APA, 2013), GAD is diagnosed in individuals who have endorsed experiencing excessive worry and anxiety in relation to a number of domains, more days than not, for at least 6 months. Additionally, a diagnosis of GAD requires experiencing at least 3 of 6 symptoms that are associated with anxiety and worry, such as irritability and muscle tension (APA, 2013). Pathological worry has come to be recognized as the hallmark feature of GAD, and therefore is the focus of research and clinical attention in this disorder (APA, 2013).

GAD and worry are associated with specific cognitive and emotional difficulties. These include problem solving difficulties (Davey, 1994; Stöber, 1998; Szabó & Lovibond, 2006), a threat interpretation bias (Anderson et al., 2012; Eysenck, Mogg, May, Richards, & Mathews, 1991), and emotion dysregulation (McLaughlin, Mennin, & Farach, 2007; Mennin, Heimberg, Turk, & Fresco, 2005; Salters-Pedneault, Roemer, Tull, Rucker, & Mennin, 2006). Chronic worry is proposed to underlie these cognitive and affective difficulties seen in GAD (Borkovec, Ray, & Stöber, 1998). However, the exact processes by which worry leads to information processing and emotion regulation difficulties have yet to be fully delineated. Research on the cognitive processes involved in worry suggests that worry may have negative effects on *working memory* (Crowe, Matthews, & Walkenhorst, 2007; Hayes, Hirsch, & Mathews, 2008); the ability to actively maintain information and controlled attention to meet the demands of a task (Engle, Kane, & Tuholski, 1999). It is possible therefore that the difficulties in information processing and emotion regulation seen in GAD are the result of the negative effects of worry on working memory.

Given the difficulties with problem solving, interpretation biases, and emotion regulation in GAD, and the relationship between worry and working memory, a model is proposed in which a reduction in state working memory capacity mediates the relationship between pathological worry and the aforementioned difficulties associated with GAD (See Figure 1). Each component of the proposed model is described in the following sections.

What is "Pathological Worry"?

Given its centrality to GAD, the starting point for the model in Figure 1 is *pathological worry*. Worry has been defined as "a chain of thoughts and images, negatively affect-laden and relatively uncontrollable" (Borkovec, Robinson, et al., 1983). Worry usually focuses on "future potential threat, imagined catastrophes, uncertainties, and risks" (Watkins, 2008), is associated with fear processes, and has been described as the cognitive component of anxiety (Borkovec, 1985; Borkovec, Robinson, et al., 1983). Worry has been shown to be similar to other types of pathological repetitive thought, especially depressive rumination (Watkins, Moberly, & Moulds, 2005). What distinguishes worry from ruminative repetitive thought, is that it is future oriented and is focused on concerns that the individual considers to be real and potentially serious (Watkins et al., 2005). Pathological worry is defined as excessive (disproportionate to the source of the worry), pervasive (occurs in a wide variety of situations, about a wide variety of topics), and uncontrollable (difficult to disengage from) (Brown, 1997).

Worry is primarily a thought-based process that involves verbal, abstract, negative, and repetitive cognitions (Borkovec et al., 1998; Goldwin & Behar, 2012). In a nonclinical sample, worry was shown to contain significantly more abstract thinking than baseline mentation in which individuals were instructed to think of anything they wanted (Goldwin & Behar, 2012). Abstract thought is defined as “indistinct, cross-situational, equivocal, unclear, and aggregated" (Stöber & Borkovec, 2002). Compared to concrete thoughts, abstract thoughts are simpler and lacking in detail or context (Trope & Liberman, 2003). In individuals with GAD, worries become more concrete after successful treatment with cognitive-behavioural therapy (Stöber & Borkovec, 2002). This has led to the suggestion that the abstractness of worry may be inherent to its pathological nature (Stöber & Borkovec, 2002). Worry has also been shown to involve predominantly verbal thought (vs. imagery based thought) and has been described as “talking” to oneself about feared future events (Borkovec et al., 1998).

Worry is associated with an increase in negative affect (McLaughlin, Borkovec, Sibrava 2007). The contrast avoidance model of worry suggests that individuals with GAD are not averse to negative emotions per se but rather are intolerant of large shifts in their emotional state (e.g., from a neutral state to a negative one; Newman & Llera, 2011). The model proposes that worry serves to maintain a negative emotional state so that an individual can avoid unexpected negative shifts in emotion (Newman & Llera, 2011). By perpetuating negative emotionality in individuals with GAD, worry may serve to maintain the disorder.

Identifying the form, content, and function of pathological worry aids in the understanding of how worry may lead to the information processing and emotion regulation issues seen in GAD. The relationship between worry and these issues is outlined below.

Interpretation of Ambiguity in Generalized Anxiety Disorder

It has been suggested that chronic worry contributes directly to the adverse *cognitive effects* of GAD (Borkovec et al., 1998; Ruscio, Seitchik, Gentes, Jones, & Hallion, 2011; Segerstrom, Tsao, Alden, & Craske, 2000). Individuals high in trait anxiety and worry have *difficulty processing ambiguous stimuli and have a tendency to interpret ambiguous information in a negative or threatening way* (Eysenck, MacLeod, & Mathews, 1987; Macleod & Cohen, 1993). This tendency to impose threat interpretations on ambiguity is thought to be a central maintaining factor in anxiety disorders (Beck & Clark, 1997). Individuals low in trait anxiety have a bias towards interpreting ambiguous (but potentially threatening) information in a benign way (Hirsch & Mathews, 1997). Training individuals who are low in trait anxiety to interpret ambiguous information negatively leads to heightened anxiety-related cognitions (Hirsch, Mathews, & Clark, 2007). Conversely, training benign interpretations of ambiguity has been associated with a reduction in trait anxiety (Mathews, Ridgeway, Cook, & Yiend, 2007), fewer negative thought intrusions following a worry period in both nonclinical and GAD samples (Hayes, Hirsch, Krebs, Mathews, 2010; Hirsch, Hayes, & Mathews, 2009), and greater residual working memory capacity while worrying (Hirsch et al., 2009). The effects of modifying interpretation bias on anxiety and worry suggest that they are reciprocally linked.

Individuals with GAD additionally have difficulty processing and appraising ambiguous information, which impacts their decision making and problem solving abilities. GAD and worry are associated with greater intolerance of uncertainty (Dugas, Gagnon, Ladouceur, & Freeston, 1998). Intolerance of uncertainty is related to greater attention to uncertain events, and increased distress in the face of uncertainty, leading to difficulty making decisions (Jacoby, Abramowitz, Buck, & Fabricant, 2014; Ladouceur, Talbot, & Dugas, 1997). One study found that a worry induction led to a reduced ability to categorize ambiguous stimuli (Metzger, Miller, Cohen, Sofka, & Borkovec, 1990). As ambiguity of a problem increases, individuals with high worry show a greater increase in the amount of evidence they need to make a decision compared to individuals with low worry (Tallis, Eysenck, & Mathews, 1991). This increased need for evidence leads to delayed decision-making (Tallis et al., 1991) and hinders efficient problem solving (Ladouceur et al., 1997). Taken together these findings suggest that worry contributes to functional difficulties in appraising and managing ambiguity.

Emotion Dysregulation

Worry is associated with difficulty regulating emotions (Mennin et al., 2005). Worry has been conceptualized as a cognitive avoidance strategy that facilitates the avoidance of upsetting emotions or thoughts (Borkovec, Alcaine, & Behar, 2004). This has led to the suggestion that individuals with GAD have difficulty adaptively regulating their emotions (Mennin, Heimberg, Turk, & Fresco, 2002). Mennin et al. (2005) proposed that emotion dysregulation manifests in individuals with GAD through: "(1) heightened intensity of emotions; (2) poor understanding of emotions; (3) negative reactivity to one's emotional state (e.g., fear of emotion); and (4) maladaptive emotional management responses." There is support for this as individuals with GAD report greater emotional intensity, difficulty identifying emotions, greater negative reactivity to emotions, and difficulty coping with negative emotions than controls (Mennin et al., 2005). In an analogue GAD sample, chronic worry was associated with reported difficulty engaging in goal directed behaviours when distressed, and difficulty using emotion regulation strategies (Salters-Pedneault et al., 2006). Worry has also been experimentally linked with emotion dysregulation. The immediate effects of worry on cognition and emotion have been studied using worry inductions. In a worry induction, experimenters induce worry by having participants identify their most prominent worry topic and worry about it for around 10 minutes (Borkovec & Inz, 1990; Thayer, Friedman, & Borkovec, 1996). Compared to a period of nonworried thought, worry inductions lead to heightened cardiovascular activity, and more intense negative mood following a sad movie clip (York, Borkovec, Vasey, & Stern, 1987). Another study found that a period of worry (compared to neutral or relaxing thought) led to *less* cardiovascular activity when subsequently viewing upsetting images (Borkovec & Hu, 1990). Despite this finding, it was also reported worry compared to neutral thought led to greater subjective fear when exposed to the upsetting images (Borkovec & Hu, 1990). In individuals with GAD, compared to nonanxious controls, worry induction leads to more intense negative affect (McLaughlin, Mennin, et al., 2007). This supports the assertion by Mennin et al. (2005) that GAD is associated with heightened intensity of emotion, especially negative affect. Taken together these studies provide initial support for the presence of one facet of emotion dysregulation in individuals with GAD; heightened emotional intensity, and the causal role of worry in heightening negative affect.

Worry has been shown to contribute to cognitive and emotional difficulties in GAD. However, the mechanisms governing the relationships of worry to interpretation biases, emotion dysregulation, and other difficulties such as problem solving, have yet to be outlined. One possible mechanism is the restriction in working memory that occurs when people worry.

Working Memory

Working memory is a limited capacity cognitive system that facilitates the temporary storage and controlled processing of information related to complex mental tasks (Baddeley, 1992). Good working memory allows for efficient allocation of attentional resources and facilitates successful information processing and learning (Baddeley, 2003). Individual differences in working memory predict performance on real world cognitive tasks including reading (Daneman & Carpenter, 1980), writing (Benton, 1984), reasoning (Kane et al., 2004), language comprehension (King & Just, 1991), and learning (Shute, 1991). Many theoretical models of working memory have been put forth, the most widely accepted of which comes from Baddeley and Hitch (1974). This model proposes a tripartite structure of working memory composed of (1) the central executive, an attentional control system, and two subsidiary systems: (2) the visuospatial sketchpad, which stores visual and spatial information, and (3) the phonological loop which holds verbal and acoustic information as well as an articulatory rehearsal system (Baddeley & Hitch, 1974). Working memory therefore balances storage and processing of information to allow for the dynamic interaction of long-term memory, perception, and action in cognitive tasks (Baddeley, 2003). For example, during problem solving, working memory would allow an individual to hold the problem in mind, generate multiple interpretations and solutions, bring forth and evaluate memories of times when similar problems were encountered, and settle on a problem solution. Working memory capacity additionally facilitates controlled attention— "sustained attention in the face of interference or distraction" (Engle et al., 1999). Working memory capacity varies across and within individuals (Schmeichel, 2007) as a result of contextual factors (e.g., cognitive load, fatigue) or as the product of training (Bomyea & Amir, 2011; Engle et al., 1999).

Different metaphors have been used to describe the limited capacity of working memory. Hirst and Kalmar (1987) used the metaphors of fuel, structure, and skills to explain dual-task effects in cognitive performance. The fuel metaphor posits that cognitive processes depend on the availability of a resource, "fuel," which is depleted with the use of cognitive resources (Hirst & Kalmar, 1987). Executive control of working memory can be impaired by previous attempts at executive control (Schmeichel, 2007). For example, an inhibition writing task requiring participants to write a story without the letters *a* and *n* led to subsequent impairment on a digit span task (Schmeichel, 2007). The structure metaphor refers to the fact that cognitive processes will be impaired when two or more tasks place demands on the same cognitive structure (Hirst & Kalmar, 1987). An example of this is the difficulty of listening to two voices at once (Schmeichel, 2007). Concurrent activities confer a “load” on working memory that leads to impaired performance (Rosen & Engle, 1997; Schmeichel, 2007). Finally, the skills metaphor suggests that controlled cognitive processes involve skills that can be improved through “practice, learning, or changes in strategy” (Schmeichel, 2007).

Working memory and worry. Self-reported trait worry is significantly related to working memory performance; specifically, it is negatively associated with performance on central executive tasks ($\beta = -0.722$; Crowe et al., 2007). In an undifferentiated, nonclinical sample, tasks that utilized the central executive and phonological loop significantly interfered with ability to worry (Rapee, 1993). This suggests that worry and working memory tasks utilize the same cognitive resources (Rapee, 1993). During a period of experimentally induced worry, individuals high in worry (identified by a cut-score of 55 of the *Penn State Worry Questionnaire*, a self-report measure of worry) had less residual working memory capacity on a random key pressing task than individuals who do not worry often (Hayes et al., 2008). In an undifferentiated undergraduate sample, individuals had worse working memory performance when attempting to control thoughts after a period of worry than after a period of neutral thought (Hallion, Ruscio, & Jha, 2014). In this same study worry was found to negatively impact working memory performance regardless of attempts to control worried thought (Hallion et al., 2014). This implies that it is worry itself, rather than attempts to control worry, that negatively affects working memory (Hallion et al., 2014). Unlike people who worry a lot, those low in worry show no difference in working memory when worrying versus when thinking of a positive topic (Hayes et al., 2008). This suggests that worry has negative implications for working memory and that this effect may be specific to individuals who experience high worry. It is unclear as of yet what the effects of worry on working memory are in individuals with a diagnosis of GAD, a disorder whose central feature is pathological levels of worry.

Possible explanations for the relationship between worry and working memory. Worry has been shown to decrease working memory capacity (Hayes et al., 2008). Two possible explanations for this are 1) that worry's abstract/verbal quality results in an increased cognitive load or 2) that the anxiety and negative affect associated with worry have a negative effect on attentional control.

***Abstract thought, verbal thought, and working memory*.** Worry is verbal in its form and contains abstract content (e.g., "What if something bad happens?"). Verbal and abstract thought are related to inefficient, or resource intensive, information processing strategies and reduced working memory capacity (Jessen et al., 2000; Kounois & Holcomb, 1994; Leigh & Hirsch, 2011). Inefficient information processing strategies consume cognitive resources disproportionately to the tasks' demands and therefore might restrict working memory capacity (Leigh & Hirsch, 2011). The cognitive demands of worry due to its abstract and verbal qualities could explain its association with reductions in working memory capacity.

Abstract information is processed less quickly, less accurately, and less deeply than concrete information (e.g., "heaven" vs. "table"; Jessen et al., 2000). One theory put forth to explain this difference is the dual activation theory, which postulates that information is processed simultaneously by verbal and imagery based systems (Paivio, 1991). Concrete words are encoded faster and more accurately because they are processed by both the verbal and imagery based systems (Jessen et al., 2000). Conversely, abstract stimuli are not dually encoded and therefore are not processed as efficiently (Kounois & Holcomb, 1994). The greater time it takes to process abstract information suggests that abstract information places a greater demand on cognitive resources.

Verbal information is not processed as efficiently as image-based information. In an experiment, participants asked to worry in a verbal mode showed less available working memory capacity on a random interval generation task than did those worrying in an imagery mode (Leigh & Hirsch, 2011). This suggests that the verbal quality of worry is especially demanding of cognitive resources (Leigh & Hirsch, 2011). Worrying in a verbal mode (compared to imagery) led to an increased attention to threat information in people high in worry (Williams, Mathews, & Hirsch, 2014) and an increase in negative thought intrusions (Stokes & Hirsch, 2010). Verbal worry results in reduced working memory capacity, threat-oriented attentional shifts, and increased thought intrusions. The negative cognitive effects of the abstract and verbal qualities of worry could explain the relationship between worry and reduced working memory capacity.

Anxiety, negative affect, and working memory. Worry also produces negative affect and anxiety (McLaughlin, Borkovec, et al., 2007), which may have adverse effects on working memory (Eysenck, Derakshan, Santos, & Calvo, 2007; Kensinger & Corkin, 2003). Individuals with high worry have higher levels of baseline anxiety and negative mood (McLaughlin, Borkovec, et al., 2007). Inducing worry also leads to further significant increases in anxiety and negative affect (McLaughlin, Borkovec, et al., 2007). The effects of state anxiety and negative moods on working memory are still unclear, however. Anxiety and negative affect have been shown to decrease attention and working memory capacity in nonclinical samples (Eysenck et al., 2007). Negative emotional content in a working memory task impairs performance (Kensinger & Corkin 2003). State anxiety decreases attentional control and increases attention to threat-related stimuli (Eysenck et al., 2007). However, in three separate studies looking at the effects of worry on working memory, state differences in anxiety and negative affect were not found to contribute to the negative effects of worry on working memory capacity (Hallion et al., 2014; Hayes et al., 2008; Leigh & Hirsch, 2011). This suggests that the negative effect of worry on working memory may be independent of the effects of state anxiety and negative affect.

Worry and working memory: Outstanding questions. In individuals high in worry, worrying is associated with restrictions in working memory. This could be due to worry's activation of anxiety and negative affect or due to its abstract/verbal content. Initial research suggests that it is the verbal quality of worry that accounts for its negative effects on working memory (Leigh & Hirsch, 2011) and for threat-oriented shifts in attention (Williams et al., 2014).

The negative effects of worry on working memory have yet to be studied directly in a clinical sample of individuals with GAD. Additionally, the effect of reduced working memory capacity on information-processing in people with GAD has not been examined.

The Possible Role of Working Memory in Worry-Related Information Processing

The reduction in working memory capacity associated with worry could explain the difficulties individuals with GAD display in information processing such as threat interpretation biases and difficulty appraising and categorizing ambiguous stimuli. Generally, individuals with a larger working memory capacity can hold multiple interpretations of ambiguous words in mind for longer during a reading task than individuals with smaller working memory capacities (Macdonald, Just, & Carpenter, 1992; Miyake, Just, & Carpenter, 1994). This suggests that processing ambiguity requires working memory capacity and that restriction of working memory capacity could impair ambiguity processing. In one study, individuals with smaller working memory capacities more quickly reverted to the most likely interpretation of an ambiguous homograph (e.g., “boxer” referring to a fighter rather than a breed of dog) (Macdonald et al., 1992; Miyake et al., 1992). As individuals with GAD are biased towards making threat interpretations, a restricted working memory capacity could lead to the maintenance of threat interpretations of ambiguous stimuli. Reduced working memory may increase reliance on less cognitively demanding heuristic strategies for processing information. Uncertain and ambiguous situations are inherently more difficult to process using heuristic strategies, as they are not easily understood using simple rules. This difficulty managing ambiguous information along with the tendency to interpret it negatively, could lead to an avoidance of uncertain situations and ambiguity in individuals with GAD. Furthermore, the reduced attentional control associated with working memory deficits might make it difficult for individuals with GAD to search for evidence and make decisions in the face of uncertainty. It is therefore predicted that under working memory restrictions, individuals with GAD will have a heightened tendency to favour threat interpretations of ambiguous stimuli.

Conclusion

To summarize, pathological worry is associated with a set of information processing and emotion regulation difficulties that contribute to impairment and distress in GAD. These include interpretation bias, emotion dysregulation, and problem solving difficulties. It is possible that a reduction in working memory capacity caused by worry could underlie the specific cognitive and emotional difficulties seen in GAD. This reduction in working memory may be due to the abstract or verbal content of worry, which is related to inefficient information processing strategies and increased cognitive load. It could also be due to worry's activation of negative affect and anxiety, which have detrimental effects on working memory and attention. The present study specifically focused on interpretation bias in the context of this model of worry and working memory.

Research Questions and Hypotheses

This study addressed the following questions in people with a diagnosis of GAD: (1) What is the association between worry-related changes in working memory performance and measures of GAD symptoms and related processes (negative problem orientation, intolerance of uncertainty, emotion regulation, attentional control, cognitive avoidance, and metacognitions)? (2) How does the type of worry (verbal vs. imagery based) affect working memory and interpretations of ambiguity? The above effects were compared between experimental conditions (verbal vs. imagery) to assess the differential effects of verbal and imagery based worry on working memory and interpretation biases. (3) Does a restriction in working memory capacity mediate the relationship between worry and threat interpretations of ambiguity?

It was hypothesized that (1) A greater restriction in working memory capacity when worrying, as indicated by the discrepancy between baseline performance on a working memory task and performance while actively worrying, will be related to higher levels of trait worry, GAD symptoms, negative problem orientation, greater intolerance of uncertainty, poor emotion regulation, worse attentional control, greater cognitive avoidance, greater metacognitive effort to control negative thoughts, and threat interpretation biases; (2) Worrying in a verbal form will lead to a greater restriction in working memory capacity than worrying in images; (3) Worrying in a verbal form will lead to more threat interpretations of ambiguous events than worrying in images; (4) A restriction in working memory capacity will mediate the relationship between worry and interpretation biases.

Method

Participants

Participants were recruited through online and print advertisements and from a database of participants who had previously participated in worry-related studies and had agreed to be contacted. Interested individuals were initially screened over the phone. They were asked questions to assess the presence of pathological worry and GAD symptoms, and completed the *Mini International Neuropsychiatric Interview* screen (MINI; Sheehan et al., 1998) and the *Penn State Worry Questionnaire* (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990). Inclusion criteria included (1) the presence of excessive and uncontrollable worry; (2) endorsement of at least 3 of 6 Criterion C GAD symptoms as defined in DSM-5 (APA, 2013); (3) stable medication dosage (if taking medication) for at least 6 weeks prior to study entry; (4) no diagnosis of another primary psychological disorder; (5) a PSWQ score of 62 or above (Behar, Alcaine, Zuellig, & Borkovec, 2003). Previous research in an undifferentiated sample compared the PSWQ to the *Generalized Anxiety Disorder Questionnaire-IV* (GAD-Q-IV; Newman et al., 2002), an established self-report measure of GAD symptoms, and found a cutoff score of 62 showed high specificity (.86) in identifying cases of GAD (Behar et al., 2003). A cutoff score of 45 has been shown to have sufficient sensitivity and specificity identifying cases of GAD when a sample of individuals high in worry is recruited (Behar et al., 2003). Given this consideration, participants who reported excessive worry and endorsed symptoms consistent with GAD but did not meet the more conservative cutoff score of 62 were still invited to participate at the assessor's (KT) discretion, based on clinical judgment and consultation with the primary thesis supervisor. PSWQ scores reported during the phone screen ranged from 59 to 79 with the majority (95.1%) of participants scoring above 62. Participants were excluded if they endorsed symptoms consistent with a “primary” diagnosis of a disorder other than GAD. Comorbid disorders were considered primary if participants reported that the symptoms associated with them were more concerning/distressing than their GAD symptoms, if symptoms of the comorbid disorder preceded GAD symptoms, and/or if symptoms of the comorbid disorder occurred more frequently than GAD symptoms.

A total of 144 participants were screened over the phone; 49 were found to be eligible and were invited to participate. Of the 95 not eligible, 49 did not endorse excessive and uncontrollable worry as assessed by GAD criteria or the PSWQ, 19 endorsed symptoms consistent with a primary diagnosis of major depressive disorder, 18 endorsed symptoms consistent with a primary diagnosis of social anxiety disorder, seven endorsed symptoms consistent with another primary disorder (e.g., OCD), one was excluded for poor English proficiency, and one did not finish the phone screen. Of the 49 invited, 42 people participated in the study and were randomized to either the imagery training (n = 21) or verbal training condition (n = 21). Data screening (see below) eliminated 6 participants from analyses due to incomplete data or poor compliance to instructions, resulting in a final sample of 36 participants, 18 in each condition.

Demographic characteristics of the final sample. Participants in the final sample ranged in age from 18 to 59 years (M = 33.63 years, SD = 13.30), including nine males and 27 females. Participants reported their ethnocultural background as European origin/White 52.7%, Asian-American/Asian Origin/Pacific Islander 22.3%, Latino-a/Hispanic 5.6%, or “Other” 19.4% (i.e., ethnocultural background not specified). Forty-four percent reported being currently enrolled in a school program (19.4% full-time, 25% part-time), and 58.3% reported currently being employed (33.3% full-time, 25% part-time).

Of the 36 participants included in the analyses, 32 (88.9%) met criteria for a diagnosis of GAD based on the MINI (Sheehan et al., 1998). GAD-Q-IV scores ranged from 3.67 to 12.5 with 33 (91.7%) scoring above the GAD-Q-IV cutoff score for GAD of 5.7 (Newman et al., 2002). PSWQ scores reported during the study ranged from 51 to 80 with 29 (80.6%) scoring above the PSWQ cutoff score of 62 and all 36 participants scoring above the PSWQ cutoff score of 45 (Behar et al., 2003). Additionally, 21 (58.3%) participants reported symptoms consistent with one or more comorbid diagnoses as assessed by the MINI; 12 met criteria for a current major depressive episode, 12 for another anxiety disorder, and five for another comorbid disorder.

Participants in the imagery and verbal training conditions did not differ on age, $t(34) = .41$, $p = .69$, or demographic and clinical characteristics (see Table 1).

Table 1

Sample Characteristics Separted by Condition

	Imagery (*n* = 18)	Verbal (*n* = 18)	χ2	*df*	*p*
Sex – Frequency (%)			3.70	1	.054
Male	7(38.9%)	2(11.1%)			
Female	11(61.1%)	16(88.9%)			
Ethnocultural Background – Frequency (%)			0.27	5	.99
European origin/white	9(50%)	10(55.5%)			
Asian-American/Asian Origin/Pacific Islander	4(22.2%)	4(22.2%)			
Latino-a/Hispanic	1(5.6%)	1(5.6%)			
Other	4(22.2%)	3(16.7%)			
School Status – Frequency (%)			0.450	1	.50
Full time	3(16.7%)[a]	4(22.2%)[a]			
Part-time	4(22.2%)[a]	5(27.8%)[a]			
Employment Status – Frequency (%)			1.03	1	.31
Unemployed	6(33.3%)	9(50.0%)			
Employed – full time	6(33.3%)	6(33.3%)			
Employed – part-time	6(33.3%)	3(16.7%)			
DSM-IV Diagnoses – Frequency (%)					
GAD	16(88.9%)	16(88.9%)	-	-	-
Comorbid Mood Disorder	6(33.3%)	6(33.3%)	-	-	-
Comorbid Anxiety Disorder	5(27.8%)	7(38.9%)	0.50	1	.48
Other Comorbid Disorder	3(16.7%)	2(11.1%)	.23	1	.63

Note. [a] item was only applicable to participants currently enrolled in a school program (*n* = 16, 7 in imagery condition, 9 in verbal condition).

Materials

The *MINI Screen (*Sheehan et al., 1998) is a preliminary screen for the Mini International Neuropsychiatric Interview (MINI; see below). Screening questions that are endorsed during the MINI Screen indicate that the interviewer should administer the corresponding module in the MINI Interview.

The *Mini International Neuropsychiatric Interview* (MINI; Sheehan et al., 1998) is a brief structured diagnostic interview used to assess DSM IV TR Axis I disorders. Test-retest reliability for GAD in the MINI is high (k = .78). Additionally, the interview has high diagnostic specificity (86%) and high sensitivity (91%) for identifying cases of GAD (Sheehan et al., 1997). The MINI has high rates of agreement with the *Structured Clinical Interview for the DSM-IV* (k = .70; Sheehan et al., 1997) and was used in this study as it is much briefer than the latter. The DSM-IV interview was used as the DSM-5 version was not published at the time the study was conducted. Criteria for GAD were mostly unchanged from DSM-IV to DSM-5 so this interview provided a close approximation to the most current definition of GAD. The DSM-IV criteria for GAD specified that the disorder cannot occur exclusively during the course of posttraumatic stress disorder, a mood disorder, a psychotic disorder, or a pervasive developmental disorder (APA, 2001). This exclusion was removed from DSM-5 criteria for GAD (APA, 2013).

The following measures were used for hypothesis testing.

The *Penn State Worry Questionnaire* (PSWQ; Meyer et al., 1990) contains 16 items that assess the tendency to engage in excessive and uncontrollable worry. The questionnaire has been shown to be reliable and valid in clinical and nonclinical populations (Brown, Antony, & Barlow, 1992; Davey, 1993; Meyer et al., 1990). The PSWQ has very high internal consistency in clinical populations (α = .88 to .95; Molina & Borkovec, 1994). A cutoff score of 62 for inclusion has shown good specificity for detecting individuals with GAD in an unspecified sample (Behar et al., 2003). A cutoff score of 45 has shown good specificity and sensitivity in a sample of advertised-for individuals with high worry (as was used in the present study; Behar et al., 2003)

The *Generalized Anxiety Disorder Questionnaire-IV* (GAD-Q-IV; Newman et al., 2002) is a 9-item self-report measure that assesses the DSM-IV diagnostic criteria for GAD. As diagnostic criteria for GAD changed only minimally from DSM-IV to DSM-5, tools assessing DSM-IV criteria for GAD should be able to provide an accurate measure of GAD as currently conceptualized. Total scores range from 0 to 13. A cut score of 5.7 represents 89% specificity and 83% sensitivity for differentiating between individuals with GAD and individuals who do not have GAD. The GAD-Q-IV has 88% agreement with the Anxiety Disorders Interview Schedule on classifying individuals with GAD. The GAD-Q-IV has good test retest reliability (Newman et al., 2002), high convergent validity with other measures of GAD features, and discriminant validity with measures of depression (Robinson, Klenck & Norton, 2010).

The *Negative Problem Orientation Questionnaire* (NPOQ; Gosselin, Pelletier, & Ladouceur, 2001; Robichaud & Dugas, 2005a) contains 12 items that measure the tendency to view problems as a threat, doubt one's own problem solving ability, and to be pessimistic about the outcome of a problem. The NPOQ has high internal consistency ($\alpha = .91$), good test-retest reliability, good construct validity, and specificity to worry (Robichaud & Dugas, 2005a, 2005b).

The *Intolerance of Uncertainty Scale* (IUS; Buhr & Dugas, 2002; Sexton & Dugas, 2009) is a 27-item self-report measure that assesses negative beliefs about uncertainty. Scores on the IUS reflect the general tendency or predisposition to see uncertainty as unacceptable (Buhr & Dugas, 2002). The IUS has demonstrated high internal consistency, good test-retest reliability, as well as convergent and discriminant validity with measures of worry, depression, and anxiety (Buhr & Dugas, 2002).

The *Difficulties in Emotion Regulation Scale* (DERS; Gratz & Roemer, 2004) is a 36-item scale assessing various dimensions of emotion regulation. It consists of 6 subfactors: lack of awareness of emotional responses, lack of clarity of emotional responses, nonacceptance of emotional responses, limited access to emotion regulation strategies perceived as effective, difficulties controlling impulses when experiencing negative emotions, and difficulties engaging in goal-directed behaviours when experiencing negative emotions. It has been shown to have high internal consistency, good test retest reliability, and good predictive validity (Gratz & Roemer, 2004).

The *Attentional Control Scale* (ACS; Derryberry & Reed, 2002) is a 20-item self-report scale measuring individual differences in voluntary attentional control. It is composed of three correlated subfactors: ability to focus attention, ability to shift attention between tasks, and ability to flexibly control thought (Derryberry & Reed, 2002). It has good internal reliability ($\alpha = .88$) (Derryberry & Reed, 2002).

The *Cognitive Avoidance Questionnaire* (CAQ; Sexton & Dugas, 2008) is a 25-item self-report measure that assesses the tendency to use cognitive avoidance strategies to manage intrusive or uncomfortable thoughts. It contains five subscales: thought suppression, thought substitution, distraction, avoidance of threatening stimuli, and the transformation of images into thoughts. It has been shown to have good internal consistency and temporal stability as well as good convergent and divergent validity (Sexton & Dugas, 2008).

The *Metacognitions Questionnaire Short Form* (MCQ-30; Wells & Cartwright-Hatton, 2004) is a 30-item self-report measure of individual differences in metacognitive beliefs, judgments, and monitoring tendencies. It is composed of five factors: cognitive confidence, positive beliefs about worry, cognitive self-consciousness, negative beliefs about the uncontrollability of thoughts and danger, and beliefs about need to control thoughts. It has been shown to have good internal consistency, convergent validity, and test-retest reliability (Wells & Cartwright-Hatton, 2004).

The hypotheses for the present study posit that in individuals with GAD, induced worry will lead to restricted working memory capacity. There is evidence that state anxiety (Eysenck et al., 2007) and depressive symptoms (Gohier et al., 2009; Rose & Ebmeier, 2006) can also affect working memory. Given this, the following measures were included to examine state anxiety and depressive symptoms as potential covariates.

The *State-Trait Inventory for Cognitive and Somatic Anxiety* (STICSA; Ree, French, MacLeod, & Locke, 2008) is a 21-item measure that assesses cognitive and somatic symptoms of anxiety, either in reference to one's mood at the moment (state) or in general (trait). Both the state and trait versions were administered in the present study. The STICSA has good reliability, high internal consistency and good construct, convergent, and discriminant validity (Grös, Antony, Simms, & McCabe, 2007; Ree et al., 2008).

The *Center for Epidemiological Studies—Depression Scale* (CES-D; Radloff, 1977) is a 20-item questionnaire that measures depressive symptoms experienced in the previous 7 days. The measure is intended for use in nonclinical populations and is not for diagnostic purposes. The CES-D has been shown to have high internal consistency, good test-retest reliability, and good construct validity (Radloff, 1977).

Visual Analogue Scales (VAS) were used to measure participants' state mood and anxiety, worry content ratings, and thought content ratings. VAS utilize a 100mm line with bipolar anchors (e.g., *not at all anxious* to *very anxious*) on which participants mark an "X" to in response to a question (e.g., "What is your current level of anxiety?"). These scales were used to minimize response biases on repeated-measures.

Tasks. The *Random Interval Generation Task* (RIG; Vandierendonck, De Vooght, & Van der Goten, 1998) is a test of working memory that involves participants pressing the space bar on a computer key board in a random, unpredictable rhythm, approximately once per second. Participants are encouraged to ask questions about task instructions and are provided feedback on a 15-second practice trial. They then engage in the task for 5 minutes. Intervals between key presses are recorded in milliseconds and are analyzed for randomness. More random responding indicates *greater* residual working memory capacity. See “Results” section for a description of task scoring. This task has been shown to load onto the executive control function of working memory while not interfering with the subsidiary storage systems (i.e., phonological loop and visuospatial sketchpad; Vandierendonck et al., 1998). Task performance on the RIG task has been shown to be impaired in dual-task paradigms involving other simultaneous central executive tasks and not during simultaneous span tasks involving the subsidiary storage systems (Vandierendonck et al., 1998). This supports the assertion that the RIG primarily draws on central executive resources.

The RIG task was selected for this study as it has been used in other studies of worry and working memory (Leigh & Hirsch, 2011). Additionally, previous studies have indicated that worry specifically affects executive control (Crowe et al., 2007) and this task allowed for the examination of this finding in the present study. This task was administered in two versions: single RIG and worry RIG. To assess baseline performance, participants completed a single RIG in which they generated random key presses for 5 minutes. In the worry RIG version, participants were instructed to press the key while simultaneously engaging in worry. Participants were randomized to worry in either a verbal or image-based form. Participants’ performance on the worry RIG may have been negatively affected by (1) worry or (2) dual-task cost. This limits the interpretations that can be made about worry’s effect on working memory capacity within individuals (i.e., whether the difference between a participant’s single RIG and worry RIG performance is in fact due to worry). However, the primary research question in the present investigation concerns between-groups differences in the effects verbal versus image-based worry during the worry RIG task. Because of this, the study design did not include a nonworry dual-task RIG condition. The single RIG task was included primarily to control for baseline differences in working memory capacity. It was predicted that working memory capacity would be more restricted during the worry RIG than the single RIG, regardless of condition, because of the dual-task cost of worrying and performing the RIG task. It was predicted that the restriction in working memory would be greater in the verbal condition, compared to the imagery condition, because of the greater cognitive load associated with verbal mentation.

The *Corsi Block Task* (Corsi, 1972) is a computerized task of visuospatial working memory. On the screen participants see nine, two-dimensional grey squares of equal size displayed against a white background. The nine squares represent spatial target locations. In the task, some of the squares (ranged from 4-7) sequentially change colour to black temporarily for 1500ms each to identify a pattern. Over the course of testing, target sequences are presented and following each, participants are asked to remember and reproduce the target sequence by clicking the squares with their mouse in the same order in which they changed colour. Participants are presented with written task instructions and then given a practice trial with a 2-target location pattern. At the beginning of each trial, participants are asked to fixate on the screen where the 9 squares are presented for 1200ms. The target sequence is presented and immediately after presentation, participants are instructed to reproduce the sequence. Participants are presented with patterns of varying lengths, beginning with a sequence of 4 target locations and building up to 7. The sequences are taken from the spatial span task of the *Wechsler Memory Scale – Third Edition* (Wechsler, 1997). Three trials of each length are presented for a total of 12 trials. An index of visuospatial memory span is created based on the percent of trials in which the participant correctly recalled the sequence. Scores range from 0 to 1, with higher scores indicating greater accuracy in responding and greater working memory capacity. This task was included to assess whether self-reported worry and GAD symptomatology differentially related to the central executive, measured by the RIG task, and visuospatial components of working memory, as assessed by the Corsi Block task. Based on past research (Crowe et al., 2007) it was anticipated that trait worry would be more strongly related to central executive performance. The Corsi Block task has been shown to also utilize central executive resources (Vandierendonck, Kemps, Fastame, & Szmalec, 2004) so a complete dissociation between this task and the RIG task was not expected. In this way, the inclusion of the Corsi Block task additionally served to validate the RIG task as a working memory task.

The *Word Sentence Association Paradigm for GAD* (WSAP for GAD; Koerner, Dugas, Gosselin, & Langlois, 2013; Ogniewicz, Dugas, Langlois, Gosselin, & Koerner, in press) is a task designed to assess interpretation biases in GAD, specifically, the tendency to accept or reject threat and benign interpretations. This task was adapted from a word sentence association paradigm created to assess interpretation bias in social anxiety disorder (Beard & Amir, 2009). In the task, participants are presented with 120 word-sentence pairs, half of which include threat words, and half benign words. The word-sentence pairs reflect 10 worry domains common to GAD: health of self, health of others, physical harm to self, physical harm to others, social relationships, family relationships, romantic relationships, finances, academic performance, and work competence themes (Davey, Hampton, Farrell, & Davidson, 1992; Dugas, Freeston, Doucet, Lachance, & Ladouceur, 1995; Dugas, Freeston, Ladouceur, Rhéaume, & Provencher, 1998). Word-sentence pairs are presented in different random order across administrations to control for order effects. The WSAP task is run on E-Prime 2.0 Professional version (Psychology Software Tools, Inc., 2007). During the task, each trial begins with a fixation cross at the center of the screen for 500 milliseconds (ms) followed by a cue word appearing for 500ms that is either threatening (e.g., “blood”) or benign (e.g., “ketchup”). The cue word is then replaced with an ambiguous sentence (e.g., “your shirt has red stains all over it”). Participants are asked to indicate through key press as quickly and accurately as possible whether the word and sentence are related or unrelated. Responses are scored to provide indices of the percentage of threat interpretations accepted and percentage of benign interpretations rejected. Additionally, reaction times for decision key presses (“related” or “unrelated”) are recorded in milliseconds.

Procedure

The MINI Screen and the *Penn State Worry Questionnaire* were administered over the phone to assess eligibility. Eligible participants were invited to the lab for one testing session.

See Figure 2 for a diagram of experimental procedures. Participants were first taken through an informed consent procedure. They indicated their current mood and anxiety levels using a visual analogue scale (VAS). They rated mood on a scale ranging from 0 (*negative*) to 100 (*positive*), and anxiety on a scale from 0 (*not at all*) to 100 (*very anxious*). A MINI was conducted to confirm a diagnosis of GAD and to assess the presence of other psychological disorders. Participants who did not endorse symptoms consistent with a diagnosis of GAD (n = 4) or who reported symptoms consistent with a comorbid or secondary diagnosis of another psychological disorder (n = 21) during the MINI assessment completed the remainder of the study and were retained in analyses if their PSWQ fell within ±1.96 z-scores of the sample mean. The PSWQ scores for all of these participants met this criterion and the participants were retained for analyses. This approach was taken as the study's research questions concern the effects of pathological worry, rather than GAD per se, on working memory capacity. Worry is considered a dimensional trait that varies in quantity, not quality, in individuals with GAD and those without (Ruscio, Borkovec & Ruscio, 2001). Therefore participants with high worry who did not meet criteria for GAD or who met criteria for another diagnosis, still had relevancy for addressing the research questions. Additionally, GAD is frequently comorbid with other psychiatric disorders (Stein, 2001). The inclusion of participants with comorbid diagnoses contributes the ecological validity of the present sample.

Participants completed the PSWQ, GAD-Q-IV, NPOQ, IUS, DERS, ACS, CAQ, MCQ-30, STICSA-S, STICSA-T, and CESD. They again indicated their mood and anxiety levels using a VAS. Participants completed the single RIG, the Word Sentence Association Paradigm task, and the Corsi Block test. Participants were given a 10-minute break intended to allow them to recover from any taxing effects of completing these questionnaires and tasks. Following this break, participants once again rated their mood and anxiety. Participants identified a current worry topic. They rated the content of their worry based on how concerning, personally relevant, and distressing it was using three 100mm VAS ranging from *not at all* to *totally* (Leigh & Hirsch, 2011).

Mentation Style Training. Participants were randomized to one of two mentation training conditions: verbal (n = 18 in the final sample) or imagery (n =18 in the final sample). To train verbal thinking, participants were asked to think "in words, sentences, and questions, as though you are talking to yourself" (Leigh & Hirsch, 2011). They were then instructed to think, in words and sentences, about cutting a lemon. Finally, they practiced by thinking in verbal form about "friendship" for 1 minute. To engage in imagery, participants were asked to: "generate an image of the situation and tune into what you can see, feel, smell, hear and taste in the image as though you are actually there right now" (Leigh & Hirsch, 2011; Stokes & Hirsch, 2010). Participants were then asked to imagine cutting a lemon. They further practiced imagery by imagining cooking dinner for 1 minute. All participants were asked to report on their ability to engage in imagery or verbal mentation on a VAS ranging from *not at all* to *totally* after each scenario and were given additional feedback or instructions if necessary (Leigh & Hirsch, 2011).

Worry Induction and Worry Test Phase. In keeping with procedures outlined by Leigh and Hirsch (2011), participants were instructed to worry in a verbal form or an imagery form according to the condition they were assigned to. Participants were reminded of the worry topic they identified and were asked to discuss it and to provide worry appraisal ratings. In worry appraisal ratings, participants rated the worst outcome of their worry topics on 100mm VAS indicating "How likely is this to happen?", "How catastrophic would it be?", and "How well do you think you would cope with it?", from *not at all* to *totally* (Leigh & Hirsch, 2011). They were then instructed to focus on the worse outcome of that worry in either a verbal or imagery form (in accordance with their assigned condition) for 5 minutes (*worry induction*). Following this they continued to worry in that form while completing the RIG task for 5 minutes (*worry test phase*). Participants then completed the WSAP while continuing to worry (worry test phase). They then retrospectively rated their mood prior to the RIG task and provided thought content ratings on VAS, indicating how well they felt they engaged in imagery/verbal thought during the worry induction (from *not at all* to *totally*) and what percentage of their thought content was in the trained form of mentation (from *0%* to *100%*). In line with previous research (e.g., McLaughlin, Borkovec, et al., 2007) it was expected that the worry induction would cause an increase in negative affect, reflected in higher anxiety ratings and lower mood ratings.

Finally, participants were debriefed and compensated $30.00 for their participation.

Results

Data Screening

All data were screened for outlier values falling outside a z-score of $\pm$ 3.33 (Tabachnick & Fidell, 2012). One extreme outlier was identified using this method and replaced with the next extreme value according to the method described by Tabachnick and Fidell (2007). Data were normally distributed with the exception of the CAQ, $D(31) = .179$, $p < .05$, and the GAD-Q-IV, $D(31) = .235$, $p < .01$. Data were not transformed. For each participant, missing data points on a questionnaire were replaced by his or her mean score for the other items on that questionnaire. Missing data were identified on the ACS (n = 1), CAQ (n = 1), and MCQ (n = 2). From the initial sample of 42 participants, 3 completed only baseline questionnaire measures and were excluded from analyses.

Of the 39 participants with complete data, 8 showed a response pattern in the WSAP task reflecting poor compliance to the task's instructions and were excluded from analyses involving this measure (see below). The final analyses of WSAP data included 31 participants, 13 in the imagery training condition, and 18 in the verbal training condition. Excluded participants were not significantly different from the rest of the sample on any baseline measures with the exception of reporting significantly fewer depressive symptoms on the CESD, $t(37) = -0.61$, $p < .05$.

Of the 39 participants with complete data, 3 had single RIG data that reflected poor compliance with task instructions and were excluded from analyses utilizing these scores. Excluded participants were not significantly different from the rest of the sample on any baseline measures. With the exception of analyses involving WSAP scores, the results below are reported for 36 participants, 18 in each condition, with complete data and good compliance to baseline single RIG instructions. Only one participant had both poor RIG and poor WSAP data and was excluded from all analyses.

Independent samples t-tests were performed to compare the verbal and imagery training conditions on self-reported GAD symptoms and trait worry, depression symptoms, GAD-related processes, working memory performance on the single RIG and Corsi Block tasks, baseline interpretation bias, and baseline state mood and anxiety. No significant differences were found between training conditions on these measures (See Table 2).

Table 2

Baseline Differences on Measures in the Full Sample and Separated by Condition

	Full Sample (*N* = 36)		Imagery Training (*n* = 18)		Verbal Training (*n* = 18)					
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	*d*
PSWQ	67.44	8.00	67.28	9.07	67.61	6.96	-0.12	34	.90	0.04
GAD-Q-IV	10.14	2.19	10.02	1.75	10.27	2.61	-0.34	34	.74	0.11
CESD	24.86	10.91	25.00	12.06	24.72	9.98	0.08	34	.94	0.03
STICSA-S	40.72	11.60	43.61	11.71	37.83	11.05	1.52	34	.14	0.51
STICSA-T	46.30	10.50	45.61	10.60	46.94	10.64	-0.38	34	.71	0.13
NPOQ	36.02	11.10	35.11	11.12	36.94	11.31	-0.49	34	.63	0.16
IUS	86.69	24.61	81.06	28.17	92.33	19.63	-1.39	34	.17	0.47
DERS	96.94	19.87	95.83	15.75	98.06	23.70	-0.33	34	.74	0.11
ACS	47.67	7.21	48.78	6.36	46.56	8.00	0.92	34	.36	0.31
CAQ	67.58	15.91	69.56	20.25	65.61	10.16	0.74	34	.47	0.26
MCQ-30	72.97	11.56	75.28	12.56	70.67	10.29	1.21	34	.24	0.40

Working Memory										
Single RIG – R	37.10	18.47	36.35	16.40	37.85	20.80	-0.24	34	.81	0.08
Single RIG – RNG	.57	.19	.58	.16	.56	.22	0.18	34	.86	0.11
Corsi Block	.73	.16	.73	.18	.73	.16	0.09	34	.93	0.00
Interpretation Bias										
WSAP Benign Reject	.21	.17	.19	.19	.24	.15	-0.84	34	.41	0.29
WSAP Threat Accept	.64	.22	.68	.25	.60	.20	1.01	34	.32	0.36
State Mood and Anxiety VAS										
Mood	59.97	14.37	58.11	12.45	61.94	16.32	-0.78	33	.44	0.27
Anxiety	49.11	20.77	47.67	22.26	50.65	19.62	-0.42	33	.68	0.14

Note. PSWQ = Penn State Worry Questionnaire; GAD-Q-IV = Generalized Anxiety Disorder Questionnaire – IV; CES-D = Centre for Epidemiological Studies – Depression Scale; STICSA-S = State Trait Inventory for Cognitive and Somatic Anxiety – State; STICSA-T = State Trait Inventory for Cognitive and Somatic Anxiety – Trait; NPOQ = Negative Problem Orientation Questionnaire; IUS = Intolerance of Uncertainty Scale; DERS = Difficulty in Emotion Regulation Scale; ACS = Attentional Control Scale; CAQ = Cognitive Avoidance Questionnaire; MCQ-30 = Metacognitions Questionnaire Short Form; RIG-R = Random Interval Generation Task - Redundancy; RIG-RNG = Random Interval Generation Task – Random Number Generation; WSAP = Word Sentence Association Task; VAS = Visual Analogue Scale.

Analysis of RIG Data

Response time was recorded for every key press on the single RIG and worry RIG using E-prime software. Response times were converted to a chronological series of time intervals indicating the time between consecutive key presses. Data were scored for two measures of randomness: Redundancy (*R*; Attneave, 1959; Baddeley 1966) and Random Number Generation Score (*RNG*; Evans, 1978). These two scores are considered to be the most sensitive and have been used in prior research (Baddeley, Emslie, Kolodny, & Duncan, 1998; Leigh & Hirsch, 2011; Towse, 1998). Redundancy is a measure, ranging from 0% to 100% that represents the degree to which the same time intervals between key presses are made over the testing period (Attneave, 1959; Baddeley, 1966). For the RIG task, the time interval between key presses would be considered the "response". A score of 0% would indicate that all possible responses were selected with equal frequency (Towse & Neil, 1998). For example from the set "1, 2, 3, 4", "1, 2, 3, 4" were selected. A score of 100% would reflect complete redundancy in responding, that is, the same response was selected each time (Towse & Neil, 1998). For example, from the set "1, 2, 3, 4", "1, 1, 1, 1" were selected. Higher scores on R reflect less random performance and less available working memory capacity. Random Number Generation Score is a measure of how many times the same time interval between key presses occurs consecutively (Baddeley et al., 1998; Towse & Neil, 1998). Whereas R reflects the response *frequencies* RNG reflects also the *sequence* of responses by examining contiguous pairs of responses (Towse & Neil, 1998). Scores on RNG range from 0 to 1 where a score of 1 would reflect "complete predictability of pair sequences" (Towse & Neil, 1998). For example, "1, 1, 1, 1", where a "1" is always followed by a "1." A score of 0 would reflect equal occurrence of all possible pair sequences (Towse & Neil, 1998). Again, higher scores reflect less random performance and lower working memory capacity. These measures were calculated using RGCalc software (Towse & Neil, 1998). RGCalc analyzes discrete data sets so as per Leigh and Hirsch (2011), continuous data were recoded into 20 interval bins each reflecting 200ms spans (i.e., 0 - 200ms recoded into “1,” 201 - 400ms recoded into “2,” etc.). The final bin reflected any time intervals of 3801ms or greater. These recoded data were then entered into RGCalc.

Single RIG scores were compared to scores on the Corsi Block task in order to confirm the conceptual validity of the RIG task as a working memory task. The RIG and Corsi Block task rely on different components of working memory, central executive and visuospatial respectively. There is evidence however that during higher span trials, the Corsi Block task also draws on central executive resources (Vandierendonck et al., 2004). In fact, concurrent administration of a RIG task while performing the Corsi Block Task impairs Corsi Block performance (Vandierendonck et al., 2004). Therefore Corsi Block and RIG performance were expected to be moderately correlated. Pearson correlations were calculated for single RIG scores (R and RNG) and Corsi Block scores. As expected Corsi Block scores were negatively correlated with R scores ($r = -.33$, $p < .05$) and RNG scores ($r = -.27$, $p = .12$) but only reached significance for R scores. R and RNG scores were highly inter-correlated ($r = .97$, $p < .01$).

Analysis of WSAP Data

WSAP data were scored for two measures of a threat interpretation bias: 1) the tendency to reject benign interpretations of ambiguous sentences, that is, to judge the benign/ambiguous word-sentence pair as unrelated (“benign reject”), and 2) the tendency to accept threat interpretations of ambiguous sentences, or judging threatening/ambiguous word sentence pairs as related (“threat accept”). Benign reject and threat accept scores range from 0 to 1, reflecting the proportion of trials a participant rejected/accepted a benign/threat interpretation respectively.

Higher scores on threat accept reflect a *greater* threat interpretation bias and higher scores on benign reject represent a *lower* benign interpretation. Prior research using a WSAP in individuals high in social anxiety reported that these two indices (threat accept and benign reject) were not highly correlated (Beard & Amir, 2009), suggesting that they reflect different facets of interpretation bias. The response pattern in a subset of participants (n = 8) reflected poor compliance to task instructions. These participants responded with a "1" key press in response to the stimulus sentence for more than 90% of trials during baseline administration and during worry test phase administration. Their responses were not considered to be a valid indication of their interpretation bias and were thus excluded from analyses. After these participants were removed, mean threat accept and benign reject scores were comparable to previously reported means for an analogue GAD sample (Ogniewicz et al., in press).

Hypothesis 1: Baseline Associations of Self-Reported GAD and Related Symptoms and Processes to Working Memory Capacity

Sample means were examined and compared to means reported for similar samples. A prior study utilizing the RIG task in a sample of individuals high in worry reported notably lower means for single RIG performance (R; M = 26.53, SD = 10.45, RNG; M = .47, SD = .13, Leigh & Hirsch, 2011) than in the present study (R; M = 37.10, SD = 18.47, RNG; M = .57, SD = .19). This suggests that the present sample had more restricted working memory capacity at baseline than was observed in another sample of high worriers. Self-reported worry on the PSWQ was also lower in the prior study (M = 63.46, SD = 5.18; Leigh & Hirsch, 2011) than in the present one (M = 67.44, SD = 7.97), suggesting that the present sample had more severe GAD symptomatology. Furthermore, mean self-reported trait worry as measured by the PSWQ was slightly higher in the present sample (M = 67.44, SD = 8.00) than pretreatment means reported in clinical trials for GAD (Dugas et al., 2003 [*M* = 62.56, *SD* = 9.50]; Evans et al., 2008 [*M* = 60.82, *SD* = 11.0]; Ladouceur, Dugas, Freeston, Léger, & Thibodeau, 2000 [*M* = 65.86, *SD* = 8.96]). Mean Corsi Block percent accuracy scores in the present sample (*M* = 73, *SD* = 16) were comparable to those previously reported in samples of young adults completing a touch screen version of a computerized Corsi Block task (Rowe, Hasher, & Turcotte, 2008 [*M* = 71, *SD* = 16]; Rowe, Hasher, & Turcotte, 2009 [*M* = 68, *SD* = 16]). Mean self-reported attentional control (ACS) in the present sample (*M* = 47.67) was comparable to what has been previously reported for a high trait anxious group labeled as having "low attentional control" (*M* = 46.6; Derryberry & Reed, 2002). Due to differences in sample characteristics, no definitive conclusions can be made from these comparisons, however this suggests, tentatively, that the present sample was characterized by low baseline attentional control.

Pearson correlations were performed between measures of GAD and related symptoms and processes, age, and baseline (i.e., pre experimental manipulation) working memory capacity indices (See Table 3). At baseline, lower working memory capacity as indicated by higher single RIG R scores was significantly correlated with lower self-reported attentional control (ACS), higher intolerance of uncertainty (IUS), a negative problem orientation (NPOQ), and greater emotion regulation difficulties (DERS), specifically the DERS subscales "Nonacceptance of emotional responses" (r = .40, p <.05) and "Limited access to emotion regulations strategies perceived as effective" (r = .40 , p < .05). Lower working memory capacity as indicated by higher single RNG scores was associated with elevated scores on the IUS and the DERS. Poorer visuospatial working memory performance at baseline as measured by the Corsi Block task was significantly correlated with higher scores on the IUS, greater self-reported use of thought suppression strategies (CAQ), and greater state anxiety (STICSA-S and VAS). However, self-reported trait worry (PSWQ), GAD symptoms (GAD-Q-IV), depressive symptoms (CESD), trait anxiety (STICSA-T) and metacognitive beliefs (MCQ-30) were not significantly related to measures of working memory at baseline.

Pearson correlations between interpretation bias and indices of working memory capacity were also performed. Interpretation bias, as indicated by benign reject or threat accept scores, was not correlated with single RIG R, single RIG RNG, or Corsi Block accuracy.

Pearson correlations were performed between age and indices of working memory. Age was significantly correlated with Corsi Block accuracy but not with R or RNG. This raises some concern with the validity of the RIG task, which, as a central executive measure, should be correlated with age. However, RIG scores significantly correlated in the expected direction with self-reported attentional control and the Corsi Block task, which provides evidence for its convergent validity as a central executive measure.

Due to the significant correlation between Corsi Block accuracy and age, significant Corsi Block correlations were re-examined by performing partial correlations controlling for age. Correlations between Corsi Block accuracy and thought suppression ($r = -.45$, $p < .05$), intolerance of uncertainty ($r = -.40$, $p < .05$), and state anxiety as measured by the STICSA-S ($r = -.55$, $p < .01$), remained significant. Corsi Block accuracy was no longer significantly correlated with state anxiety as measured by the VAS ($r = -.23$, $p = .20$) when age was controlled for.

Next, Pearson correlations were computed to test the hypothesis that a worry-related change in working memory capacity (difference between single RIG and worry RIG R/RNG scores) would be related to higher levels of trait worry, GAD symptoms, negative problem orientation, greater intolerance of uncertainty, poor emotion regulation, worse attentional control, greater cognitive avoidance, greater metacognitive effort to control negative thoughts, and a threat interpretation bias. Contrary to prediction, paired-sample t-tests failed to show any significant change in R and RNG from the single RIG to the worry RIG, R; $t(35) = -1.61$, $p = .12$, $d = 0.15$, RNG; $t(35) = -.34$, $p = .73$, $d = 0.05$. Change in working memory performance was not correlated with baseline measures of GAD and related symptoms and processes.

Table 3

Zero-order Correlations Between Baseline Working Memory Capacity Indices and Measures of GAD and Related Symptoms and Processes

Measure	RIG-R		RIG-RNG		Corsi Block	
	r	*p*	*r*	*p*	*r*	*p*
PSWQ	.10	.56	.02	.93	.09	.59
GAD-Q-IV	.20	.23	.14	.41	-.27	.12
CESD	.29	.09	.28	.10	-.05	.78
STICSA-S	.26	.12	.21	.21	-.34	.04*
STICSA-T	.24	.16	.15	.40	-.19	.26
NPOQ	.40	.02*	.30	.08	-.17	.32
IUS	.46	.005**	.34	.046*	-.39	.02*
DERS	.49	.002**	.40	.02*	-.23	.18
ACS	-.34	.04*	-.31	.06	-.03	.88
CAQ Total Score	.19	.26	.18	.28	-.32	.06
CAQ Thought Suppression					-.44	.007**
MCQ-30	.16	.35	.15	.37	.04	.83
Interpretation Bias						
WSAP Threat Accept	.20	.24	.17	.30	.03	.85
WSAP Benign Reject	-.12	.49	-.11	.54	-.20	.25
VAS Anxiety	.16	.62	-.23	.61	-.37	.045*
Age	.02	.90	-.03	.88	-.54	.001**

Note. PSWQ = Penn State Worry Questionnaire; GAD-Q-IV = Generalized Anxiety Disorder Questionnaire – IV; CES-D = Centre for Epidemiological Studies – Depression Scale; STICSA-S = State Trait Inventory for Cognitive and Somatic Anxiety – State; STICSA-T = State Trait Inventory for Cognitive and Somatic Anxiety – Trait; NPOQ = Negative Problem Orientation Questionnaire; IUS = Intolerance of Uncertainty Scale; DERS = Difficulty in Emotion Regulation Scale; ACS = Attentional Control Scale; CAQ = Cognitive Avoidance Questionnaire; MCQ-30 = Metacognitions Questionnaire Short Form; VAS Anxiety = Visual Analogue Scale State Anxiety Rating.

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

Hypotheses 2 and 3: Impact of Induced Worry on Working Memory Capacity and Interpretation Bias

Pretraining worry content ratings. Independent samples *t*-tests were conducted to ensure there were no significant differences in worry content ratings between training conditions prior to the experimental inductions. Participants in the imagery and verbal training conditions did not significantly differ in their ratings of how concerning, $t(34) = 0.44$, $p = .42$, $d = 0.15$, personally relevant, $t(34) = -1.10$, $p = .12$, $d = 0.40$, or distressing, $t(34) = 0.88$, $p = .19$, $d = 0.29$, they perceived their worries to be.

Mentation training check. Participants reported their ability to engage in the trained form of mentation from 0 (*not at all*) to 100 (*totally*) after the first training scenario ($M = 81.56$, $SD = 14.20$), second training scenario ($M = 80.43$, $SD = 15.57$), and during the worry induction ($M = 69.56$, $SD = 19.48$). The mean scores suggest that participants were successful at engaging in their trained form of mentation during training and while worrying. Independent samples *t*-tests were used to ensure that participants in both conditions did not significantly differ in their ability to engage in verbal and image-based worry by comparing thought content ratings. There were no significant differences between conditions on participants' reported success in engaging in the trained form of mentation during the first training scenario, $t(34) = 0.32$, $p = .75$, $d = 0.11$, second training scenario, $t(34) = 0.43$, $p =.67$, $d = 0.15$, or during the worry induction, $t(34) = -0.37$, $p = .71$, $d = 0.13$.

Mood comparison. Mixed 2 x 3 analysis of variance (ANOVA) tests were performed to assess the effects of Condition (verbal vs. imagery), and Time (baseline, pre, and postworry induction) on state mood and anxiety ratings. For all ANOVA analyses, posthoc analyses were performed to follow up on all main and interaction effects. This was done to allow for the identification of mean difference effects that might not be reflected in main effects or interaction effects due to the small sample size, and to examine effect sizes. See Hancock and Klockar (1996) for a review of the rationale for following up on nonsignificant omnibus tests. Statistical significance was set at $p < .05$ and a Bonferroni correction was applied to all posthoc tests. It was predicted that within the undifferentiated sample, the worry induction would lead to significantly higher anxiety and lower (or more negative) mood. No a priori hypotheses were made regarding the effects of condition on mood and anxiety ratings.

There was a significant effect of Time on anxiety ratings, $F(2) = 10.33$, $p < .001$, partial $\eta^2 = .24$ There was no main effect of Condition, $F(1) = 0.18$, $p = .68$, partial $\eta^2 = .005$, or Condition x Time interaction, $F(2) = 0.85$, $p = .42$, partial $\eta^2 = .03$, on anxiety ratings (see Table 4 for anxiety ratings by condition). Posthoc analyses showed that anxiety ratings significantly *decreased* from baseline ($M = 49.11$, $SD = 20.77$) to preworry induction ($M = 37.51$, $SD = 20.15$), $p < .01$, $d = 0.57$, and significantly *increased* from pre to postworry induction ($M = 54.14$, $SD = 22.71$), $p < .001$, $d = 0.78$. There were no significant between-groups differences in anxiety ratings at any time point. Effect sizes for between group differences were small, ranging from $d = 0.14$ to $d = 0.33$.

There was a significant effect of Time on mood ratings, $F(2) = 8.39$, $p < .01$, partial $\eta^2 = .20$. There was no main effect of Condition, $F(1) = 0.85$, $p = .37$, partial $\eta^2 = .03$, or Condition x Time interaction, $F(2) = 0.39$, $p = .68$, partial $\eta^2 = .01$. Posthoc analyses showed that mood ratings significantly decreased from baseline ($M = 59.97$, $SD = 14.37$), to postworry induction ($M = 44.20$, $SD = 23.36$), $p < .01$, $d = 0.84$, but not from preworry induction ($M = 53.46$, $SD = 21.15$) to postworry induction, $p = .08$, $d = 0.42$. There were no between-groups differences in mood ratings at any time point and effect sizes for between-groups differences were small, ranging from *d* = 0.08 to *d* = 0.40.

These findings indicate that as predicted, in the whole sample, anxiety increased following the worry induction. Mood decreased (from more positively valanced to more negatively valanced) significantly over the course of the experiment, but there was no significant drop from pre to postworry induction. Therefore this decrease in mood cannot necessarily be attributed to the worry induction. There were no significant main effects of Condition on mood or anxiety ratings.

While anxiety ratings did significantly increase following the worry induction, mean anxiety ratings showed only moderate levels of anxiety, not approaching the maximum score of 100 (Imagery; *M* = 55.94, *SD* = 22.43, Verbal; *M* = 50.78, *SD* = 23.66). Given this, it is hard to determine whether the worry induction was successful at activating anxiety in participants. A previous study using the same induction procedures in a high-worry sample reported comparable means for state anxiety ratings postworry induction (Imagery; *M* = 48.63, *SD* = 26.69, Verbal; *M* = 53.33, *SD* = 28.21, Leigh & Hirsch, 2011). The same study also reported that despite moderate anxiety ratings participants had a high percentage of negative thought content during a worry induction (Imagery; *M* = 71.96, *SD* = 19.38, Verbal; *M* = 69.33, *SD* = 17.90, Leigh & Hirsch, 2011). Another study using a sample of individuals high in self-reported worry also showed only moderate levels of state anxiety following a 5-minute worry induction (*M* = 35.15, *SD* = 5.59; Hayes et al., 2008). Both of these studies found that induced worry had a significant effect on working memory capacity that was independent of state anxiety ratings (Hayes et al., 2008; Leigh & Hirsch, 2011). These findings suggest that state anxiety ratings cannot be expected to reach extreme levels during a worry induction and that these ratings may not be a good indication of the potency of a worry induction.

Table 4

State Mood and Anxiety Ratings at Baseline, Pretraining, and Postworry Induction Separated by Condition

Measure	Imagery	Verbal
State Mood Rating – *M(SD)*		
Baseline	58.11(12.45)	61.94(16.32)
Pretraining	49.33(21.42)	58.83(20.41)
Postworry Induction	43.33(23.05)	47.06(25.01)
State Anxiety Rating – *M(SD)*		
Baseline	47.67(22.26)	50.65(19.62)
Pretraining	40.72(21.56)	33.06(18.55)
Postworry Induction	55.94(22.43)	50.78(23.66)

To test the hypothesis that the verbal training condition would lead to a significantly greater restriction in working memory compared to the imagery training condition, two 2 (Condition) by 2 (Time) mixed ANOVAs were carried out with R and RNG scores as the dependent variables. There were no significant main effects of Condition, R; $F(1) = 0.08$, $p = .93$, partial $\eta^2 = .0002$, RNG; $F(1) = 0.17$, $p = .68$, partial $\eta^2 = .01$, Time, R; $F(1) = 2.54$, $p = .12$, partial $\eta^2 = .07$, RNG; $F(1) = 0.12$, $p = .73$, partial $\eta^2 = .004$, or Condition x Time interaction effects, R; $F(1) = 0.30$, $p = .59$, partial $\eta^2 = .01$, RNG; $F(1) = 1.97$, $p = .17$, partial $\eta^2 = .06$, on working memory performance. Posthoc analyses were performed. See Table 5 for working memory scores across time points by condition. During the worry test phase, there were no significant differences in working memory performance between the verbal and imagery conditions, R; $p = .81$, $d = 0.02$, RNG; $p = .68$, $d = 0.29$. There was no significant change in performance in the verbal condition from baseline to worry test phase, R; $p = .47$, $d = .09$, RNG; $p = .22$, $d = 0.21$. There was no significant change in performance in the imagery condition from baseline to worry test phase, R; $p = .14$, $d = 0.22$, RNG; $p = .46$, $d = 0.15$.

To test the hypothesis that the verbal training condition would lead to significantly greater threat interpretation bias than the imagery training condition, two 2 (Condition) by 2 (Time) mixed ANOVAs were carried out using two measures of interpretation bias (threat accept and benign reject) as the dependent variables.

There were no significant main effects of Condition, $F(1) = 0.49$, $p = .49$, partial $\eta^2 = .02$ Time, $F(1) = 0.28$, $p = .60$, partial $\eta^2 = .01$, or Condition x Time interaction effects, $F(1) = 0.44$, $p = .51$, partial $\eta^2 = .02$, on threat accept scores. Posthoc analyses were performed. See Table 6 for mean threat accept and benign reject scores across time by condition. There were no significant differences in threat accept scores during the worry test phase between conditions, $p =$

.77, d = 0.08. There was no significant change in threat accept scores from baseline to worry test phase in the verbal condition, p = .37, d = 0.19, or in the imagery condition, p = .93, d = 0.02.

There were no significant main effects of Condition, $F(1) = 0.31$, $p = .58$, partial $\eta^2 = .01$, Time, $F(1) = 1.95$, $p = .17$, partial $\eta^2 = .06$, or Condition x Time interaction effects, $F(1) = 0.40$, $p = .53$, partial $\eta^2 = .01$, on benign reject scores. Posthoc analyses were performed. There were no significant differences in benign reject scores during the worry test phase between conditions, p = .85, d = 0.09. There was no significant change in benign reject scores from baseline to worry test phase in the verbal condition, p = .13, d = 0.37, or in the imagery condition, p = .62, d = 0.11.

Hypothesis 4: Working Memory Capacity as a Mediator of the Effect of Worry on Interpretations of Ambiguous Situations

Given that there were not changes in working memory capacity or in interpretation bias from baseline to postworry induction, the mediation hypothesis could not be tested.

Table 5

Mean and SD for R and RNG scores at Baseline and Worry Test Phase Separated by Condition

	R Scores		RNG Scores	
Time point – *M(SD)*	Imagery	Verbal	Imagery	Verbal
Baseline	36.35(16.40)	37.85(20.80)	.58(.16)	.56(.22)
Worry Test Phase	40.10(18.30)	39.67(18.68)	.55(.22)	.61(.21)

Table 6

Compared Means and SDs for R and RNG scores at Baseline and Worry Test Phase Separated by Condition in the Present Study and as reported in Leigh and Hirsch (2011)

	Present Study		Leigh & Hirsch, 2011	
	Imagery	Verbal	Imagery	Verbal
R Scores – *M(SD)*				
Baseline	36.35(16.40)	37.85 (20.80)	26.53(10.45)	
Worry Test Phase	40.10(18.30)	39.67(18.68)	29.15(15.27)	34.62(15.51)
RNG Scores – *M(SD)*				
Baseline	.62(.15)	.56(.22)	.47(.13)	
Worry Test Phase	.62(.19)	.60(.20)	.47(.18)	.53(.17)

Note. Data for Leigh and Hirsch (2011) reflect within group means and standard deviations reported by condition. Data are reported here only for the "High Worry" group in Leigh and Hirsch's (2011) investigation. For R and RNG scores, higher scores indicate a greater restriction in working memory.

Table 7

Mean and SD for Threat Accept and Benign Reject scores at Baseline and Worry Test Phase Separated by Condition

	Threat Accept		Benign Reject	
Time point – *M(SD)*	Imagery	Verbal	Imagery	Verbal
Baseline	.52(.20)	.60(.20)	.29(.21)	.24(.15)
Worry Test Phase	.53(.25)	.55(.26)	.32(.22)	.30(.21)

Discussion

Based on a review of the extant literature, I developed a working theory of the central role of working memory capacity in GAD and the cognitive and emotional difficulties that characterize this disorder (see Figure 1). This study was a partial test of the theory in its attempt to address the questions: (1) What is the relationship of GAD symptoms and related cognitive and emotional processes to working memory performance? (2) How does a momentary induction of verbal or image-based worry affect working memory capacity and the manner in which people with GAD interpret ambiguous situations? (3) Does a restriction in working memory capacity mediate the effect of worry on interpretations of ambiguity? The present study focused on one part of the model, interpretation bias, as an outcome to ensure feasibility of the study design and because of its centrality to the psychopathological processes in GAD.

This study found that induced worry, in verbal or image-based form, did not significantly affect working memory performance on a central executive task, or interpretation bias. Additionally, trait worry and GAD symptoms were unrelated to working memory capacity or interpretation bias at baseline or during a period of induced worry. Lower baseline, or unmanipulated, working memory capacity was related to higher self-reported state anxiety, emotion dysregulation, intolerance of uncertainty, thought suppression, negative problem orientation, and lower self-reported attentional control.

Relationship between Working Memory Restriction and GAD-Related Measures

The first hypothesis, that the degree of restriction in working memory capacity following an experimental induction of worry would be associated with "trait" measures of GAD symptoms and related processes, was not supported. In fact, there was a failure to replicate previous studies demonstrating that inducing worry temporarily restricts working memory capacity (Hallion et al., 2014; Hayes et al., 2008; Leigh & Hirsch, 2011). This includes a failure to replicate a study using procedures that are nearly identical to those used in the present study (Leigh & Hirsch, 2011). Specifically, there was no significant change in working memory capacity as measured by a random interval generation task when participants with GAD were asked to actively worry in the lab, even though such changes have been demonstrated in previous studies. Consequently, it was not surprising to observe that changes (or lack of) in working memory capacity following induced worry did not significantly correlate with measures of trait worry, GAD symptoms, or GAD-related cognitive and emotional processes.

Analyses showed that the worry induction (in both the verbal and imagery conditions) on average did lead to significant expected changes in anxiety, suggesting that these findings are not likely due to poor compliance with worry instructions. It must be noted however that anxiety ratings following the worry induction, though comparable to previous studies (Leigh & Hirsch, 2011; Hayes et al., 2008), were only moderate. This calls into question whether the induction was effective at inducing a worried, anxious state. However, the same worry induction procedure used in the present study was previously shown to impair working memory performance despite only moderate levels anxiety (Leigh & Hirsch, 2011). The present study would have benefitted from the inclusion of measures assessing participants' ability to engage in worry and their degree of negative thought content during the worry induction procedure. State anxiety ratings may not be a valid indicator of a person's engagement in worried thought and therefore converging measures would provide a more thorough assessment of the worry induction's success. Individuals reported that they were able to engage in their trained form of mentation during the worry induction. This provides indirect confirmation that participants complied with the worry induction instructions. Taken together, participants' reported success at engaging in imagery or verbal thinking during the worry induction and the significant change in state anxiety ratings suggest good compliance with instructions. Despite this, without further manipulation checks to validate this procedure, insufficient worry induction cannot be fully ruled out as an explanation for the failure to find an effect of induced worry on working memory.

There are several other plausible explanations for the failure to find a change in working memory capacity following a brief period of induced worry. First, it is possible that participants' working memory performance at baseline, prior to the worry induction, was already at floor, beyond which a worry manipulation would be unlikely to have a significant effect. One piece of evidence in favour of this explanation is that baseline performance on the random interval generation task in the present sample was notably poorer than the performance of those in Leigh and Hirsch's (2011) investigation. Mean single RIG scores in the present study were much greater (denoting worse performance) than the mean scores of Leigh and Hirsch's (2011) high-worry sample during the same single RIG task *and* during a worry RIG task. That is, participants in the present sample had more difficulty producing random key presses even in the absence of a competing task than did Leigh and Hirsch's (2011) participants when they were instructed to produce random key presses and worry at the same time, which is presumably more taxing. Additionally, mean self-reported attentional control in the present sample was comparable to what has been previously reported for a high trait anxious group labeled as having "low attentional control" (Derryberry & Reed, 2002). This provides further evidence that the present sample was characterized by low levels of central executive functioning at baseline, leading to possible floor effects in single RIG performance.

Differences across studies may be attributable to the use of a diagnosed sample in the present investigation. It could be that at higher levels of worry severity, working memory is less susceptible to state influence. Individuals who are higher in the tendency to worry or experience anxiety have difficulty with working memory tasks, especially those that utilize the central executive, even when there are minimal additional demands, or no demands, placed on them (Bishop, 2009; Crowe et al., 2007; Hayes et al., 2008). This supports the hypothesis that participants in this sample, by virtue of having high levels of *trait* worry, may have had poor working memory performance even in the absence of induced (or *state*) worry. The “fuel” metaphor of working memory posits that working memory is a finite resource that can be exhausted by prior attempts at executive control (Hirst & Kalmar, 1987). It could be that individuals with GAD are generally “low on fuel” as a result of their chronic worry. Previous studies show that induced worry leads to restricted working memory capacity (Hallion et al., 2014; Hayes et al., 2008; Leigh & Hirsch, 2011). This suggests that individuals with GAD who are *chronically* worried may have chronically restricted working memory capacity. Further, because individuals in the present sample by definition experience frequent and uncontrollable worry, it is possible that they were worrying during baseline administration of the single RIG task, and as such, differences in performance were not observed when worry was induced. However, this interpretation is complicated by the present study’s failure to find associations between self-reported trait worry and working memory performance. That is, participants’ baseline working memory performance was unrelated to their reported levels of trait worry or GAD symptoms. Comparison to a nonclinical, low-worry sample could help to explore state and trait differences in working memory performance in people with GAD and people without GAD who are low in the tendency to worry. Without norms for the random interval generation task or a comparison group, it cannot be said whether participants with GAD in this sample had “poor” working memory performance or if they were impaired relative to a nonclinical group.

Comparison to reported means from a previous study (Leigh & Hirsch, 2011) showed that participants in this study had notably worse performance than a low-worry group. A low-worry comparison in future studies would allow for the investigation of how trait features (e.g., low working memory capacity) interact with state factors (e.g., induced worry). These comparisons would clarify whether the present findings do in fact represent a floor effect in the working memory performance of individuals with GAD and whether the effects of induced worry vary as a function of worry severity.

One notable difference between the present study's procedure and that used by Leigh and Hirsch (2011) is that participants in the present study completed a diagnostic interview and a large set of questionnaires prior to baseline working memory assessment. It could be that this procedure was cognitively taxing or increased worry in participants, leading to poorer baseline performance on the RIG, a measure of central executive capacity. Poor baseline performance due to cognitive load or worry could have contributed to a failure to find significant decrements in working memory capacity following a worry induction. Future studies may benefit from assessing baseline working memory capacity at the beginning of the procedure.

Another explanation for the failure to find changes in working memory capacity while worrying could be that this "dual task" was not difficult enough to cause significant decrements in performance. One possibility is that there are limitations with the working memory task used. It could be that the RIG task is not difficult enough to be negatively affected by concurrent worry, or that the index of working memory it provides is not sensitive to the effects of worry, as induced in this study. Findings from Leigh and Hirsch (2011) using the same procedure contradict this interpretation. Another possibility is that worry, as induced in this study, was not taxing enough to affect working memory capacity. Given that GAD is characterized by frequent and uncontrollable worry, worrying in this population may be a relatively automatic mental activity, or "default state," and consequently does not consume central executive resources. Past research with undiagnosed high-worry samples would seem to contradict this however (e.g., Leigh & Hirsch, 2011). If worry, in GAD, is an automatic process it should have the greatest automaticity in those who worry the most, as they would have had greater rehearsal of their worries. Therefore if induced worry did not interfere with working memory because it is a practiced cognitive activity, individuals higher in trait worry would be expected to have less worry-related interference during a working memory task. However, previous studies have found the opposite; individuals *higher* in the tendency to worry have poorer working memory performance on central executive tasks (Crowe et al., 2007) and greater working memory restriction when worrying (Hayes et al., 2008). Therefore one would expect induced worry to have negative consequences for working memory in a clinical sample. The present finding that induced worry did not significantly affect working memory performance constitutes a major discrepancy with previous studies.

It could be that it is not worrying per se that negatively affects working memory, but rather, *attempts at controlling* worry. It has been suggested that redirecting attention away from worried thoughts requires executive control resources, which may be limited in GAD (Hirsch & Mathews, 2012). In our study, participants were instructed to engage in worry, not control it. If efforts to control worry account for its negative effects on working memory then this could explain why no change in working memory performance was seen in our sample during a period of induced worry. In a study examining the effects of thought control efforts on working memory, it was found that controlling induced worry led to greater interference with a working memory task than did controlling neutral thoughts (Hallion et al., 2014). However, this study also found that worry on its own interfered with working memory to the same degree as worry control efforts (Hallion et al., 2014). These findings suggest that worry, specifically, has negative effects on working memory and that this relationship is not accounted for by thought control efforts. Therefore the finding in the present study that induced worry did not affect working memory is unlikely to be attributable to the absence of worry-control efforts.

To summarize, the failure to replicate a relationship between induced worry and working memory could be due to a preexisting restriction in working memory capacity in this sample or it could be because worry, as induced in this study, did not impose a significant load on central executive resources as measured by the RIG task.

Effects of Verbal Worry Versus Image-Based Worry on Working Memory Capacity

The hypothesis that verbal worry would lead to a greater restriction in working memory capacity than would image-based worry was not supported. This finding was not surprising given the failure to find a main effect of induced worry on working memory capacity. This is the first time this hypothesis has been tested in a study employing a between-groups design in which participants were randomly assigned to verbal or image-based worry. Leigh and Hirsch (2011) asked their participants to engage in both verbal worry and image-based worry (counterbalanced) while completing a random interval generation task. They found that in individuals high in worry, residual working memory capacity was significantly lower during verbal worry than during image-based worry (Leigh & Hirsch, 2011). However, the difference was small (d = 0.36; Leigh & Hirsch, 2011). Our study, using a between-groups design, found a negligible difference between worry conditions in working memory capacity while worrying (d = 0.02). Additionally there were no significant changes in memory capacity within conditions across RIG administrations (Verbal, d = 0.09; Imagery, d = 0.22). The between-groups design of our study coupled with a small sample size may have led to this difference in effect relative to what was observed in the Leigh and Hirsch (2011) study. As noted earlier, it may be that performance on the RIG task was already so poor in the sample at baseline, that it was not possible to detect further decrements that may have resulted from simultaneous verbal (or image-based) worry. Additionally it is possible that the mentation training used was not robust enough to produce between group effects. While participants reported good success engaging in the trained form of mentation, the training was relatively brief. Future studies could examine whether a longer training procedure would lead to greater success at engaging in imagery or verbal thinking, or produce larger between-group differences.

Effect of Worry on Interpretation Bias

The hypothesis that verbal worry, compared to image-based worry, would be associated with greater threat interpretation bias was not supported. Within the undifferentiated sample, there was no significant change in interpretation bias from baseline administration to worry test phase administration (that is, no main effect of time). Additionally, interpretation bias at baseline was not significantly related to trait worry or working memory capacity. Failure to find changes in interpretation bias between administrations could be due to (1) task limitations or (2) could reflect a true absence of an effect of worrying on interpretation bias. With regard to task limitations, approximately one fifth of participants had to be excluded from analyses due to poor compliance with task instructions. This poor compliance suggests that participants may not have understood task instructions or that their task motivation was low. Issues with task compliance have not been reported in previous use of this task (Ogniewicz et al., in press). After participants with poor compliance were removed, mean interpretation bias scores were comparable to those previously found in an analogue GAD sample (Ogniewicz et al., in press). This provides greater confidence that the lack of change in interpretation bias was not solely due to poor compliance. Another limitation in interpreting the lack of change in interpretation bias following induced worry is that the same version of the task was administered twice, within the same testing session. It is possible that the WSAP for GAD is not sensitive to changes in interpretation bias when it is repeatedly administered over a short time. Additionally, participants may have been primed by the first exposure to the word-sentence pairs leading them to produce the same responses during the second administration.

Task limitations aside, the null finding could reflect something about the relationship between worry and interpretation bias. It could be that interpretation bias reflects a relatively automatic and ingrained tendency that is unaffected by state changes in worry or anxiety. Additionally, the relationship between interpretation bias and anxiety may be unidirectional. Whereas manipulating interpretation bias has been shown to affect anxiety (e.g., Mathews et al., 2007), the present findings suggest that manipulating anxiety, or worry, may not affect interpretation bias. In the absence of a second measure of interpretation bias in this study, it is difficult to make conclusions as to whether these findings reflect a limitation with the task or that interpretation bias is not related to changes in worry and working memory in people with GAD.

Trait Working Memory Capacity and GAD-Related Processes

Although the study's hypotheses were not supported, an unexpected set of findings emerged at baseline, with respect to the "unloaded" (that is, trait) working memory assessments. Poorer performance on the random interval generation task (that is, the single RIG, a measure of the central executive) was associated with self-reported problems with attentional control, emotion regulation difficulties, higher intolerance of uncertainty, and a more negative problem orientation. Individuals with poorer performance on the Corsi Block task, which assesses visuospatial working memory, reported a more habitual tendency to engage in thought suppression as a coping strategy, higher intolerance of uncertainty, and higher state anxiety. Thus, it appears that trait working memory capacity may have important implications for the psychopathological processes involved in GAD.

The positive correlation between self-reported attentional control and single RIG task performance indicates that this task has good convergent validity with another measure of attentional control. Attentional control is relevant to GAD as one of the disorder's main features is uncontrollable worry. Additionally, the diagnostic criteria for GAD include "difficulty concentrating" (APA, 2013). The relationship between a self-reported and a behavioural measure of attentional control implies that individuals with GAD have good insight into their own attentional control abilities. Therefore when individuals with GAD report uncontrollable worry, this likely reflects an objective difficulty exerting attentional control over worried thoughts. Notably, the present sample of individuals with GAD reported attentional control comparable to a previous high trait anxiety sample describe as having low attentional control (Derryberry & Reed, 2002). This suggests that low attentional control may be a feature of GAD. The meta-cognitive model of GAD proposes that individuals with GAD do not make efforts to control worry after it is initiated (Wells, 1999). Additionally, a cognitive model of GAD suggests that difficulty with attentional control may maintain worry (Hirsch & Mathews, 2012). Differences in attentional control in GAD may have important implications for understanding pathological processes in the disorder, and low attentional control should be taken into consideration during worry interventions. Hirsch and Mathews (2012) put forth a cognitive model of GAD that proposes that worry is influenced by both bottom-up and top-down attentional biases. They argue that individuals with GAD have a preconscious attentional bias for threat information (bottom-up) which leads to negative thought intrusions and worry, and also a deficit in attentional control (top-down) that makes it difficult for individuals with GAD to shift attention away from worried thoughts (Hirsch & Mathews, 2012). They hypothesize that worry would be best treated by a combination of strategies to reduce bottom-up attentional biases (e.g., attention bias modification) and increase top-down attentional control over thoughts (e.g., delaying worry until an assigned “worry time”) (Hirsch & Mathews, 2012). The findings from the present study suggest that individuals with GAD who have lower working memory capacity may especially benefit from interventions that focus on increasing attentional control over worried thoughts. Such interventions might include, for example, mindfulness strategies (Roemer & Orsillo, 2005) or worry-postponing strategies (Borkovec, Wilkinson, Folensbee, & Lerman, 1983; Wells, 1999) that emphasize shifting attention and disengagement from worry. Attention-based treatments for GAD to date have primarily focused on modifying bottom-up attentional biases (e.g., Amir, Beard, Burns, & Bomyea, 2009) rather than explicitly training attentional control. Future research could investigate whether training domain-general attentional control would have therapeutic benefits for people with GAD by leading to generalized improvements in attentional control over worried thoughts.

This study found that in people with GAD, those who performed worse on a central executive working memory task also reported greater difficulty regulating their emotions. Specifically, lower working memory capacity was associated with nonacceptance of emotional responses and a limited ability to identify or use effective emotion regulation strategies. Research evidence demonstrates that emotion regulation depends on executive control resources (Schmeichel, 2007). Performing a working memory task that draws on executive control impairs subsequent ability to inhibit an emotional response (Schmeichel, 2007). Further, efforts to control emotional response impair subsequent executive control performance (Schmeichel, 2007). Imaging studies implicate the prefrontal cortex in the functional neural network involved in appraising and regulating emotional experience (Ochsner, Bunge, Gross, & Gabrieli, 2002) and point to the role of higher cognitive processes, such as working memory, in emotion regulation (Ochsner & Gross, 2005). It has been suggested that working memory is important for the self-regulatory actions of controlling attention away from attention-capturing stimuli (e.g., threat information in GAD), suppressing unwanted repetitive thoughts, and down-regulating negative affect (Hofmann, Schmeichel, & Baddeley, 2012). Given prior research evidence and the present findings, it is possible therefore that restricted working memory in GAD may have negative effects on an individual's ability to regulate their emotional experience. This could contribute to a perception that negative emotional experiences are uncontrollable leading to a greater aversion to negative emotional states.

The contrast avoidance model of GAD (Newman & Llera, 2011) proposes that individuals with GAD seek to avoid negative shifts in their emotional state by perpetuating a state of negative emotionality with worry. The emotion regulation model of GAD also suggests that worry functions as an emotion regulation strategy, albeit a maladaptive one (Mennin et al., 2005). The present findings suggest that in GAD, individuals with lower working memory capacity are especially averse to negative shifts in emotional response and have greater difficulty identifying adaptive emotion regulation strategies. As suggested by the contrast avoidance and emotion regulation models of GAD, these emotion regulation deficits may maintain the use of worry as an emotional regulation strategy in individuals with lower working memory capacity.

Lower baseline working memory capacity, on both central executive and visuospatial working memory tasks, was associated with greater self-reported intolerance of uncertainty. This relationship could be due to the cognitive effort required to manage uncertain and ambiguous information. Individuals with low working memory capacity may have more difficulty making sense of uncertain or ambiguous information, leading to greater intolerance of uncertainty. Research has shown that during an uncertainty related decision-making task, intolerance of uncertainty in individuals with high trait anxiety is associated with greater distress and greater information requirements (Jacoby et al., 2014). More research is needed to examine the relationship between the ability to manage uncertainty, working memory, and beliefs about uncertainty. Future studies could investigate whether difficulties managing uncertainty and ambiguity are associated with working memory deficits in people with GAD. Individuals with lower working memory capacity have greater difficulty holding multiple interpretations of ambiguous situations in mind at once and more quickly revert to the most likely interpretation on an ambiguous phrase (Macdonald et al., 1992; Miyake et al., 1994). Not being able to entertain multiple interpretations at once may be especially distressing in individuals with GAD who tend to endorse threat interpretations as the most likely interpretation. Further, working memory deficits may make it difficult for an individual to appraise the actual probability of threat outcomes in ambiguous situations. This difficulty managing ambiguous or uncertain situations could underlie beliefs that uncertainty is dangerous, unmanageable, or intolerable.

Lower working memory capacity was related to negative beliefs about problems in individuals with GAD. These negative beliefs include a general tendency to perceive problems as threats, doubt one's own problem solving abilities, and believe that problems are not tolerable (D'Zurilla, Nezu, & Maydeu-Olivares, 2001). Working memory resources are required for problem solving and reasoning (Baddeley, 1974). Restricted working memory capacity could make it difficult for individuals to shift attention away from their worry in order to search for problem solutions and to stay on task with problem solving attempts (Miller, Watson, & Strayer, 2012). Problem solving difficulties could explain the relationship between working memory performance and negative problem orientation. Further research is needed to investigate the role of executive control in GAD-related problem solving. For example future studies could investigate whether working memory performance is related to problem solving ability in GAD and whether this varies as a function of state factors such as worry and anxiety. Problem solving could be assessed both through self-reported problem solving ability and through problem solving tasks. For example, a problem elaboration procedure (e.g., Stöber et al., 2000) in which participants are required to identify antecedents and consequences of a personal problem could be used to assess the ability to conceptualize problems. The Means-Ends Problem Solving task (Platt & Spivack, 1975) could be used to assess effectiveness of problem solutions. With the use of diverse problem solving tasks, future studies could investigate how working memory affects different steps of the problem solving process in GAD (e.g., problem conceptualization, solution generation, solution selection).

The correlation between state anxiety and visuospatial working memory performance contradicts predictions that anxiety most strongly affects the central executive component of working memory (e.g., Eysenck et al., 2007). One explanation for this could be that the Corsi Block task also draws on central executive resources. It has been suggested that visuospatial tasks often rely on central executive functioning, as they are likely less familiar or practiced than other tasks (e.g., verbal tasks) (Baddeley, 1996). Therefore visuospatial working memory performance would reflect both visuospatial span capacity as well as central executive efforts to maintain attention and manage task demands. In support of this, a dual-task study showed that when a random interval generation task (drawing on central executive resources) was performed at the same time as the Corsi Block task, performance on the latter was negatively affected (Vandierendonck et al., 2004). This indicates that the Corsi Block task also relies on central executive resources and supports the prediction that random interval generation and Corsi Block performance should be correlated (Vandierendonck et al., 2004). However, if the correlation between the Corsi Block task and state anxiety is due to this task's loading on the central executive, it is unclear why RIG performance would not also correlate with state anxiety and thought suppression. It could be that the visuospatial component of working memory specifically is related to state anxiety and thought suppression.

Individuals with worse visuospatial working memory performance on the Corsi Block task endorsed a greater tendency to have unwanted thoughts (e.g., "I have thoughts that I try to avoid") as well as greater effort to avoid unwanted thoughts (e.g., "I try not thinking about the most upsetting aspect of some situations"). However, working memory performance was not necessarily related to the *success* of these thought suppression strategies. Greater working memory capacity is related to better ability to suppress unwanted thoughts (Brewin & Smart, 2005). Additionally, working memory training was shown to reduce intrusive thoughts during a thought suppression task (Bomyea & Amir, 2011). Individuals with GAD with low working memory capacity may therefore have more difficulty controlling unwanted thoughts, which would explain their greater tendency to have unwanted thoughts and expend effort (both cognitively and behaviourally) to avoid them.

One reason why visuospatial working memory performance was not expected to be related to trait worry was that worry is a primarily verbal (rather than image-based) process (Borkovec et al., 1998). However, the cognitive avoidance theory of GAD proposes that the verbal quality of worry in part functions as a strategy for suppressing upsetting mental imagery

(Borkovec et al., 1998). Visuospatial working memory may therefore have implications for understanding image suppression in GAD. Worry is associated with less concrete (Goldwin & Behar, 2012) and less image-based thought (Borkovec & Inz, 1990). The abstract, verbal qualities of worry are theorized to temporarily reduce distress about a worry topic but with the consequence of hindering emotional processing and maintaining fear (Borkovec et al., 1998). A lesser ability to hold visuospatial information in mind in individuals with GAD could be associated with less vivid, more abstract mental imagery. The present study found a relationship between visuospatial working memory and the tendency to experience intrusive thoughts and attempts to suppress unwanted thoughts. People with lower visuospatial working memory capacity may have a lower capacity to engage in mental imagery. An inability to engage in imagery could lead to restricted processing of emotional information, the maintenance of fear, and consequent increases in negative thought intrusions. In individuals with high worry, verbal worry leads to increases in negative thought intrusions whereas image-based worry leads to a decrease in negative thought intrusions (Stokes & Hirsch, 2010). A connection between low image-based thinking and negative thought intrusions could explain the association between visuospatial working memory and efforts at thought suppression found in this study. Supporting this, posthoc analyses showed that greater visuospatial working memory capacity was significantly correlated with higher self-reported ability to engage in image-based thinking during the worry induction in the imagery training condition ($r = .49$, $p < .05$). That is, participants who had lower visuospatial working memory capacity reported greater difficulty engaging in image-based thinking while worrying.

The Corsi Block task was included in this study primarily to rule out a relationship between worry and the subsidiary storage systems. As expected, central executive performance was more highly related to GAD-related processes than was visuospatial performance. The Corsi Block task was not expected to be associated with GAD-related processes as it is primarily visuospatial task. However, performance on this task was meaningfully associated with state anxiety, intolerance of uncertainty, and thought suppression. Whereas the Corsi Block task also recruit the central executive, central executive performance was unrelated to state anxiety and thought suppression. These findings suggest that visuospatial working memory capacity may have implications for understanding the cognitive and emotional processes involved in GAD, particularly the ability to engage in image-based thinking and the image suppression function of worry. Replication with another visuospatial measure would be necessary to determine whether these correlations reflect a true relationship between visuospatial working memory and these constructs or if they are driven by the Corsi Block task's use of central executive resources.

Limitations and Future Directions

The present study has a number of strengths. Firstly, the use of a diagnosed GAD sample in this study allows for greater generalizability to clinical populations. It also allows for comparison to previous findings from GAD analogue samples. This study is the first study, to our knowledge, to examine working memory in a diagnosed GAD sample. The self-reported trait worry level in this study suggests that this sample had a higher level of clinical severity than previously reported samples (e.g., Leigh & Hirsch, 2011). The present findings indicate that the previously reported association between induced worry and working memory capacity may not generalize to a more severe clinical sample. Another strength of the present sample is that it was drawn from the community whereas previous investigations of worry and working memory have utilized samples drawn from university settings (Hallion et al., 2014; Hayes et al., 2008; Leigh & Hirsch, 2011). The present sample has large age range and a higher mean age than previous studies, which is more likely reflective of a GAD treatment-seeking sample. Additionally, a community sample likely has greater diversity in socioeconomic status and educational attainment than a sample of university students. These differences are important as working memory performance is related to variables such as age (e.g., Salthouse & Babcock, 1991) and educational attainment (e.g., St. Clair-Thompson & Gathercole, 2006).

A strength of this study's design is its use of multiple tasks and repeated assessment of working memory capacity. By including measures of both central executive and visuospatial working memory, this study investigated the ways in which GAD symptoms and associated processes relate to the different components of working memory. Additionally, the repeated administration of the RIG and WSAP tasks allowed for greater precision in assessing the effects of induced and trait worry on working memory capacity and interpretation bias. Baseline performance on the RIG and WSAP served as participants' own control for their performance while worrying. This enabled us to rule out baseline differences in working memory or interpretation bias between conditions as a possible explanation for the findings. Additionally, by assessing working memory at baseline and while worrying we investigated the relationships between both trait and state worry and working memory. Finally, another strength of this study is that it was designed to replicate a previous investigation of worry and working memory (Leigh & Hirsch, 2011). Leigh and Hirsch (2011) demonstrated that verbal worry (compared to image-based worry) led to a restriction in working memory capacity. The present study's failure to replicate this finding extends the understanding of working memory in GAD and suggests that the effect of verbal worry on working memory may not be reliable or may not generalize to a more clinically severe community population.

The present findings should be interpreted in light of this study's limitations, some of which have already been outlined. One possible limitation is the use of the WSAP as the only measure of interpretation bias. There was a substantial subset of participants who did not comply with WSAP task instructions. This calls into question whether the remaining WSAP data are valid. Comparison of mean scores to previous studies (Ogniewicz, in press) suggests that the data are reliable, but the inclusion of a second measure of interpretation bias (such as the Ambiguous-Unambiguous Situations Diary; Davey et al., 1992) would have provided a better means for assessing this. Without a definitive way of validating the WSAP interpretation bias scores, it cannot be concluded whether the null effects are attributable to task limitations or a true absence of relationship between induced worry, working memory, and interpretation bias.

The absence of a low worry comparison group in the present study limits conclusions about trait working memory capacity ability in GAD—whether individuals with GAD have a deficit in working memory performance compared to those low in the tendency to worry or if they fall within the normal range. Comparing mean scores in the present study to previous studies suggests that individuals diagnosed with GAD have worse central executive functioning than low-worry samples *and* analogue GAD samples (Leigh & Hirsch, 2011). Visuospatial working memory in this GAD diagnosed sample however was comparable to what has been previously reported in samples of young adults (Rowe, et al., 2008, 2009). Future studies using a low worry comparison group could examine whether there is in fact a reliable trait difference in working memory performance (specifically central executive performance) between individuals with GAD and those without. Another limitation, due to the absence of a comparison group, is that it is unclear whether the revealed associations between working memory and GAD-related difficulties are specific to individuals with GAD or if the same patterns would be found in those low in trait worry. Additionally, the previously demonstrated association between working memory and worry in low to moderate trait worry samples may not apply to a high-worry GAD sample. Replication of this study with a low-worry group would constitute an important future direction that would help to investigate group differences in trait working memory performance and its correlates.

This study showed that working memory in GAD is related to several processes that are central to models of pathological worry (i.e., attentional control, intolerance of uncertainty, problem solving, emotion regulation). This finding is an exciting one that offers many avenues for further inquiry. Multiple previous studies demonstrated that induced worry leads to restricted working memory capacity (Hallion et al., 2014; Hayes et al., 2008; Leigh & Hirsch, 2011). These studies indicate that working memory is an important variable to consider in the study of GAD, a disorder characterized by chronic pathological worry. The present study built upon this line of inquiry by investigating the consequences of restricted working memory capacity in a sample of people diagnosed with GAD. This study failed to replicate previously demonstrated effects of induced worry on working memory. However, trait working memory, measured by both a central executive and visuospatial task, was meaningfully related to cognitive and emotional processes associated with GAD. These findings extend the current understanding of working memory in GAD by linking trait working memory to constructs that are central to models of GAD, especially the intolerance of uncertainty model (Dugas et al., 1998), and the emotion dysregulation model (Mennin et al., 2005).

Consideration of trait working memory could lead to a better understanding of how the cognitive and emotional difficulties associated with GAD develop and are maintained. The findings from the present study are correlational, leaving open the possibility that the cognitive and emotional difficulties in GAD lead to restricted working memory capacity *or* that these variables reciprocally influence each other. Future studies could utilize experimental manipulations to examine causal relationships between working memory capacity and GAD-related processes such as intolerance of uncertainty, emotion regulation, and problem solving. Additionally, working memory assessments could be included in treatment studies of GAD to examine whether temporal changes in GAD-related processes are associated with changes in working memory performance. Future studies would also benefit from the use of behavioural tasks assessing variables such as difficulty processing ambiguity, emotion regulation, or problem solving in order to corroborate the present findings. Similarities have been drawn between worry and other forms of repetitive negative thought (Watkins, 2008). Findings regarding working memory and worry may have broader implications for other forms of psychopathology characterized by repetitive negative thought. Future studies would benefit from comparison to other clinical groups characterized by repetitive negative thought in such as rumination in major depressive disorder or postevent rumination in social anxiety. This would be useful for examining whether the relationships between worry and working memory are specific to worry and GAD or apply more broadly to repetitive negative thinking.

Reconsideration of Proposed Model

The present study proposed a model of difficulties in GAD that focused on the effects of a worry-related restriction in working memory capacity. The findings of this study indicate that, as proposed, working memory is an important correlate of the difficulties present in GAD (e.g., emotion dysregulation, intolerance of uncertainty). However, contrary to prediction this study found that it was *trait* working memory performance that was associated GAD-related difficulties. Additionally, these associations were not influenced by worry (self-reported or experimentally induced). The results of this study suggest that careful consideration is required of the role of *trait* versus *state* working memory in GAD. Importantly, the relationship between worry and working memory in GAD may not be as clear-cut as previously assumed.

Taking into consideration the present findings, a revised model of working memory's relation to worry and the cognitive and emotional difficulties related to GAD is presented in Figure 3. The revised model proposes that chronic worry in the context of GAD is associated with restricted working memory capacity relative to individuals low in the tendency to worry. A bidirectional arrow indicates that lower working memory capacity may be a risk factor for chronic worry, and that chronic worry may have a negative effect on working memory capacity. In keeping with the first model (Figure 1), the revised model proposes that lower working memory capacity in GAD is related to difficulty with problem solving, managing ambiguous information, and emotion regulation. In consideration of the present findings, this model also proposes that the aforementioned difficulties are associated with beliefs about problems, ambiguity, and emotions respectively. Finally, the cognitive and emotional difficulties associated with GAD are proposed to contribute to chronic worry by maintaining fear processes and anxious beliefs.

Conclusion

This is the first known study to examine the effects of induced worry on working memory and interpretation bias in a clinical sample with GAD. This study failed to replicate previous findings that induced worry is related to a restriction in working memory capacity or that verbal and image-based worry differentially affect working memory capacity. Interpretation bias was not found to change as a function of induced worry or working memory capacity. Notably, this study demonstrated that baseline (that is, unloaded) working memory performance on a central executive task, and to a lesser extent visuospatial working memory, is related to important psychopathological features of GAD including emotion dysregulation, intolerance of uncertainty, and negative problem orientation. Future studies should investigate the possibility of trait differences in working memory capacity in individuals with GAD compared to individuals low in the tendency to worry and the implications of this for the development and maintenance of the disorder.

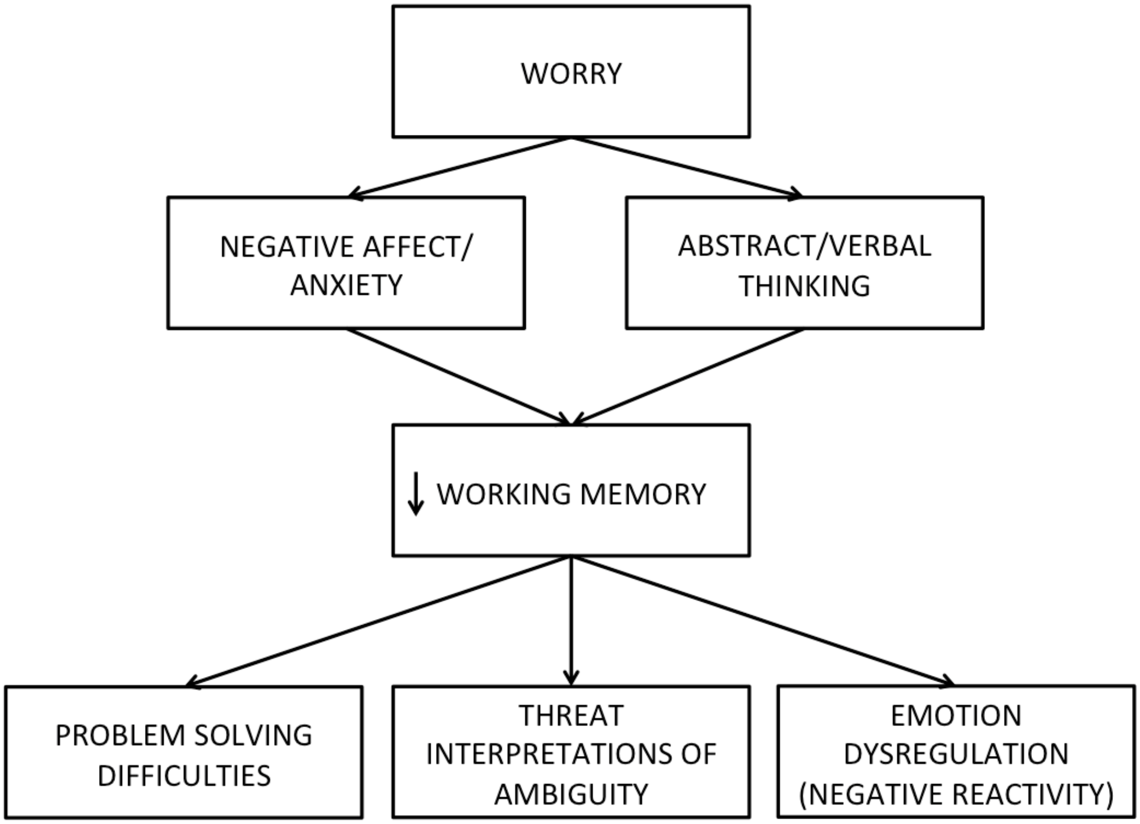

Figure 1. A proposed model of working memory's mediation of the effects of worry on processes related to generalized anxiety disorder.

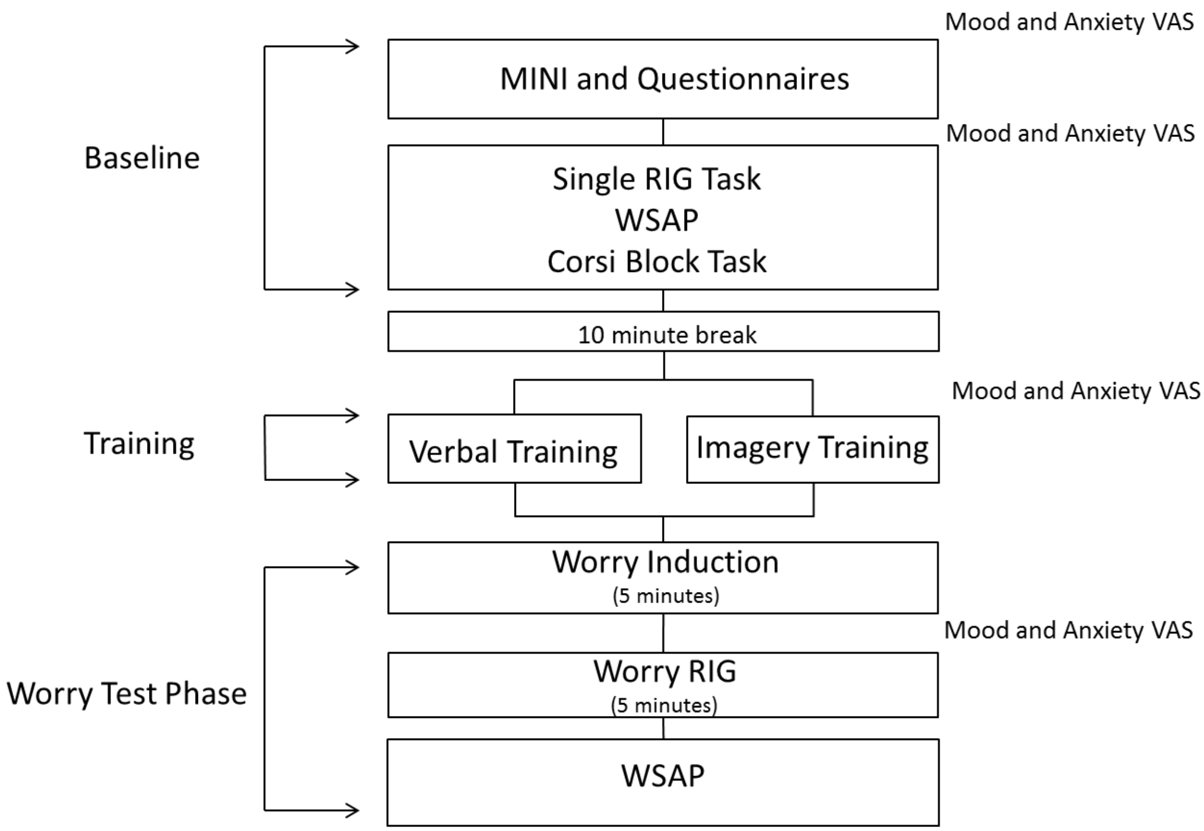

Figure 2. Outline of Experimental Procedure.

Note. MINI = Mini International Neuropsychiatric Interview, RIG = Random Interval Generation, WSAP = Word Sentence Association Paradigm, VAS = Visual Analogue Scale.

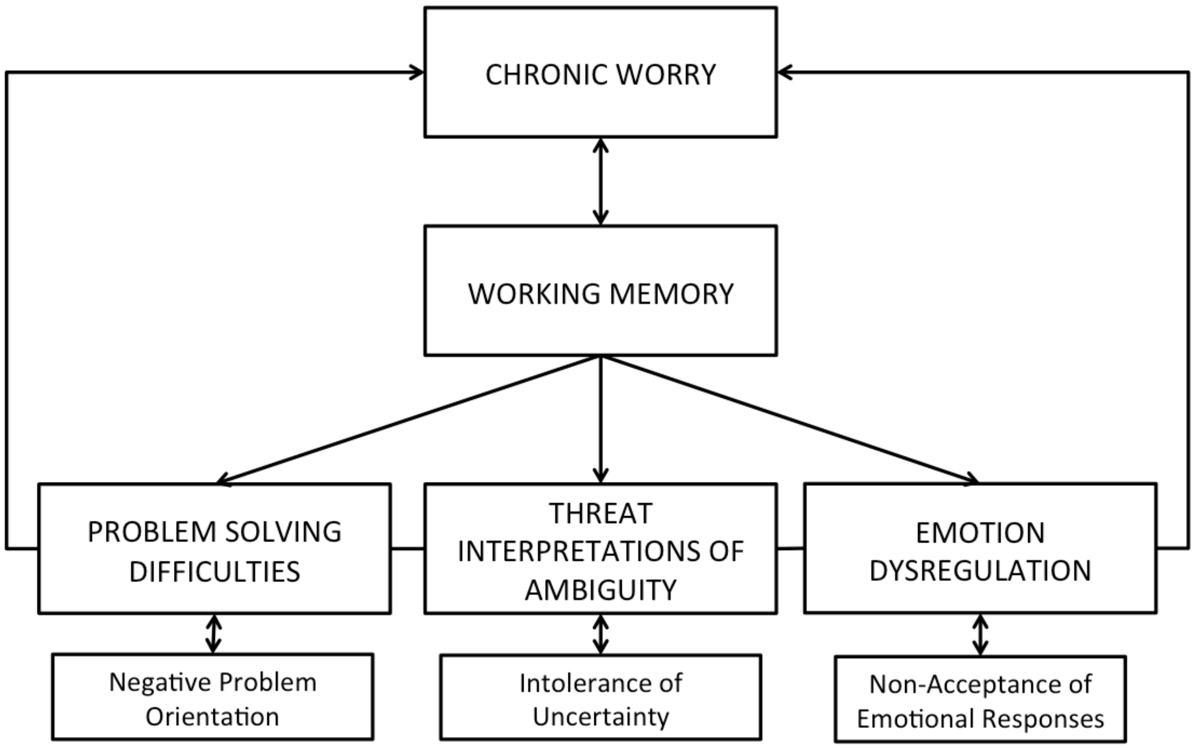

Figure 3. A revised model of working memory's relationship to worry and processes related to generalized anxiety disorder.

Appendix A – Consent Agreement

Information and Consent Form
How Do Worriers Multitask?

You are being asked to participate in a research study. Before you give your consent to be a volunteer, it is important that you read the following information and ask as many questions as necessary to be sure you understand what you will be asked to do.

Investigators: Kathleen Tallon, BA, Department of Psychology, Ryerson University
Naomi Koerner, PhD, Department of Psychology, Ryerson University
Lixia Yang, PhD, Department of Psychology, Ryerson University

Purpose of Study:

The purpose of this study is to examine how worry affects the way people multitask and make sense of everyday situations.

Description of the Study:

You will be asked to make one, 3-hour visit to the Psychology Research and Training Centre at 105 Bond Street. After providing written informed consent, you will be asked several questions about current emotional and psychological experiences (for example, mood and anxiety).
Please note that the interview will be audio recorded to ensure accurate interpretation of your responses. The audio recording will not have your name on it and it will be listened to only by research assistants for the purpose of this research. The audiorecording will be stored in a password protected area and will be encrypted (that is, encoded a certain way so no one can listen to the audiorecording without a password).

Please write your initials in one of the following boxes:

☐ I agree to have my responses audio recorded as described above.

☐ I do not agree to have my responses audio recorded.

After our interview, you will be asked to complete a set questionnaires about your thoughts, emotions, and behaviour. Questionnaires will be completed on the computer. If you do not wish to complete questionnaires on the computer, paper-based questionnaires will be made available. You will complete two concentration tasks and a decision-making task on the computer. There will then be a ten minute break. Following the break you will be trained to think from a particular perspective. You will be asked to describe a situation that you are worried about and will be given instructions to think about the situation in a particular way while again completing a concentration task and a decision making task. The tasks should take between 2.5 – 3 hours to complete. Following completion of the tasks you will be debriefed and compensated for your participation.

Questionnaire data will be entered into a computer using online software called Qualtrics. The data are securely and confidentially stored on a remote server and you will be identified by number only. Please note that because the data is securely stored on a USA based server (Qualtrics), it is subject to the Patriot Act. If you care to know more about this, please visit the following link: http://epic.org/privacy/terrorism/hr3162.html. Under the Patriot Act, stored data may be intercepted in rare cases if United States officials have a reason to believe the data contains information related to suspected terrorism. However, your name is not stored with your questionnaire data, and therefore would not be available to these officials.

Potential Risks or Discomforts: There is minimal risk involved if you agree to take part in this study. You may experience some uncomfortable emotions when responding to questions about your thoughts, emotions, and behavior or when asked to think about situations that are worrisome to you; however, this is likely to be short-lived. You have the right to skip questions. You also have the right to discontinue your participation at any time.

Potential Benefits of the Study to You or Others: I cannot guarantee that you will receive any direct benefits from participating in this study. You may derive benefit from the self-assessment as it may increase your awareness of your thoughts, emotions and behaviours. You may develop a better understanding of research methodology and you will be providing researchers with valuable insight.

Confidentiality: Information disclosed in this study will remain completely confidential; however, there are five cases in which the investigators might need to break confidentiality:
(1) if you intend to harm yourself;
(2) if you intend to harm someone else;
(3) if there is reasonable suspicion that a child up to the age of 16 years has been abused or neglected, or is at risk of neglect or abuse, we are required by law to report this to the Children's Aid Society right away;
(4) if our files are subpoenaed by the courts (records can be opened by a specific court order);
(5) if a regulated health professional has engaged in inappropriate sexual behaviour toward a patient and you provide us with the name of this individual, we are obligated to report them to their regulatory body.

This informed consent agreement and all data that identify you will be stored in a locked storage space in the Psychology Research and Training Centre. An ID number as opposed to your name will be used on the phone interview you took part in prior to coming to the Psychology Research and Training Centre, on your in-person interview, and all questionnaires you complete, and in all computer files that contain the data you generate during the study. Your phone interview, in-person interview and questionnaires will be kept in a locked file cabinet, separate from this consent agreement and any identifying information. Audio-recordings will be stored in a password protected area and encrypted. This consent form, your telephone interview and in-person interview, and the questionnaires will be kept for 7 years after the publication of this research, after which they will be shredded. Your confidentiality will be protected to the full extent allowed by law. Only group findings will be reported in publications and presentations arising from this research.

Compensation for Participation: As compensation for participating in this study, you will receive $30.

You are asked to arrange to transport yourself to the Psychology Research and Training Centre at Ryerson University. You will not receive compensation for the telephone interview that you completed to determine eligibility. If you decide to stop participating, you will still be entitled to full compensation.

Voluntary Nature of Participation: Participation in this study is voluntary. Your choice of whether or not to participate will not influence your future relations with Ryerson University. If you decide to participate, you are free to withdraw your consent and to stop your participation at any time without penalty or loss of benefits to which you are allowed. Your right to withdraw your consent also applies to our use of your data. If you decide that you do not want us to keep or analyze data that you have provided during the course of your participation in this study, please feel free to notify us before the end of your session with us. At any point in the study, you may refuse to answer any question or stop participation altogether.

Questions about the Study: If you have any questions about the How Do Worriers Multitask? study, please ask. If you have questions later about the research, you may contact Kathleen Tallon at 416-979-5000 extension 2182 or Naomi Koerner at 416-979-5000 extension 2151.

If you have questions regarding your rights as a participant in this study, you may contact Dr. Lynn Lavallee at the Ryerson University Research Ethics Board for information.

Dr. Lynn Lavallee, Chair of the Ryerson Research Ethics Board
Office of the Vice President, Research and Innovation
Ryerson University, 350 Victoria Street, Room YDI 1154
Toronto, Ontario, Canada M5B 2K3
Phone: (416) 979-5000 Ext. 4791, Fax: (416) 979-5336
Email: rebchair@ryerson.ca Website: http://www.ryerson.ca/research

Agreement

Your signature below indicates: (1) that you have read the information in this agreement and have had a chance to ask any questions you have about the How Do Worriers Multitask? study ; (2) that you agree that information collected from you during the telephone interview for the How Do Worriers Multitask? study can be retained and analyzed and (3) that you agree to be in the How Do Worriers Multitask? study (as described in this consent form) and (4) that you have been told that you can change your mind and withdraw your consent to participate at any time. You have been given a copy of this agreement. You have been told that by signing this consent agreement you are not giving up any of your legal rights.

____
Name of Participant (please print)

____ __________________
Signature of Participant Date

____ __________________
Signature of Researcher Who Obtained Informed Consent Date

Appendix B – Debriefing Form

How do Worriers Multitask? Study

Purpose of the Study:

Individuals who report chronic worry typically say that they have difficulty concentrating and "shutting off" their worry. Many people also report feeling "distracted" when they are worrying. Finally, we have observed that people who worry a lot assume the "worst case scenario" when they are faced with a problem, especially one whose outcome is unclear or uncertain. One reason for this may be that worry takes up a lot of mental energy and depletes an individual's *working memory* capacity. Working memory is the ability to hold information in the mind in order to complete complicated mental tasks like problem solving, learning, or decision making. Previous studies have shown that worry can reduce working memory capacity temporarily. Worrying "competes" for mental resources that may make it difficult to reason through a problem or concentrate on another task. This may be, for example, why many people who worry a lot report that they sometimes "zone out" during a conversation or while reading. Essentially, when one is worrying and trying to attend to something else at the same time, they are mentally trying to "multitask" and it is known that this kind of multitasking is not effective. In this study, we are trying to determine whether thinking at length about worrisome situations influences the way people then interpret ambiguous information. Your input will help advance our understanding of difficulties that are associated with chronic worry. Your willingness to participate in this study is greatly appreciated.

Resources: We provide everyone who completes this study with the same list of resources, in case they are interested in learning more about worry or anxiety. Our list of resources has titles of books on the management of worry and anxiety, as well as referral sources (please turn over this page for the list).

Contact Information: If you have any questions or concerns about this investigation or your participation in this study you may contact:

Kathleen Tallon	Naomi Koerner	Dr. Lynn Lavallee
Department of Psychology	Department of Psychology	Chair; Research Ethics Board
Ryerson University	Ryerson University	Ryerson University
350 Victoria Street	350 Victoria Street	350 Victoria Street
Toronto, ON M5B 2K3	Toronto, ON M5B 2K3	Toronto, Ontario, M5B 2K3
(416) 979-5000 x2182	(416) 979-5000 x2151	(416) 979-5000 x6300,
kathleen.tallon@psych.ryerson.ca	naomi.koerner@psych.ryerson.ca	rebchair@ryerson.ca

If you would like any information about the results of the study once it is completed, please contact Kathleen Tallon or Dr. Naomi Koerner.

A note about disclosure: In order to maintain the integrity of this research, we ask that you not disclose the purpose of this study to others who may be interested in taking part in this study. When participants have too much prior knowledge about the purpose of a study, this can affect how they behave in the study and the data for that person may not be usable.

Thank you very much for participating in this study!

Self-Help Books

Antony, M.M., & Norton, P.J. (2009). The anti-anxiety workbook: Proven strategies to overcome worry, panic, phobias, and obsessions. New York: Guilford Press.

Hazlett-Stevens, H. (2005). Women who worry too much: How to stop worry and anxiety from ruining relationships, work, & fun. Oakland, CA: New Harbinger.

Meares, K., & Freeston, M. (2008). Overcoming worry: A self-help guide using cognitive behavioral techniques. New York: Basic Books.

Other anxiety resources are available at:
http://www.martinantony.com/links-RecReadingsandVideos.html

Referrals in Toronto Area

OHIP-Covered and Sliding Scale Referrals

Adult Mental Health Program
Humber River Regional Hospital, Toronto
Contact: Heather Wheeler, Ph.D.
Tel: 416-658-2003

Anxiety Disorders Clinic
Centre for Addiction and Mental Health
250 College St., Toronto
Tel: 416-979-6819

Ryerson University Centre for Student Development and Counseling
(Available to Ryerson Students Only)
350 Victoria St., Room JOR-07C, Lower Ground Floor, Jorgenson Hall, Toronto
Tel: 416-979-5195

Private Psychology Referrals

CBT Associates of Toronto
100 Adelaide St. West, Suite 805, Toronto
Tel: 416-363-4228
Web: http://www.cbtassociates.net/
E-Mail: eilenna.denisoff@cbtassociates.net or peter.farvolden@cbtassociates.net

Hank Frazer, Ph.D., C.Psych.
3852 Finch Ave., Unit 309, Scarborough
Tel: 416-298-9143 or 416-298-1102

Tae Hart, Ph.D., C.Psych.
Tel: 416-473-7132
Email: stacey.hart@psych.ryerson.ca

Trevor Hart, Ph.D., C.Psych
114 Maitland St., Toronto
Tel: 416-979-5000, ext. 1-6192
E-Mail: therapy@drhart.ca

David Moscovitch, Ph.D., C.Psych.
Randy Katz, Ph.D., C.Psych.
The Clinic on Dupont
101 Dupont Street, Toronto, ON
Tel: 416-966-1692

Neil Pilkington, Ph.D., C.Psych.
2 Carlton Street, Suite 1718, Toronto
Tel: 416-977-5666
E-Mail: dr.neil.pilkington@rogers.com

Brian Ridgley, Ph.D.
Ridgley, Thomas, and Associates
60 St. Clair Avenue East, Suite 900, Toronto
Tel: 416-944-3747
E-Mail: brianridgley@rogers.com

Heather Wheeler, Ph.D., C.Psych.
1333 Sheppard Ave. East, Suite 225, Toronto
Tel: 416-788-3038; E-Mail: hwheeler@rogers.co

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual for mental disorders (4th ed., text rev.).* Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual for mental disorders, 5th Ed.* Arlington, VA: American Psychiatric Association.

Amir, N., Beard, C., Burns, M., & Bomyea, J. (2009). Attention modification program in individuals with generalized anxiety disorder. *Journal of Abnormal Psychology, 118,* 28-33. doi:10.1037/a0012589

Anderson, K. G., Dugas, M. J., Koerner, N., Radomsky, A. S., Savard, P., & Turcotte, J. (2012). Interpretive style and intolerance of uncertainty in individuals with anxiety disorders: A focus on generalized anxiety disorder. *Journal of Anxiety Disorders*, *26*, 823-832. doi:10.1016/j.janxdis.2012.08.003

Attneave, F. (1959). *Applications of information theory to psychology: A summary of basic concepts, methods, and results*. Oxford, UK: Henry Holt.

Baddeley, A. D. (1966). The capacity for generating information by randomization. *Quarterly Journal of Experimental Psychology*, *18*, 119-129. doi:10.1080/14640746608400019

Baddeley, A. (1992). Working memory. *Science*, *255*, 556-559. doi:10.1126/science.1736359

Baddeley, A. (1996). The fractionation of working memory. *Proceedings of the National Academy of Sciences*, *93*, 13468-13472.

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience, 4,* 829-839. doi:10.1038/nrn1201

Baddeley, A., Emslie, H., Kolodny, J., & Duncan, J. (1998). Random generation and the executive control of working memory. *Quarterly Journal of Experimental Psychology*, *51A*, 819-852. doi:10.1080/027249898391413

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. *Psychology of Learning and Motivation*, *8*, 47-89. doi:10.1016/S0079-7421(08)60452-1

Beard, C., & Amir, N. (2009). Interpretation in social anxiety: When meaning precedes ambiguity. *Cognitive Therapy and Research*, *33*, 406-415. doi:10.1007/s10608-009-9235-0

Beck, A. T., & Clark, D. A. (1997). An information processing model of anxiety: Automatic and strategic processes. *Behaviour Research and Therapy*, *35*, 49-58. doi:10.1016/S0005-7967(96)00069-1

Behar, E., Alcaine, O., Zuellig, A. R., & Borkovec, T. D. (2003). Screening for generalized anxiety disorder using the Penn State Worry Questionnaire: A receiver operating characteristic analysis. *Journal of Behavior Therapy and Experimental Psychiatry*, *34*, 25-43. doi:10.1016/S0005-7916(03)00004-1

Benton, S. L. (1984). Cognitive capacity differences among writers. *Journal of Educational Psychology*, *76*, 820-34. doi:10.1037/0022-0663.76.5.820

Bishop, S. J. (2009). Trait anxiety and impoverished prefrontal control of attention. *Nature Neuroscience*, *12*, 92-98. doi:10.1038/nn.2242

Bomyea, J., & Amir, N. (2011). The effect of an executive functioning training program on working memory capacity and intrusive thoughts. *Cognitive Therapy and Research*, *35*, 529-535. doi:10.1007/s10608-011-9369-8

Borkovec, T. D. (1985). Worry: A potentially valuable concept. *Behaviour Research and Therapy, 23, 481-482.* doi:10.1016/0005-7967(85)90178-0

Borkovec, T. D., Alcaine, O., & Behar, E. (2004). Avoidance theory of worry and generalized anxiety disorder. In R. G. Heimberg, C. L. Turk, & D. S. Mennin (Eds.), *Generalized anxiety disorder: Advances in research and practice* (pp. 77–108). New York, NY: Guilford Press.

Borkovec, T. D., & Hu, S. (1990). The effect of worry on cardiovascular response to phobic imagery. *Behaviour Research and Therapy, 28,* 69-73. doi: 10.1016/0005-7967(90)90056-O

Borkovec, T. D., & Inz, J. (1990). The nature of worry in generalized anxiety disorder: A predominance of thought activity. *Behaviour Research and Therapy*, *28*, 153-158. doi:10.1016/0005-7967(90)90027-G

Borkovec, T. D., Ray, W. J., & Stöber, J. (1998). Worry: A cognitive phenomenon intimately linked to affective, physiological, and interpersonal behavioral processes. *Cognitive Therapy and Research, 22*, 561-576. doi:10.1023/A:1018790003416

Borkovec, T. D., Robinson, E., Pruzinsky, T., & DePree, J. A. (1983). Preliminary exploration of worry: Some characteristics and processes. *Behaviour Research and Therapy*, *21*, 9-16. doi:10.1016/0005-7967(83)90121-3

Borkovec, T. D., Wilkinson, L., Folensbee, R., & Lerman, C. (1983). Stimulus control applications to the treatment of worry. *Behaviour Research and Therapy*, *21*, 247-251. doi:10.1016/0005-7967(83)90206-1

Brewin, C. R., & Smart, L. (2005). Working memory capacity and suppression of intrusive thoughts. *Journal of Behavior Therapy and Experimental Psychiatry, 36*, 61-68. doi:10.1016/j.jbtep.2004.11.006

Brown, T. A. (1997). The nature of generalized anxiety disorder and pathological worry: current evidence and conceptual models. *Canadian Journal of Psychiatry, 42*, 817-825.

Brown, T. A., Antony, M. M., & Barlow, D. H. (1992). Psychometric properties of the Penn State Worry Questionnaire in a clinical anxiety disorders sample. *Behaviour Research and Therapy, 30*, 33-37. doi:10.1016/0005-7967(92)90093-V

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: Psychometric properties of the English version. *Behaviour Research and Therapy*, *40*, 931-945. doi:10.1016/S0005-7967(01)00092-4

Corsi, P. M. (1972). Human memory and the medial temporal region of the brain. *Dissertation Abstracts International*, *34*, 819.

Crowe, S. F., Matthews, C., & Walkenhorst, E. (2007). Relationship between worry, anxiety and thought suppression and the components of working memory in a non-clinical sample. *Australian Psychologist*, *42*, 170-177. doi:10.1080/00050060601089462

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, *19*, 450-466. doi:10.1016/S0022-5371(80)90312-6

Davey, G. C. (1993). A comparison of three worry questionnaires. *Behaviour Research and Therapy*, *31*, 51-56. doi:10.1016/0005-7967(93)90042-S

Davey, G. C. (1994). Worrying, social problem-solving abilities, and social problem-solving confidence. *Behaviour Research and Therapy*, *32*, 327-330. doi:10.1016/0005-7967(94)90130-9

Davey, G. C., Hampton, J., Farrell, J., & Davidson, S. (1992). Some characteristics of worrying: Evidence for worrying and anxiety as separate constructs. *Personality and Individual*

Differences, 13, 133-147. doi:10.1016/0191-8869(92)90036-O

Derryberry, D., & Reed, M. A. (2002). Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology, 111*, 225-236. doi:10.1037//0021-843X.111.2.225

Dugas, M. J., Freeston, M. H., Doucet, C., Lachance, S., & Ladouceur, R. (1995). Structured versus free-recall measures: Effects on report of worry themes. *Personality and Individual Differences, 18,* 355–362. doi:10.1016/0191-8869(94)00151-H

Dugas, M. J., Freeston, M. H., Ladouceur, R., Rhéaume, J., Provencher, M., & Boisvert, J.-M. (1998). Worry themes in primary GAD, secondary GAD, and other anxiety disorders. *Journal of Anxiety Disorders, 12,* 253–261. doi:10.1016/S0887-6185(98)00013-9

Dugas, M. J., Gagnon, F., Ladouceur, R., & Freeston, M. H. (1998). Generalized anxiety disorder: A preliminary test of a conceptual model. *Behaviour Research and Therapy, 36*, 215-226. doi:10.1016/S0005-7967(97)00070-3

Dugas, M. J., Ladouceur, R., Léger, E., Freeston, M. H., Langolis, F., Provencher, M. D., & Boisvert, J. M. (2003). Group cognitive-behavioral therapy for generalized anxiety disorder: treatment outcome and long-term follow-up. *Journal of Consulting and Clinical Psychology, 71*, 821-825. doi:10.1037/0022-006X.71.4.821

D'Zurilla, T. J., Nezu, A. M., Maydeu-Olivares, A. (2001). *Manual for the Social Problem Solving Inventory-Revised*. North Tonawanda, NY: Multi-Health Systems.

Engle, R. W., Kane, M. J., & Tuholski, S. W. (1999). Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence, and functions of the prefrontal cortex. In A. Miyake & P. Shah (Eds.), *Models of working* *memory: Mechanisms of active maintenance and executive control* (pp. 102–134). New York, NY: Cambridge University Press.

Evans, F. J. (1978). Monitoring attention deployment by random number generation index to measure subjective randomness. *Bulletin of the Psychonomic Society, 12*, 35-38. doi:10.3758/BF03329617

Evans, S., Ferrando, S., Findler, M., Stowell, C., Smart, C., & Haglin, D. (2008). Mindfulness-based cognitive therapy for generalized anxiety disorder. *Journal of Anxiety Disorders, 22*, 716-721. doi:10.1016/j.janxdis.2007.07.005

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*, 336-353. doi:10.1037/1528-3542.7.2.336

Eysenck, M. W., MacLeod, C., & Mathews, A. (1987). Cognitive functioning and anxiety. *Psychological Research, 49*, 189-195. doi:10.1007/BF00308686

Eysenck, M. W., Mogg, K., May, J., Richards, A., & Mathews, A. (1991). Bias in interpretation of ambiguous sentences related to threat in anxiety. *Journal of Abnormal Psychology, 100*, 144-150. doi:10.1037//0021-843X.100.2.144

Gohier, B., Ferracci, L., Surguladze, S. A., Lawrence, E., El Hage, W., Kefi, M. Z., ... & Le Gall, D. (2009). Cognitive inhibition and working memory in unipolar depression. *Journal of Affective Disorders, 116*, 100-105. doi:10.1016/j.jad.2008.10.028

Goldwin, M., & Behar, E. (2012). Concreteness of idiographic periods of worry and depressive rumination. *Cognitive Therapy and Research, 36*, 840-846. doi:10.1007/s10608-011-9428-1

Gosselin, P., Pelletier, O., & Ladouceur, R. (2001, July). The Negative Problem Orientation Questionnaire (NOPQ): Development and Validation among a Non-clinical Sample. *Poster presented at the meeting of the World Congress of Behavioural and Cognitive Therapies, Vancouver, BC*.

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment, 26*, 41-54. doi:*10.1007/s10862-008-9102-4.*

Grös, D. F., Antony, M. M., Simms, L. J., & McCabe, R. E. (2007). Psychometric properties of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA): Comparison to the State-Trait Anxiety Inventory (STAI). *Psychological Assessment*, *19*, 369-381. doi:10.1037/1040-3590.19.4.369

Hallion, L. S., Ruscio, A. M., & Jha, A. P. (2014). Fractionating the role of executive control in control over worry: A preliminary investigation. *Behaviour Research and Therapy, 54*, 1-6. doi:10.1016/j.brat.2013.12.002

Hancock, G. R., & Klockars, A. J. (1996). The quest for α: Developments in multiple comparison procedures in the quarter century since Games (1971). *Review of Educations Research, 66*, 269-306. doi:10.3102/00346543066003269

Hayes, S., Hirsch, C. R., Krebs, G., & Mathews, A. (2010). The effects of modifying interpretation bias on worry in generalized anxiety disorder. *Behaviour Research and Therapy, 48*, 171-178. doi:10.1016/j.brat.2009.10.006

Hayes, S., Hirsch, C., & Mathews, A. (2008). Restriction of working memory capacity during worry. *Journal of Abnormal Psychology, 117*, 712-717. doi:10.1016/j.brat.2009.10.006

Hirsch, C. R., Hayes, S., & Mathews, A. (2009). Looking on the bright side: Accessing benign meanings reduces worry. *Journal of Abnormal Psychology*, *118*, 44-54. doi:10.1037/a0013473

Hirsch, C., & Mathews, A. (1997). Interpretative inferences when reading about emotional events. *Behaviour Research and Therapy, 35*, 1123-1132. doi:10.1016/S0005-7967(97)80006-X

Hirsch, C. R., & Mathews, A. (2012). A cognitive model of pathological worry. *Behaviour Research and Therapy, 50*, 636-646. doi:10.1016/j.brat.2012.06.007

Hirsch, C. R., Mathews, A., & Clark, D. M. (2007). Inducing an interpretation bias changes self-imagery: A preliminary investigation. *Behaviour Research and Therapy*, *45, 9,* 2173-2181. doi:10.1016/j.brat.2006.11.001

Hirst, W., & Kalmar, D. (1987). Characterizing attentional resources. *Journal of Experimental Psychology: General*, *116*, 68-81. doi:10.1037/0096-3445.116.1.68

Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences*, *16*, 174-180. doi:10.1016/j.tics.2012.01.006

Jacoby, R. J., Abramowitz, J. S., Buck, B. E., & Fabricant, L. E. (2014). How is the beads task related to intolerance of uncertainty in anxiety disorders? *Journal of Anxiety Disorders, 28,* 495-503. doi:10.1016/j.janxdis.2014.05.005

Jessen, F., Heun, R., Erb, M., Granath, D. O., Klose, U., Papassotiropoulos, A., & Grodd, W. (2000). The concreteness effect: Evidence for dual coding and context availability. *Brain and Language*, *74*, 103-112. doi:10.1006/brln.2000.2340

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: A latent-variable approach to verbal and visuospatial memory span and reasoning. *Journal of Experimental Psychology-General*, *133*, 189-217. doi:10.1037/0096-3445.133.2.189

Kensinger, E. A., & Corkin, S. (2003). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory and Cognition*, *31*, 1169-1180. doi:10.1037/1528-3542.3.4.378

King, J., & Just, M. A. (1991). Individual differences in syntactic processing: The role of working memory. *Journal of Memory and Language, 30*, 580-602. doi:10.1016/0749-596X(91)90027-H

Koerner, N., Dugas, M.J., Gosselin, P., & Langlois, F. (2013, May). A preliminary test of the intolerance of uncertainty model of generalized anxiety disorder. In Michel Dugas (Chair), symposium presented at the meeting of the Canadian Association of Cognitive and Behavioural Therapies, Montreal, QC.

Kounios, J., & Holcomb, P. J. (1994). Concreteness effects in semantic processing: ERP evidence supporting dual-coding theory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 804-823. doi:10.1037/0278-7393.20.4.804

Ladouceur, R., Dugas, M. J., Freeston, M. H., Léger, E., Gagnon, F., & Thibodeau, N. (2000). Efficacy of a cognitive–behavioral treatment for generalized anxiety disorder: Evaluation in a controlled clinical trial. *Journal of Consulting and Clinical Psychology, 68*, 957-964. doi:10.1037/0022-006X.68.6.957

Ladouceur, R., Talbot, F., & Dugas, M. J. (1997). Behavioral expressions of intolerance of uncertainty in worry experimental findings. *Behavior Modification, 21*, 355-371. doi:10.1177/01454455970213006

Leigh, E., & Hirsch, C. R. (2011). Worry in imagery and verbal form: Effect on residual working memory capacity. *Behaviour Research and Therapy, 49*, 99-105. doi:10.1016/j.brat.2010.11.005

MacDonald, M. C., Just, M. A., & Carpenter, P. A. (1992). Working memory constraints on the processing of syntactic ambiguity. *Cognitive Psychology*, *24*, 56-98. doi:10.1016/0010-0285(92)90003-K

MacLeod, C., & Cohen, I. L. (1993). Anxiety and the interpretation of ambiguity: A text comprehension study. *Journal of Abnormal Psychology*, *102*, 238-247. doi:10.1037/0021-843X.102.2.238

Mathews, A., Ridgeway, V., Cook, E., & Yiend, J. (2007). Inducing a benign interpretational bias reduces trait anxiety. *Journal of Behavior Therapy and Experimental Psychiatry, 38*, 225-236. doi:10.1016/j.jbtep.2006.10.011

McLaughlin, K. A., Borkovec, T. D., & Sibrava, N. J. (2007). The effects of worry and rumination on affect states and cognitive activity. *Behavior Therapy*, *38*, 23-38. doi:10.1016/j.beth.2006.03.003

McLaughlin, K. A., Mennin, D. S., & Farach, F. J. (2007). The contributory role of worry in emotion generation and dysregulation in generalized anxiety disorder. *Behaviour Research and Therapy, 45*, 1735-1752. doi:10.1016/j.brat.2006.12.004

Mennin, D. S., Heimberg, R. G., Turk, C. L., & Fresco, D. M. (2002). Applying an emotion regulation framework to integrative approaches to generalized anxiety disorder. *Clinical Psychology: Science and Practice, 9*, 85-90. doi:10.1093/clipsy.9.1.85

Mennin, D. S., Heimberg, R. G., Turk, C. L., & Fresco, D. M. (2005). Preliminary evidence for an emotion dysregulation model of generalized anxiety disorder. *Behaviour Research and Therapy, 43*, 1281-1310. doi:10.1016/j.brat.2004.08.008

Metzger, R. L., Miller, M. L., Cohen, M., Sofka, M., & Borkovec, T. D. (1990). Worry changes decision making: The effect of negative thoughts on cognitive processing. *Journal of Clinical Psychology*, *46*, 78-88. doi:10.1002/1097-4679

Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy*, *28*, 487-495. doi:10.1016/0005-7967(90)90135-6

Miller, A. E., Watson, J. M., & Strayer, D. L. (2012). Individual differences in working memory capacity predict action monitoring and the error-related negativity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*, 757-763. doi:10.1037/a0026595

Miyake, A., Carpenter, P. A., & Just, M. A. (1994). A capacity approach to syntactic comprehension disorders: Making normal adults perform like aphasic patients. *Cognitive Neuropsychology*, *11*, 671-717. doi:10.1080/02643299408251989

Molina, S., & Borkovec, T. D. (1994). The Penn State Worry Questionnaire: Psychometric properties and associated characteristics. In G. C. L. Davey & F. Tallis (Eds.), Worrying: Perspectives on theory, assessment and treatment (pp. 265–283). Oxford, UK: John Wiley and Sons.

Newman, M. G., & Llera, S. J. (2011). A novel theory of experiential avoidance in generalized anxiety disorder: A review and synthesis of research supporting a contrast avoidance model of worry. *Clinical Psychology Review*, *31*, 371-382. doi:10.1016/j.cpr.2011.01.008

Newman, M. G., Zuellig, A. R., Kachin, K. E., Constantino, M. J., Przeworski, A., Erickson, T., & Cashman-McGrath, L. (2002). Preliminary reliability and validity of the Generalized Anxiety Disorder Questionnaire-IV: A revised self-report diagnostic measure of generalized anxiety disorder. *Behavior Therapy*, *33*, 215-233. doi:10.1016/S0005-7894(02)80026-0

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. (2002). Rethinking feelings: an FMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience, 14*, 1215-1229. doi:10.1162/089892902760807212

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, *9*, 242-249. doi:10.1016/j.tics.2005.03.010

Ogniewicz, A., Dugas, M.J., Langlois, F., Gosselin, P., & Koerner, N. (in press). An adapted word-sentence association paradigm for generalized anxiety disorder and worry assessing interpretation bias. *Journal of Experimental Psychology*.

Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology*, *45*, 255–287. doi:10.1037/h0084295

Platt, J. J., & Spivack, G. (1975). Manual for the Means-Ends Problem-Solving test (MEPS): A measure of interpersonal problem solving skills. Philadelphia, PA: Hahnemann Medical College and Hospital.

Psychology Software Tools Inc. (2007). E- Prime 2.0 Professional version. Pittsburgh, PA.

Radloff, L. S. (1977). The CES-D scale A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*, 385-401. doi:10.1177/014662167700100306

Rapee, R. M. (1993). The utilisation of working memory by worry. *Behaviour Research and Therapy*, *31*, 617-620. doi:10.1016/0005-7967(93)90114-A

Ree, M. J., French, D., MacLeod, C., & Locke, V. (2008). Distinguishing cognitive and somatic dimensions of state and trait anxiety: Development and validation of the State-Trait

Inventory for Cognitive and Somatic Anxiety (STICSA). *Behavioural and Cognitive Psychotherapy*, *36*, 313-332. doi:10.1017/S1352465808004232

Robichaud, M., & Dugas, M. J. (2005a). Negative problem orientation (part I): Psychometric properties of a new measure. *Behaviour Research and Therapy*, *43*, 391-401. doi:10.1016/j.brat.2004.02.007

Robichaud, M., & Dugas, M. J. (2005b). Negative problem orientation (Part II): Construct validity and specificity to worry. *Behaviour Research and Therapy*, *43*, 403-412. doi:10.1016/j.brat.2004.02.008

Robinson, C. M., Klenck, S. C., & Norton, P. J. (2010). Psychometric properties of the Generalized Anxiety Disorder Questionnaire for DSM-IV among four racial groups. *Cognitive Behaviour Therapy*, *39*, 251-261. doi:10.1080/16506073.2010.486841

Roemer, L., & Orsillo, S. M. (2005). *Acceptance and mindfulness-based approaches to anxiety*. New York, NY: Springer.

Rose, E. J., & Ebmeier, K. P. (2006). Pattern of impaired working memory during major depression. *Journal of Affective Disorders, 90*, 149-161. doi: 10.1016/j.jad.2005.11.003

Rosen, V. M., & Engle, R. W. (1997). The role of working memory capacity in retrieval. *Journal of Experimental Psychology: General*, *126*, 211-227. doi:10.1037/0096-3445.126.3.211

Rowe, G., Hasher, L., & Turcotte, J. (2008). Age differences in visuospatial working memory. *Psychology and Aging*, *23*, 79-84. doi:10.1037/0882-7974.23.1.79

Rowe, G., Hasher, L., & Turcotte, J. (2009). Age and synchrony effects in visuospatial working memory. *Quarterly Journal of Experimental Psychology*, *62*, 1873-1880. doi:0.1080/17470210902834852

Ruscio, A. M., Borkovec, T. D., & Ruscio, J. (2001). A taxometric investigation of the latent structure of worry. *Journal of Abnormal Psychology*, *110*, 413. doi:10.1037//0021-843X.130.3.413

Ruscio, A. M., Seitchik, A. E., Gentes, E. L., Jones, J. D., & Hallion, L. S. (2011). Perseverative thought: A robust predictor of response to emotional challenge in generalized anxiety disorder and major depressive disorder. *Behaviour Research and Therapy*, *49*, 867-874. doi:10.1016/j.brat.2011.10.001

Salters-Pedneault, K., Roemer, L., Tull, M. T., Rucker, L., & Mennin, D. S. (2006). Evidence of broad deficits in emotion regulation associated with chronic worry and generalized anxiety disorder. *Cognitive Therapy and Research*, *30*, 469-480. doi:10.1007/s10608-006-9055-4

Salthouse, T. A., & Babcock, R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology*, *27*, 763-776. doi:10.1037/0012-1649.27.5.763

Schmeichel, B. J. (2007). Attention control, memory updating, and emotion regulation temporarily reduce the capacity for executive control. *Journal of Experimental Psychology: General*, *136*, 241-255. doi:10.1037/0096-3445.136.2.241

Segerstrom, S. C., Tsao, J. C., Alden, L. E., & Craske, M. G. (2000). Worry and rumination: Repetitive thought as a concomitant and predictor of negative mood. *Cognitive Therapy and Research*, *24*, 671-688. doi:10.1023/A:1005587311498

Sexton, K. A., & Dugas, M. J. (2008). The cognitive avoidance questionnaire: validation of the English translation. *Journal of Anxiety Disorders*, *22*, 355-370. doi:10.1016/j.janxdis.2007.04.005

Sexton, K. A., & Dugas, M. J. (2009). Defining distinct negative beliefs about uncertainty: Validating the factor structure of the Intolerance of Uncertainty Scale. *Psychological*

Assessment, *21*, 176-186. doi:10.1037/a0015827

Sheehan, D. V., Janavs, J., Baker, R., Harnett-Sheehan, K., Knapp, E., Sheehan, M., ... & Lepine, J. P. (1998). MINI-Mini International Neuropsychiatric Interview-English Version 5.0. 0-DSM-IV. *Journal of Clinical Psychiatry*, *59*, 34-57.

Sheehan, D. V., Lecrubier, Y., Harnett Sheehan, K., Janavs, J., Weiller, E., Keskiner, A., ... & Dunbar, G. C. (1997). The validity of the Mini International Neuropsychiatric Interview (MINI) according to the SCID-P and its reliability. *European Psychiatry*, *12*, 232-241. doi:10.1016/S0924-9338(97)83297-X

Shute, V. J. (1991). Who is likely to acquire programming skills? *Journal of Educational Computing Research*, *7*, 1-24. doi:10.2190/VQJD-T1YD-5WVB-RYPJ

Stein, D. J. (2000). Comorbidity in generalized anxiety disorder: impact and implications. *Journal of Clinical Psychiatry*, *62*, 29-34.

Stöber, J. (1998). Worry, problem elaboration and suppression of imagery: The role of concreteness. *Behaviour Research and Therapy*, *36*, 751-756. doi:10.1016/S0005-7967(98)00027-8

Stöber, J., & Borkovec, T. D. (2002). Reduced concreteness of worry in generalized anxiety disorder: Findings from a therapy study. *Cognitive Therapy and Research*, *26*, 89-96. doi:10.1023/A:1013845821848

Stokes, C., & Hirsch, C. R. (2010). Engaging in imagery versus verbal processing of worry: Impact on negative intrusions in high worriers. *Behaviour Research and Therapy*, *48*, 418-423. doi:10.1016/j.brat.2009.12.011

St Clair-Thompson, H. L., & Gathercole, S. E. (2006). Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. *Quarterly Journal of*

Experimental Psychology, 59, 745-759. doi:10.1080/17470210500162854

Szabó, M., & Lovibond, P. F. (2006). Worry episodes and perceived problem solving: A diary-based approach. *Anxiety, Stress, and Coping*, *19*, 175-187. doi:10.1080/10615800600643562

Tabachnick, B. G., & Fidell, L. S. (2012). *Using multivariate statistics (6th ed.)*. Boston, MA: Pearson Education.

Tallis, F., Davey, G. C. L., & Capuzzo, N. (1994). The phenomenology of nonpathological worry: A preliminary investigation. In G.C.L. Davey & F. Tallis (Eds.), *Worrying: Perspectives on theory assessment and treatment* (pp. 61-89). Chichester, UK: John Wiley and Sons.

Tallis, F., Eysenck, M., & Mathews, A. (1991). Elevated evidence requirements and worry. *Personality and Individual Differences*, *12,* 21-27. doi:10.1016/0191-8869(91)90128-X

Thayer, J. F., Friedman, B. H., & Borkovec, T. D. (1996). Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry*, *39*, 255-266. doi:10.1016/0006-3223(95)00136-0

Towse, J. N. (1998). On random generation and the central executive of working memory. *British Journal of Psychology, 89*, 77-101. doi:10.1111/j.2044-8295.1998.tb02674.x

Towse, J.N., & Neil, D. (1998). Analyzing human random generation behavior: A review of methods used and a computer program for describing performance. *Behavior Research Methods, Instruments, & Computers*, *30*, 583-591. doi:10.3758/BF03209475

Trope, Y., & Liberman, N. (2003). Temporal construal. *Psychological Review*, *110*, 403-421. doi:10.1037/0033-295X.110.3.403

Vandierendonck, A., De Vooght, G., & Van der Goten, K. (1998). Does random time interval generation interfere with working memory executive functions? European Journal of Cognitive Psychology, *10*, 413-422. doi:10.1080/713752284

Vandierendonck, A., Kemps, E., Fastame, M. C., & Szmalec, A. (2004). Working memory components of the Corsi blocks task. *British Journal of Psychology, 95*, 57-79. doi:10.1348/000712604322779460

Watkins, E. R. (2008). Constructive and unconstructive repetitive thought. *Psychological Bulletin, 134,*163-206. doi:10.1037/0033-2909.134.2.163

Watkins, E., Moulds, M., & Mackintosh, B. (2005). Comparisons between rumination and worry in a non-clinical population. *Behaviour Research and Therapy*, *43*, 1577-1585. doi:10.1016/j.brat.2004.11.008

Wechsler, D. (1997). *Wechsler Memory Scale* (3rd ed.). San Antonio, TX: Pearson Assessment.

Wells, A. (1999). A metacognitive model and therapy for generalized anxiety disorder. *Clinical Psychology and Psychotherapy*, *6*, 86-95.

Wells, A., & Cartwright-Hatton, S. (2004). A short form of the metacognitions questionnaire: properties of the MCQ-30. *Behaviour Research and Therapy*, *42*, 385-396. doi:10.1016/S0005-7967(03)00147-5

Williams, M. O., Mathews, A., & Hirsch, C. R. (2014). Verbal worry facilitates attention to threat in high-worriers. *Journal of Behavior Therapy and Experimental Psychiatry, 45*, 8-14. doi:10.1016/j.jbtep.2013.05.006

York, D., Borkovec, T. D., Vasey, M., & Stern, R. (1987). Effects of worry and somatic anxiety induction on thoughts, emotion and physiological activity. *Behaviour Research and Therapy, 25*, 523-526. doi:10.1016/0005-7967(87)90060-X