Impaired Disengagement from Worry:
Dissociating the Impacts of Valence and Internally-directed Attention

by

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Contemporary cognitive models of "uncontrollable" worry tend to emphasize negative valence in explaining impaired disengagement, while overlooking other potentially influential characteristics of worry, such as the internal orientation of attention. Despite a distinction in the basic cognitive neuroscience literature between internally-directed attention (e.g., to thoughts) and externally-directed attention (e.g., to external sensory stimuli), no prior studies on worry have experimentally dissociated stimulus valence and attentional direction as potential mechanisms of the cognitive impact of worry. The present study independently manipulated these dimensions to dissociate the contribution of each to impairments in sustained attention.

Participants were randomized to condition in a 2 (negative or neutral valence) x 2 (internally- or externally-directed attention) between-subjects, experimental and prospective design. After a baseline sustained attention assessment, participants alternated engaging in their assigned attention manipulation and a validated sustained attention task. To assess the predictive utility of in-lab attention performance for prospectively predicting response to a salient, ecologically valid stressor for our student sample, trait worry and distress were collected at the time of the in-lab visit (T1) and during a naturalistic stressor (the week before final exams; T2).

There was a main effect of internally-directed attention and an interaction between negative and internally-directed attention, both indicating impaired sustained attention following induction. The negative-internal (worry) group showed faster, more erroneous performance following the

induction compared to the slower, more accurate performance in the neutral-internal group, replicating findings from our previous work. Trait worry did not moderate any effects. Sustained attention at T1 did not predict distress or worry in the face of a T2 naturalistic stressor.

These findings augment the literature on the attentional consequences of worry and replicate and extend a previous finding from our group of altered speed-accuracy tradeoffs in the context of experimentally-induced worry. Due to its position at the intersection of ability and strategy, attention to this tradeoff may offer novel insights relevant to theoretical and clinical conceptualizations of worry. This study also provides evidence linking impaired disengagement to internally-directed thought more generally, which could inform the design of future investigations into subjective difficulties with attentional control and unwanted, uncontrollable thought.

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1.0 Introduction

Uncontrollable worry, which is a persistent form of anxious, apprehensive thought about the future, is one of the central diagnostic features of generalized anxiety disorder (GAD; American Psychiatric Association & American Psychiatric Association, 2013), a relatively prevalent condition that can be associated with severe impairment in role functioning (Ruscio et al., 2017). Even in non-clinical samples, “high worriers” who do not meet diagnostic criteria for GAD often characterize their worry as uncontrollable, and experience associated distress and impairment (Ruscio, 2002). Despite the substantial adverse impact of uncontrollable worry, however, the mechanisms that underlie difficulty disengaging from worry remain unclear.

When and why is worry maintained despite attempts to control it? The cognitive model of pathological worry (Hirsch & Mathews, 2012) asserts that impaired disengagement occurs as a result of an imbalance between automatic "bottom-up" and controlled "top-down" influences on attention. According to this framework, processing styles that favor negative content (such as an attentional bias for threat) increase the likelihood that worry-provoking stimuli will intrude into consciousness. Once this material has entered awareness, those same biases will tend to intensify attention toward the more salient negative content and draw focus away from the intended (benign) target of attention. If the available level of top-down control is insufficient to recenter the original object of focus, then attentional resources will be fully redirected to support a worry episode, and disengagement (ability to stop worrying) will be markedly impaired. Predictions that follow from this theory include a relationship between higher levels of trait worry and lower attentional control, particularly while individuals are actively worrying.

Evidence from subjective assessments such as thought probes paints a picture that is broadly consistent with predictions of Hirsch and Mathews' (2012) cognitive model. One study that matched participants with and without GAD on trait worry severity found that, while worry was equally frequent and intense across groups following an experimental worry induction, participants with GAD experienced less subjective control over worry intrusions after being instructed to stop worrying in order to focus on their breath (Ruscio & Borkovec, 2004). A more recent study using a similar design found that while participants with and without GAD experienced an increase in self-reported worry and rumination and distraction by internal thoughts after worrying, participants with GAD reported a stronger decrease in focus during a subsequent cognitive task compared to healthy controls (Makovac et al., 2016).

In contrast to this consistent pattern of subjective (self-reported) cognitive impairment following experimentally-induced worry, with more pronounced subjective effects for individuals with GAD, findings from studies that use computerized cognitive tasks to assess cognitive functioning have been more mixed. Several studies that experimentally manipulated thought valence using a dual task approach (wherein the participant completes a cognitive task while simultaneously worrying) have found that, compared to positive thought, experimentally-induced worry hampers concurrent attentional control task performance (Hayes et al., 2008; Sari et al., 2017; Stefanopoulou et al., 2014). Some of these studies found this effect to be stronger for high versus low worriers (Hayes et al., 2008) or those with GAD compared to healthy controls (Stefanopoulou et al., 2014). However, at least one study found no effect of experimentally-induced worry nor moderation by trait worry on cognitive task performance (Tallon et al., 2016). Studies using a sequential design, in which computerized cognitive tasks follow an experimental worry induction, also frequently find a detrimental effect of worry on subsequent task performance, including working memory (Beckwé & Deroost, 2016) and sustained attention (Makovac et al., 2016) tasks. These findings are typically interpreted as indicative of incomplete or failed attempts to disengage from worry. Similarly, experimentally-induced worry (compared to neutral thought) has been linked to worse performance on subsequent computerized measures of inhibition and working memory (Hallion et al., 2014), as well as worse sustained attention (compared to neutral verbal stimuli; Hallion et al., 2020). Compared to positive thought, induced worry also negatively impacts contingency sensitivity (Salters-Pedneault et al., 2008). However, contrary to the predictions of the Hirsch and Mathews (2012) cognitive model, trait worry did not moderate performance in any of these studies. Taken together, findings broadly support an adverse effect of worry on cognition, with mixed results regarding the extent to which trait worry moderates these effects.

Despite the proliferation of studies examining the cognitive effects of worry, relatively little is known about the features of worry that might account for these effects. A relevant limitation shared across most experimental designs in this area is a primary emphasis on only a few major characteristics of worry, most commonly negative valence, with less attention to other dimensions that may play a role in impaired disengagement and accompanying subjective experiences of uncontrollability. In keeping with the cognitive model's emphasis on negative processing biases, the major experimental comparison conditions for worry include positive thought (Hayes et al., 2008; Sari et al., 2017; Stefanopoulou et al., 2014), neutral thought (Hallion et al., 2014), and induced relaxation (Salters-Pedneault et al., 2008; Stevens et al., 2018). Although different in valence, these non-negative comparators share an important feature with worry: they all involve the internal orientation of attention.

The reason this methodological confound matters is that there is a well-established neurobiological and psychological distinction between attention to external (perceptual) versus internal targets (Chun et al., 2011; von Bastian et al., 2020). Sometimes called "self-generated thought" or "internally-directed cognition," internal attention broadly refers to any attention directed to internal representations, thoughts, and information (Dixon et al., 2014). Examples include memory recollection, future simulation, and mind-wandering (Chun et al., 2011). Externally-oriented attention, by contrast, is defined as attention to perceptual information in the environment (e.g., visual or auditory stimuli; Chun et al., 2011). In the brain, internally-oriented attention is reliably linked to activity in a group of regions referred to as the default mode network (Andrews-Hanna et al., 2014; Buckner et al., 2008), whereas external attention is chiefly associated with activity in a set of brain regions known collectively as the dorsal attention network (Fox et al., 2006). Activity patterns in the default mode and dorsal attention networks tend to be negatively correlated (Fox et al., 2005). Moreover, higher levels of this anticorrelation have been linked to superior performance on cognitive tasks (Kelly et al., 2008; Owens et al., 2018), further underscoring the importance of this dissociation.

The internal versus external distinction is directly relevant to the subjective concentration impairments reported by worriers in their daily lives. When trying to attend to a classroom lecture or a spreadsheet on the computer screen, for example, successfully encoding to-be-learned material requires sustained attention toward external stimuli (the professor's voice and lecture slides) rather than internally-generated thoughts or images (e.g., worry or mind-wandering). Impaired ability to shift attention from internal stimuli to external stimuli may therefore be a mechanism of subjective difficulty concentrating for worriers. Critically, cognitive outcome measures favored in the literature on impaired disengagement from worry (typically visual or auditory computer tasks) require participants to engage externally-oriented attention. Difficulty on such tasks following induced thought could relate to the shift in attentional direction (internal to external), in valence (negative or positive to neutral), or in both. In this context, the sole reliance on internally-oriented comparison conditions for worry (such as positive or neutral thought) introduces a potentially influential design confound in relation to cognitive performance.

Within the brain, the guidance of attention as it relates to valence is most closely associated with a third set of regions, known as the salience network. The salience network is believed to prioritize attention allocation to the internal or external environment on the basis of detecting motivationally-relevant stimuli, such as sounds or spontaneous thoughts (Menon & Uddin, 2010; Uddin, 2015). This network includes such limbic structures as the amygdala (Uddin et al., 2019), a region strongly linked with threat detection (Öhman, 2005). The existence of separate neural mechanisms underlying detection and response to salient stimuli on the one hand, and orienting attention internally versus externally on the other hand, bolsters the argument that worry's adverse cognitive consequences may be attributable not only to its negative valence, but also because it involves internal (versus external) orientation of attention.

A pattern of findings linking worry and related forms of perseverative thought with altered functioning in the default mode and salience networks is consistent with the notion that dysfunction may relate to both attentional direction and the valence of thought content. Meta-analysis of imaging studies in participants with GAD has revealed altered structure and function in key nodes of the default mode and salience networks (Kolesar et al., 2019). Trait worry has been linked to increases in default mode network activity (Weber-Goericke & Muehlhan, 2019), and experimentally-induced worry has been associated with changes in BOLD activity in areas of the default mode and salience networks (Steinfurth et al., 2017). Furthermore, studies that have manipulated both the valence and direction of attention found results suggestive of both independent and interactive influences. The induction of an internal versus external focus in healthy participants has been shown to affect subsequent network recruitment during an external target detection task (Stern et al., 2015). Notably, this effect was more pronounced for negative internal stimuli than for positive. A related study found that compared to healthy controls, participants with obsessive-compulsive disorder showed poorer behavioral performance on an external detection task and altered neural activity following the induction of negative internal focus compared to positive internal or neutral external focus (Stern et al., 2017). Taken together, these results suggest an interplay between the direction of attention, the valence of the target of focus, and psychopathology characterized by anxious, repetitive thought (in this case, obsessions).

To our knowledge, only one study has compared the consequences of induced worry with those of induced externally-oriented (neutral) attention (Hallion et al., 2020), and no design to date has fully dissociated the role of attentional direction from that of valence. Moreover, despite the relative abundance of studies examining the impact of experimentally-induced worry impact on cognitive performance, no study to our knowledge has examined the predictive utility of those impacts for real-world dysfunction. In light of the findings above and the gaps in the existing literature, the aim of the present study was therefore to dissociate the impacts of valence and directional orientation of attention on subsequent sustained attention. Participants were randomly assigned to one of four conditions in a 2 (direction of attention: internal or external) x 2 (valence: negative or neutral) between-subjects factorial design. The conditions consisted of negatively-valenced, internally-oriented attention (worry); neutrally-valenced, internally-oriented attention (planning); negatively-valenced, externally-oriented attention (an auditory lexical decision task in which participants discriminated negative English words from English-sounding non-words), or neutrally-valenced, externally-oriented attention (the same auditory lexical decision task, but using neutral English words and English-sounding non-words).

An auditory task was selected for multiple reasons. Because worry is primarily verbal-linguistic (Borkovec et al., 1983) and verbal-linguistic activity is known to interfere with worry (Leigh & Hirsch, 2011; Rapee, 1993), a verbal-linguistic task allowed us to rule out differences in verbal-linguistic content as an alternative explanation for differences between conditions and to minimize potential intrusion of worry in the external conditions (Hallion et al., 2020). Post-induction performance on a (visual) sustained attention task served as the outcome measure. Because the sustained attention outcome task is visual, the use of an auditory task ensured that all conditions involved a cross-modality shift, ruling out modality as another potential confound. During the week prior to finals week at the university, participants also completed follow-up surveys on their worry and emotional distress levels to assess the predictive validity of impaired disengagement measured in the laboratory for real-world functioning.

I hypothesized that we would see a main effect of internally- versus externally-oriented attention manipulations, moderated by trait worry, such that higher levels of trait worry would predict greater deficits in sustained attention following both negative (worry) and neutral (planning) internal focus. This is in line with research linking worry with alterations in brain regions governing internally directed attention, as well as findings in other populations high in anxious, repetitive thought (e.g., OCD; Stern et al., 2017). Consistent with the prominence of attentional bias for threat in the cognitive model of worry (Hirsch & Mathews, 2012), I additionally hypothesized that this relationship would be stronger in the worry condition than the planning condition. To probe the predictive utility of lab-measured sustained attention for worry under stress, the present study also included a prospective element by collecting follow-up measures of worry and emotional distress during the week prior to final exams, a salient naturalistic stressor highly relevant to our college student sample. I hypothesized that attentional susceptibility to lab-induced worry would predict more severe worry and emotional distress during this naturalistic stressor. Hypotheses were preregistered on the Open Science Framework prior to data analysis (https://osf.io/gmj73).

2.0 Method

2.1 Participants

Participants were 200 undergraduate students (53.5% women; 0.5% non-binary) recruited from the introductory psychology participant pool at a large, Eastern university. This sample was 83% Caucasian, 8.5% African American, 2.5% Asian, 5.5% biracial, and 0.5% other race; 0.04% of the sample identified as Latinx. All participants were native English speakers aged 18 years or older with normal or corrected-to-normal vision and hearing. Participants were excluded from participation if they reported any of the following: history of epilepsy or head trauma including loss of consciousness for more than five minutes in the preceding 6 months; history of serious mental illness such as bipolar or psychotic disorder; current use (past 24 hours) of benzodiazepine or stimulant medications; prior participation in a similar, earlier experiment by our research group.

2.2 Materials

2.2.1 Experimental apparatus

The experiment was administered on Dell computers running E-Prime version 2.0. Initial self-report questionnaires were completed on laboratory computers using Qualtrics, which is a password-protected and encrypted data collection system. Follow-up questionnaires were accessed through a personalized Qualtrics link sent via email and completed on the participant's personal laptop, tablet, or smartphone.

2.2.2 Attention manipulations

Participants were randomly assigned to complete one of four experimental conditions. In each experimental condition, participants completed five sets each of a two-minute experimental induction, followed by a two-minute sustained attention task. The experimental inductions were as follows:

2.2.2.1 Internal focus, neutral valence (planning)

Participants assigned to this condition were instructed to identify two neutral autobiographical planning scenarios (adapted from Speer et al., 2014). To elicit neutral planning topics, participants were first provided with a list of neutral thought topics and asked to identify two topics that relate to tasks they will likely engage in at some future time (e.g. grocery shopping, bedtime routine). To confirm appropriateness of the thought topic, participants were then asked whether the candidate task was viewed as positive, negative, or neutral, and then were separately asked how thinking about the topic made them feel, on a scale of 1 ("neither good nor bad") to 4 ("very good or bad"). Only topics characterized as "neutral" and rated as a 1 or 2 on feeling were approved for use. During these blocks, participants engaged in one of their approved neutral planning tasks while passively viewing a fixation cross in the middle of the computer screen.

2.2.2.2 Internal focus, negative valence (worry)

Participants assigned to this condition were instructed to worry about a currently pertinent topic, as they would worry about it in everyday life, but "as intensely as you can" (see Hallion & Ruscio, 2013; McLaughlin et al., 2007). A worry was defined by the experimenter as "an intrusive thought or image about potential future events or catastrophes that produce negative feelings when they occur," and examples were provided of an upcoming exam or a potential fight with a friend. During these blocks, participants were told to focused on their worry topic while passively viewing a fixation cross in the middle of the computer screen.

2.2.2.3 External focus, negative valence (lexical decision task)

Participants assigned to the negative externally-directed attention condition heard instructions to discriminate English words from English-sounding psuedowords via computer keyboard response. While listening to the stimuli, participants were instructed to passively view a fixation cross in the middle of the computer screen and then indicate via keyboard press if the stimulus was a real English word or a pseudoword. Each block consisted of 48 trials and comprised approximately 50% words versus non-words. Negatively-valenced English words were selected from the Affective Norms for the English Language Database (ANEW; Bradley & Lang, 1999). Pseudowords were selected from Olson and colleagues (2001). All lexical decision task stimuli can be seen in Table 37.

2.2.2.4 External focus, neutral valence (lexical decision task)

Participants assigned to the neutral externally-directed attention condition performed a task identical to that described above in the external focus, negative valence condition, with the sole difference that the English words were selected from the Affective Norms for the English Language Database (ANEW; Bradley & Lang, 1999) on the basis of neutral valence.

2.2.3 Behavioral task

2.2.3.1 Sustained attention to response task

The Sustained Attention to Response Task (SART; Robertson et al., 1997) is a validated computerized measure of sustained attention similar to a Go/No-Go task. In the present study, the digits 1-9 were presented in pseudo-randomized order on a computer screen, with participants responding with a button press to all digits except the target 8, to which they withheld a response. Twelve No-Go (withhold response) trials occurred in each 108-trial block. All participants completed a baseline (pre-manipulation) SART block and five subsequent blocks, one immediately following each induction block.

According to mind-wandering (or “perceptual decoupling”) accounts of SART performance (Schooler et al., 2011) failures to inhibit the prepotent “go” response (commission errors) result from not attending to the identity of the stimulus. Commission errors on the SART specifically have been linked to probe-caught task-unrelated thoughts and mind wandering (e.g., Cheyne et al., 2006; Christoff et al., 2009). These errors also correlate with measures of trait absentmindedness (Cheyne et al., 2006; Robertson et al., 1997; Smilek et al., 2010). However, there also remains an active debate in the literature whether commission errors on the SART index lapses of attention beyond differences in strategic decisions about whether to favor responding quickly or accurately, known as the speed-accuracy tradeoff (Dang et al., 2018; Seli, 2016). Because such a response strategy account could explain differences in commission errors without recourse to perceptual decoupling, we have followed previous authors in calculating a skill index, which combines commission errors and response time into a single efficiency score (Seli, 2016; Seli et al., 2013). The skill index is computed as (No-Go accuracy/*M* Go response time), where No-Go accuracy = ([total No-Go trials – commission errors]/total No-Go trials)*100 (Seli, 2016) and allows performance comparisons that control for differences in speed. Since the scaling of the skill index ratio is arbitrary, we multiplied this value by 100 to facilitate presentation of analytic results. To permit a more direct comparison to the extant experimental literature on worry and cognitive task performance, analyses were also performed with commission errors and response time as separate outcomes.

2.2.4 Self-report measures

2.2.4.1 Trait worry

The Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990) consists of 16 self-report items reflecting the frequency, intensity, and uncontrollability of worry on a 6-point Likert scale, ranging from 1 (“not at all typical of me”) to 5 (“very typical of me”). The PSWQ is a widely-used measure of trait-like worry with strong psychometric properties (Molina & Borkovec, 1994).

2.2.4.2 Distress

The Depression, Anxiety, and Stress Scale short form (DASS-21; Lovibond & Lovibond, 1995) is a 21-item self-report measure that assesses symptoms of depression, psychological tension, and physiological arousal over the past week, rated on a scale of 0 (“did not apply to me at all”) to 3 (“applied to me very much / most of the time”). The DASS-21 has been found to have acceptable to excellent internal consistency and concurrent validity (Antony et al., 1998; Henry & Crawford, 2005). Factor analyses have suggested that a general distress factor accounts for the majority of common variance in DASS-21 scores (Osman et al., 2012), supporting the use of the total score for this purpose.

2.2.4.3 Manipulation check

Participants rated on a 4-point Likert scale their degree of success in concentrating on their assigned attention manipulation (1 = *not at all focused* to 4 = *completely focused*) after completing the experimental task.

2.2.5 Procedure

Participation in the initial portion of this study took place within a single room in our laboratory space at the University of Pittsburgh. After providing informed consent, participants received instructions and practice in completing the attention task, followed by instructions and practice in their assigned directed-attention condition. Following an opportunity to ask clarifying questions, participants completed the baseline SART and five interleaved attention manipulation and SART blocks, the debriefing questions, and the PSWQ. In the week prior to finals week at the university, all participants received an email with a link to a Qualtrics survey asking them to complete the DASS-21 and PSWQ again (among other measures not analyzed here).

2.2.6 Analytic plan

Consistent with previous studies (Hallion et al., 2020), participants who were univariate outliers on age (≥ 3 *SD* above or below the sample mean; $N = 2$) were removed. Individual trial response times ≥ 3 SD above or below each participant's *M* response time were Winsorized (Wilcox, 2005).

As a manipulation check, we calculated each participant's average reported success in concentrating in their assigned manner during the manipulation periods. Participants whose self-reported focus during manipulations was "very distracted" or "not at all focused" ($N = 39$) were excluded from the main analyses, but their data were included in sensitivity analyses.

We pre-registered analyses which made use of multiple linear regression to predict average post-manipulation performance (skill index, commission errors, and response time [RT], respectively) from pre-manipulation performance, properties of the assigned manipulation, and trait worry. In the primary analyses, properties of the manipulation were captured via contrast codes for internal (versus external) conditions, negative (versus neutral) conditions, and the interaction of internal with negative. Secondary analyses used dummy codes for the individual conditions, with the experimental worry condition serving as the reference level.

Trial-to-trial variability has been identified as a common contributor to poor measurement properties when assessing RT and accuracy in attentional control tasks (von Bastian et al, 2020). To mitigate some of this noise, as a supplement to the pre-registered analyses based on a single estimate of average post-manipulation performance per participant, we used hierarchical linear modeling (HLM) to calculate growth curves across the 5 blocks of post-manipulation SART trials. HLM produces estimates of fixed effects, which resemble classic linear regression coefficients, as well as random effects, which relate to the degree of between-unit variation and can take the form of unique deviations from average intercepts or slopes. HLM's ability to accommodate variance at multiple levels allowed us to estimate the fixed effect of our manipulations while accounting for between-person variance within groups. The inclusion of indicators for each timepoint also allowed us to examine trajectories of performance over time, an important consideration for a faculty such as sustained attention which is known to be subject to the effects of fatigue, or the “vigilance decrement” (Al-Shargie et al., 2019).

For each of the three outcomes (commission error, RT, and skill index), we calculated a separate set of hierarchical linear models, using a forward building approach wherein parameters are added to a simple model and retained on the basis of nested model comparisons performed with a maximum likelihood ratio test. We began each build with a null (intercept-only) model to partition total outcome variance into between- and within-individual sources. We then assessed whether model fit improved based on the inclusion of indicators for linear and quadratic effects of time, baseline score, properties of the assigned manipulation, and trait worry as measured by PSWQ. The initial sets of models included contrasts looking for shared main effects of manipulation dimensions (i.e. internal versus external; negative versus neutral) and additional interactive effects (internal with negative, namely, worry). These model results indicated a low overall number of effects shared across dimensions; on the basis of this pattern and visual inspection of the plotted data, we also ran the models with dummy-codes for effects of condition, with worry as the reference group.

To analyze the follow-up data, in a set of multiple regression models, we used SART performance to predict distress and trait worry during the week prior to finals period, controlling for trait worry measured at the time of the initial in-person visit. Compared to the 159 participants retained in the main analyses, four were lost to follow-up, leaving the follow-up analyses with a total $N = 155$.

The Benjamini-Hochberg False Discovery Rate (Benjamini & Hochberg, 1995) was used to correct for multiple comparisons; each set of analyses (primary and follow-up) underwent this correction separately. Individual *p*-values for the analyses were ranked in ascending order of size; a critical value was calculated according to the formula $(i/m)*Q$, where i = rank, m = the total number of analyses, and $Q = 0.05$ (the false discovery rate). Only results with a rank equal to or smaller than that of the largest p-value which is smaller than its critical value were retained as significant.

3.0 Results

3.1 Effects of manipulation dimensions on SART skill index (HLM)

The results of the first set of hierarchical linear models predicting SART skill index are depicted in Table 1. The null model, a random effects ANOVA with a random intercept for each participant, yielded an intra-class correlation coefficient (ICC) of .48, indicating that 48% of the variance in skill index exists at the between-person level. This evidence of substantial clustering of scores within-person demonstrates the suitability of using the HLM approach to capture the dependence of within-participant observations. Model fit was significantly improved by the inclusion of a fixed effect of time in Model 1, $\chi^2(1) = 17.29$, $p < .001$, and a fixed effect of squared time (indicating nonlinearity) in Model 2, $\chi^2(1) = 18.17$, $p < .001$. Fit was further improved by the inclusion of fixed effects for baseline skill index in Model 3, $\chi^2(1) = 81.28$, $p < .001$, and contrast codes for internal versus external, negative versus neutral, and internal with negative in Model 4a, $\chi^2(3) = 14.02$, $p < .005$. Model 5a included a fixed effect of PSWQ score but did not significantly improve model fit, $\chi^2(1) = 0.12$, $p = .731$. Model 6a, which added an interaction between PSWQ score and internal versus external also failed to improve model fit, $\chi^2(1) < 0.01$, $p = .981$. Model fit did not improve following the inclusion of an interaction between PSWQ score and internal with negative, $\chi^2(1) = 0.36$, $p = .546$ in Model 7a.

Based on these model comparisons, Model 4a was selected as the best representation of the data. The negative coefficient for time, paired with the positive coefficient for time squared, indicates a general pattern across participants of skill index declining over time at a decreasing rate. Although the main effects of internal versus external and negative versus neutral were not significant, after accounting for these effects, the interaction of internal and negative was associated with a significantly lower skill index.

3.2 Effects of condition on SART skill index (HLM)

Another set of analyses of SART skill index were conducted using dummy-coded condition introduced after Model 3 (above); worry served as the reference group. The inclusion of this effect significantly improved model fit in Model 4b, χ^2 (3) = 14.02, p < .005. Model 5b included a fixed effect of PSWQ score but did not significantly improve model fit, χ^2 (1) = 0.12, p = .731. Model 6b, which added an interaction between PSWQ score and the conditions, also failed to improve model fit, χ^2 (3) = 0.66, p = .883.

Model 4b was selected as the best fit to the data. The coefficients (see Table 2) indicate a general temporal pattern of decelerating worsening performance and significantly better average performance for internal-neutral and external-negative compared to the internal-negative (worry) condition.

3.3 Effects of manipulation dimensions on SART commission errors (HLM)

The results of the first set of models predicting SART commission errors can be found in Table 3. The null model's ICC indicated that 65% of the variance in commission error can be attributed to between-person differences, confirming the suitability of using HLM to model the dependence in the data. Model fit improved with the inclusion of linear (χ^2 (1) = 29.28, p < .001) and quadratic (χ^2 (1) = 9.75, p < .001) indicators for the effect of time. Model 3 added baseline commission errors as a regressor, χ^2 (1) = 101.21, p < .001. Model 4a included contrast codes for internal versus external, negative versus neutral, and internal with negative, χ^2 (3) = 10.40, p < .015. Subsequent models were not significantly improved by the addition of PSWQ (χ^2 (1) = 1.9, p = .168), the interaction of PSWQ with internal versus external (χ^2 (1) = .25, p = .618), or the interaction of PSWQ and internal with negative (χ^2 (1) = 1.21, p = .271).

Model 4a was selected as the best fitting model. The positive coefficient for time accompanied by the negative coefficient for time squared indicate that commission errors tended to increase at a slowing rate over the course of the post-manipulation SART blocks. The positive coefficient for the main effect of internal versus external signifies that internal conditions, on average, were associated with more commission errors than external conditions. Although initially significant, the positive coefficient for negative compared to neutral conditions did not survive correction for multiple comparisons.

3.4 Effects of condition on SART commission errors (HLM)

Additional SART commission error analyses (Table 4) were conducted using dummy-coded condition introduced after Model 3. This inclusion significantly improved model fit in Model 4b, (χ^2 (3) = 10.4, p < .02). Fit was not improved by the inclusion of PSWQ (χ^2 (1) = 1.9, p = .168) or the interaction of PSWQ with condition (χ^2 (3) = 1.73, p = .631).

Model 4b was retained on the basis of model comparisons. The coefficients for time and time squared indicate a general tendency for commission errors to increase at a slowing rate over the course of the experiment. The negative coefficients associated with neutral internal, negative external, and neutral external signify that participants in all other conditions committed fewer average commission errors than those in the negative internal (worry) group.

3.5 Effects of manipulation dimensions on SART response time (HLM)

The results of the first set of models predicting SART RT can be found in Table 5. The ICC of the null model denotes that 83% of the variance in RT exists at the between-person level, justifying the use of HLM to account for the nesting of observations within participants. Model fit was not improved by the inclusion of linear (χ^2 (1) = 2.67, p = .101) or quadratic (χ^2 (1) = .15, p = .700) effects of time; the linear regressor for time was nonetheless retained to allow for the possible emergence of effects after accounting for other predictors. Model 3 improved model fit by accounting for baseline RT, χ^2 (1) = 144.66, p < .001. Model 4a added contrast codes for internal versus external, negative versus neutral, and negative with internal, χ^2 (3) = 9.31, p < .05). The inclusion of PSWQ in Model 5a also improved fit, χ^2 (1) = 4.55, p < .05. Model fit did not improve with the addition of an interaction between PSWQ and internal versus external (χ^2 (1) = 1.38, p = .239), nor with the interaction of PSWQ and negative with internal (χ^2 (1) = 1.22, p = .269).

Model 5a was selected on the basis of these model comparisons. The non-significant coefficient on the time predictor suggests that RT tended to be stable across blocks. The significant negative value for PSWQ indicates that higher levels of trait worry were associated with lower (faster) RTs. There were no main or interactive effects of the internal and negative dimensions.

3.6 Effects of condition on SART response time (HLM)

Further SART response time analyses (Table 6) were conducted using dummy-coded condition inserted after Model 3. The inclusion of condition significantly improved model fit, χ^2 (3) = 9.31, $p < .05$, as did the inclusion of PSWQ in Model 5b, χ^2 (1) = 4.55, $p < .05$. Model fit did not improve with the addition of an interaction between PSWQ and condition, χ^2 (3) = 4.43, p = .218.

Model 5b was selected as the best fit to the data. The positive coefficient for the neutral external condition signifies that this group had a slower average RT compared to the worry group. The negative value of the coefficient for PSWQ denotes the association of higher levels of trait worry with smaller (faster) RTs.

3.7 Effects of manipulation dimensions on SART skill index (multiple regression)

Prior to deciding to use HLM, we had pre-registered our intention to perform our analyses as classic regressions, using an average of the five post-manipulation blocks for each performance index as our outcome. The complete results of this analytic approach predicting SART skill index from manipulation dimensions can be seen in Table 7. The significant negative coefficient for Negative x Internal (b = -0.04) indicates that, after accounting for any separable main effects of Negative (versus Neutral) and Internal (versus External), the interaction of Negative with Internal was associated with a worse skill index. This is in line with the results from the corresponding HLM.

3.8 Effects of condition on SART skill index (multiple regression)

The complete results of this analytic approach predicting SART skill index from conditions can be seen in Table 8. The significant positive coefficients for neutral internal (planning; b = 0.03) and negative external (b = 0.02) indicate that these conditions each had a higher skill index than negative internal (worry; the reference group). However, worry did not significantly differ from neutral external in skill index in this analysis.

3.9 Effects of manipulation dimensions on SART commission errors (multiple regression)

The complete results of this analysis predicting SART commission errors from manipulation dimensions can be seen in Table 9. Apart from baseline commission errors, none of the predictors were significantly related to commission errors, diverging slightly from the HLM results.

3.10 Effects of condition on SART commission errors (multiple regression)

The complete results of this analysis predicting SART commission errors from conditions can be seen in Table 10. As in the HLM results, negative internal (worry; the reference group) had more commission errors than each of the other three conditions.

3.11 Effects of manipulation dimensions on SART response time (multiple regression)

The complete results of this analysis predicting SART response time from manipulation dimensions can be seen in Table 11. Similar to the results from the corresponding HLM, a higher PSWQ score was significantly predictive of faster post-manipulation RT (when controlling for baseline RT; b = -0.73), while none of the manipulation dimensions were significantly related.

3.12 Effects of condition on SART response time (multiple regression)

The complete results of this analysis predicting SART response time from conditions can be seen in Table 12. In this analysis, as in the corresponding HLM, the neutral external condition was found to be associated with slower post-manipulation RT (b = 32.52) compared to negative internal (worry; the reference group).

3.13 Sensitivity analyses

In order to examine the robustness of our obtained results to changes in inclusion criteria, we re-ran the primary analyses including the 39 individuals previously removed for reporting low levels of focus during their assigned attention manipulation (specifically, those who indicated they were “very distracted” or “not at all focused” during the inductions). While the models predicting skill index produced identical patterns of results to the originals, some effects observed in the models predicting commission errors and response time did not reach statistical significance when these participants were included. For the full set of coefficients obtained from these analyses, please see the Supplemental Materials.

3.14 Exploratory analyses examining possible differential relationship by gender

Tables 13 through 18 display side-by-side results obtained when performing each of the HLM models selected via model comparison above separately in women versus men, to test for effects that may differ according to gender. Differences in the model predicting skill index from manipulation dimensions (Table 13) include a significant effect of timepoint (*b* = -3.81) and timepoint^2 (*b* = 0.56) for women, following the temporal pattern of the original model, while these coefficients were not significantly different from zero in the men. The models for both genders included a significant negative coefficient for the interaction of Negative x Internal (*b* = -2.92 in the men and *b* = -4.79 in the women), similar to that found in the original model (*b* =-3.85). In the model predicting skill index from condition (Table 14), the model run in women returned a set of coefficients resembling the direction and pattern of significance seen in the original model, while the only significant association observed in the men was with baseline skill index (*b* = 0.60; compare with women's *b* = 0.66).

For the model predicting commission errors from manipulation dimensions (Table 15), women again shared the temporal patterns of the original model while the analysis in men did not show a significant relationship with time. Neither the model run in women nor men alone found the significantly higher level of commission errors associated with Internal versus External conditions from the original model. For the model predicting commission errors from condition (Table 16), the model run only in women again mimicked the coefficient pattern of the original model with the exception of a non-significant intercept, while the only significant relationship observed in men was with baseline commission errors (b = 0.66), which was similar to that in women (b = 0.65).

The model predicting RT from manipulation dimensions (Table 17) did not include a significant relationship with PSWQ in either men or women as in the original model (b = -0.67); the results for PSWQ were similar in the model predicting RT from conditions (Table 18). Neither men nor women showed a significant relationship between neutral external and post-manipulation RT, although this had been observed in the original model (b = 33.57).

3.15 Follow-up analyses

Tables 19 through 30 display the results of multiple regression analyses predicting DASS-21 and PSWQ scores at follow-up from SART indices and manipulation characteristics while controlling for baseline distress and worry. None of these analyses yielded any significant relationships between SART indices and distress or trait worry.

4.0 Discussion

The present study aimed to dissociate the relative contributions of attentional direction (internally-directed versus externally-directed) and valence (negative versus neutral) to explaining previously-documented adverse impacts of worry on cognition. The overall pattern of findings supports a main effect of attentional direction, wherein sustained attention task performance was worse (more commission errors) following a shift from internally-directed versus externally-directed attention, suggesting greater difficulty disengaging from internally-directed thought. There was also a main effect of valence (negative versus neutral) on performance, but this finding did not survive correction for multiple comparisons. While the interaction of negative valence with internal focus was associated with overall worse speed-corrected performance, this interaction did not relate to raw commission errors. However, the worry (internal-negative) group did demonstrate significantly worse performance compared to the other three experimental conditions (internal-neutral; external-negative; external-neutral) in group-based analyses.

Contrary to hypotheses, neither attentional direction nor valence interacted with trait worry to predict performance. Rather, internal (versus external) attention manipulations contributed to relatively more commission errors, with the worry group committing the most errors of all, irrespective of trait worry severity. These findings provide qualified support for the notion that disengaging from internally-oriented cognition, and worry in particular, is more difficult than shifting attention from one externally-oriented task to another. However, this pattern does not explain why some individuals (i.e., those with high trait worry) report more subjective real-world difficulty disengaging from worry than do others. Subjective self-appraisals of attentional control ability often fail to align with behavioral measures of attentional control in the context of anxiety

(Shi et al., 2019; Todd et al., 2022), suggesting that perceptions of impaired disengagement may emerge not from an actual deficit, but from a tendency of anxious individuals to judge their cognitive abilities more harshly.

The adverse impact of internally-directed attention on performance is consistent with the notion that internal focus, once initiated, resists attempts to disengage. Although impaired disengagement has been previously observed following experimentally-induced worry (Beckwé & Deroost, 2016; Hallion et al., 2014, 2020), this is the first study to our knowledge to demonstrate an adverse effect of internally-focused attention irrespective of valence. One possible interpretation, given that we used idiographic stimuli for both internal conditions compared with generic external stimuli, is that some of the observed impact may relate either to self-referential processing (Whitfield-Gabrieli & Ford, 2012) or the self-prioritization effect (Sui & Rothstein, 2019), wherein self-related stimuli more readily capture and maintain attention. While this possibility cannot be wholly discounted, it is worth noting that the word stimuli for the auditory task were not constrained to be non-self-referential: many of the terms may have been spontaneously processed in a self-referential manner (e.g., "fatigued," "coward," "agility," "easygoing"). Additionally, explicitly self-referential tasks typically include an overt self-evaluative element, such as being asked to classify whether a term or image is related or unrelated to the self (see Northoff et al., 2006). Nevertheless, future investigations would benefit from addressing these questions by explicitly tailoring both internal and external stimuli to be personally relevant, as this may more closely resemble real-life thought cues and be more likely to impact disengagement.

Another potential confound is contamination by worry intruding during the planning condition. To reduce the likelihood that any common effect of internal conditions would emerge as a result of participants in the planning group engaging in worry instead, we employed topic neutrality screening in the planning interview and made the *a priori* decision to exclude participants who described themselves as "not at all focused" or "focused but very distracted" on their assigned task. However, because we relied on subjective perceptions of focus, participants who engaged in worry about their assigned planning task may have nevertheless characterized themselves as highly focused on planning and survived this screening step for inclusion in the main dataset. More specific debriefing questions regarding thought content and form could help address this issue in future studies.

The present findings highlight the need to consider both the valence of stimuli and the direction of attention when examining impaired disengagement. Most previous research in this area has compared induced worry to differently-valenced internally-directed thought only (neutral or positive; e.g., Hayes et al., 2008; Stefanopoulou et al., 2014), which may lead to underestimation of worry's attention-disrupting effects, while comparing it to external stimuli only would confound the effects of shifting attentional direction and valence. Further research should examine how these dimensions relate to the interplay among functional brain networks relevant to internal and external attention (e.g., the default mode, dorsal attention, and salience networks). In this investigation we selected the auditory modality for our external conditions due to its desirable properties as a comparator and competitor with verbal worry; however, future investigations may also wish to vary the sensory modalities of both attention inductions and the cognitive outcome tasks to establish relevant boundary conditions.

This study replicates and extends findings from a previous investigation by our group, which compared experimentally-induced worry to a neutral-external task only (within-subjects; Hallion et al., 2020). We observed here a nearly identical pattern to the findings from that study:

responding was faster and less accurate following worry compared to neutral externally-oriented attention (i.e., a neutral auditory lexical decision task). Van vugt and Broers (2016) found a similar pattern, wherein participants performing a SART task using lexical stimuli showed faster, less accurate responding in a condition where stimuli were tailored to prime their own personal concerns compared to untailored stimuli. Fast, low-accuracy responding on the SART has been described as potentially reflecting an “autopilot” approach (Seli, 2016), wherein participants respond automatically to the regular presentation intervals rather than evaluating each stimulus. Since no-go targets are rare (roughly 11% of trials), such an automatic approach could afford longer, uninterrupted periods of task-unrelated thought while mitigating the accuracy decrement via an increase in average speed.

Alternatively, because SART performance is subject to the well-known speed-accuracy tradeoff (Heitz, 2014), it is possible that the difference in performance in the worry group could be accounted for by a shift in response strategy rather than change in ability. In other words, those in the worry group could have simply opted to favor speed over accuracy, leading to the observed pattern of results. To help examine this possibility, we computed a speed-accuracy corrected skill index (Seli et al., 2016), which aims to adjust for strategic differences. In these analyses, the worry condition was associated with worse speed-corrected performance after accounting for main effects of valence and attentional direction, but the internal conditions did not have a significant main effect, diverging somewhat from the error-based results. When examined at the level of individual conditions, the planning and negative-external groups showed better speed-corrected performance than the worry group, but the worry and the neutral external groups did not significantly differ when scores were corrected for speed of responding. As we have suggested previously (Hallion et al., 2020), decisions regarding how to balance speed and accuracy may be of interest in their own right as they pertain to worry or anxiety. In contrast, if researchers in this area wish to examine cognitive ability *per se*, future studies may wish to employ cognitive tasks which make use of response deadlines and other techniques intended to minimize the role of speed-accuracy tradeoffs (e.g., Draheim et al., 2020), given that simulation studies suggest that no integrated measure of speed and accuracy is perfectly insensitive to such tradeoffs (Vandierendonck, 2021).

Contrary to hypotheses, none of the sustained attention metrics collected in-lab were predictive of worry or distress at follow-up, which took place during the week prior to university finals. This null result arguably raises challenges for the ecological validity of computerized measures of attentional control to capture subjective impairments, a question on which clinical science has received some criticism (Snyder et al., 2015) and which is currently being scrutinized in the cognitive domain (von Bastian et al., 2020). While the lack of association between manipulation dimensions and pre-finals week outcomes could have occurred because finals week was not a sufficiently strong or uniform stressor across the sample, it is also possible that the lack of association was driven by insufficient ecological validity of the in-laboratory measure or by the absence of an underlying relationship between sustained attention ability and psychological distress.

This study provides new information regarding the impact of internally-oriented thought more generally on disengagement and hints at some more specific effects associated with negative internal thought (worry) specifically. Given the accumulating evidence linking patterns of speed and accuracy to worry and similar thought such as rumination, future research should more directly explore speed-accuracy tradeoffs in relation to worry and closely-related phenomena like anxiety. Other considerations may include the level of personal identification with attention stimuli and the role of other influences (such as increased fatigue or boredom in certain conditions). Imaging work linking differential patterns of performance with brain and, in particular, network activity is also needed to further our understanding of the biological substrates of impaired and successful disengagement.

Table 1 Predicting Post-Manipulation Skill Index by Manipulation Dimensions

	Model 1		Model 2		Model 3		Model 4a		Model 5a		Model 6a		Model 7a	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	20.16 ***	0.47	22.79 ***	0.77	10.19 ***	1.43	10.42 ***	1.39	10.45 ***	1.40	10.45 ***	1.40	10.53 ***	1.41
timepoint	-0.44 ***	0.11	-2.69 ***	0.54	-2.69 ***	0.54	-2.69 ***	0.54	-2.69 ***	0.54	-2.69 ***	0.54	-2.69 ***	0.54
$timepoint^2$			0.38 ***	0.09	0.38 ***	0.09	0.38 ***	0.09	0.38 ***	0.09	0.38 ***	0.09	0.38 ***	0.09
Baseline Skill Index					0.64 ***	0.06	0.63 ***	0.06	0.63 ***	0.06	0.63 ***	0.06	0.63 ***	0.06
Internal > External							-0.41	0.53	-0.43	0.54	-0.43	0.54	-0.42	0.54
Negative > Neutral							-0.84	0.53	-0.84	0.53	-0.84	0.54	-0.80	0.54
Negative x Internal							-3.85 ***	1.07	-3.89 ***	1.08	-3.89 ***	1.08	-3.87 ***	1.08
PSWQ									0.01	0.02	0.01	0.02	0.01	0.02
Int > Ext x PSWQ											0.00	0.04	-0.00	0.04
NegXInt x PSWQ													-0.04	0.07
Random Effects														
σ^2	17.52		17.02		17.02		17.02		17.02		17.02		17.02	
τ_{00}	16.40 Subject		16.50 Subject		8.53 Subject		7.53 Subject		7.52 Subject		7.52 Subject		7.49 Subject	
N	159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject	

Note. PSWQ = Penn State Worry Questionnaire. Int > Ext = Internal > External. NegXInt = Negative X Internal.

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Table 2 Predicting Post-Manipulation Skill Index by Condition

	Model 1		Model 2		Model 3		Model 4b		Model 5b		Model 6b	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	20.16 ***	0.47	22.79 ***	0.77	10.19 ***	1.43	8.84 ***	1.47	8.84 ***	1.47	9.05 ***	1.51
timepoint	-0.44 ***	0.11	-2.69 ***	0.54	-2.69 ***	0.54	-2.69 ***	0.54	-2.69 ***	0.54	-2.69 ***	0.54
timepoint^2			0.38 ***	0.09	0.38 ***	0.09	0.38 ***	0.09	0.38 ***	0.09	0.38 ***	0.09
Baseline Skill Index					0.64 ***	0.06	0.63 ***	0.06	0.63 ***	0.06	0.62 ***	0.06
Neutral Internal							2.76 ***	0.81	2.79 ***	0.82	2.67 **	0.83
Negative External							2.33 **	0.76	2.38 **	0.77	2.28 **	0.78
Neutral External							1.24	0.76	1.27	0.76	1.16	0.78
PSWQ									0.01	0.02	-0.02	0.04
Neut. Int. x PSWQ											0.04	0.05
Neg. Ext. x PSWQ											0.03	0.05
Neut. Ext. x PSWQ											0.02	0.05
Random Effects												
σ^2	17.52		17.02		17.02		17.02		17.02		17.02	
τ_{00}	16.40 Subject		16.50 Subject		8.53 Subject		7.53 Subject		7.52 Subject		7.47 Subject	
N	159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject	

Note. PSWQ = Penn State Worry Questionnaire.

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Table 3 Predicting Post-Manipulation Commission Errors by Manipulation Dimensions

	Model 1		Model 2		Model 3		Model 4a		Model 5a		Model 6a		Model 7a	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	3.36 ***	0.23	2.61 ***	0.33	0.34	0.36	0.36	0.35	0.36	0.35	0.34	0.36	0.33	0.35
timepoint	0.22 ***	0.04	0.86 ***	0.21	0.86 ***	0.21	0.86 ***	0.21	0.86 ***	0.21	0.86 ***	0.21	0.86 ***	0.21
$timepoint^2$			-0.11 **	0.03	-0.11 **	0.03	-0.11 **	0.03	-0.11 **	0.03	-0.11 **	0.03	-0.11 **	0.03
Baseline Commission Errors					0.65 ***	0.05	0.66 ***	0.05	0.65 ***	0.05	0.66 ***	0.05	0.66 ***	0.05
Internal > External							0.61 *	0.27	0.56 *	0.27	0.55 *	0.27	0.54 *	0.27
Negative > Neutral							0.54 *	0.27	0.53	0.27	0.52	0.27	0.47	0.27
Negative x Internal							0.89	0.54	0.81	0.54	0.80	0.54	0.78	0.54
PSWQ									0.01	0.01	0.01	0.01	0.01	0.01
Int > Ext x PSWQ											0.01	0.02	0.01	0.02
NegXInt x PSWQ													0.04	0.04
Random Effects														
σ^2	2.61		2.57		2.57		2.57		2.57		2.57		2.57	
τ_{00}	5.16 Subject		5.17 Subject		2.49 Subject		2.30 Subject		2.27 Subject		2.27 Subject		2.24 Subject	
N	159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject	

Note. PSWQ = Penn State Worry Questionnaire.

* *p<0.05* ** *p<0.01* *** *p<0.001*

Table 4 Predicting Post-Manipulation Commission Errors by Condition

	Model 1		Model 2		Model 3		Model 4b		Model 5b		Model 6b	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	3.36 ***	0.23	2.61 ***	0.33	0.34	0.36	1.15 **	0.44	1.10 *	0.44	1.05 *	0.44
timepoint	0.22 ***	0.04	0.86 ***	0.21	0.86 ***	0.21	0.86 ***	0.21	0.86 ***	0.21	0.86 ***	0.21
timepoint^2			-0.11 **	0.03	-0.11 **	0.03	-0.11 **	0.03	-0.11 **	0.03	-0.11 **	0.03
Baseline Commission Errors					0.65 ***	0.05	0.66 ***	0.05	0.65 ***	0.05	0.66 ***	0.05
Neutral Internal							-0.98 *	0.41	-0.94 *	0.41	-0.89 *	0.42
Negative External							-1.05 **	0.39	-0.96 *	0.39	-0.97 *	0.40
Neutral External							-1.15 **	0.38	-1.09 **	0.39	-1.04 **	0.39
PSWQ									0.01	0.01	0.02	0.02
Neut. Int. x PSWQ											-0.01	0.03
Neg. Ext. x PSWQ											-0.03	0.03
Neut. Ext. x PSWQ											-0.00	0.03
Random Effects												
σ^2	2.61		2.57		2.57		2.57		2.57		2.57	
τ_{00}	5.16 Subject		5.17 Subject		2.49 Subject		2.30 Subject		2.27 Subject		2.24 Subject	
N	159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject	

Note. PSWQ = Penn State Worry Questionnaire.

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Table 5 Predicting Post-Manipulation RT by Manipulation Dimensions

	Model 1		Model 2		Model 3		Model 4a		Model 5a		Model 6a		Model 7a	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	362.34 ***	8.31	359.88 ***	10.49	87.02 ***	18.89	83.43 ***	18.53	86.17 ***	18.33	81.58 ***	18.68	81.91 ***	18.63
timepoint	-1.77	1.08	0.34	5.59	-1.77	1.08	-1.77	1.08	-1.77	1.09	-1.77	1.09	-1.77	1.09
$timepoint^2$			-0.35	0.91										
Baseline RT					0.75 ***	0.05	0.76 ***	0.05	0.75 ***	0.05	0.77 ***	0.05	0.77 ***	0.05
Internal > External							-21.56 *	9.60	-18.70	9.56	-18.56	9.53	-18.23	9.50
Negative > Neutral							-15.23	9.57	-14.86	9.44	-13.63	9.46	-12.08	9.54
Negative x Internal							21.45	19.15	25.79	19.00	26.15	18.93	26.86	18.88
PSWQ									-0.67 *	0.31	-0.70 *	0.31	-0.73 *	0.31
Int > Ext x PSWQ											-0.76	0.64	-0.83	0.65
NegXInt x PSWQ													-1.37	1.25
Random Effects														
σ^2	1850.17		1849.75		1850.12		1850.14		1850.15		1850.16		1850.15	
τ_{00}	8901.75 Subject		8901.62 Subject		3362.81 Subject		3150.44 Subject		3050.95 Subject		3021.26 Subject		2995.40 Subject	
N	159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject	

* *p<0.05* ** *p<0.01* *** *p<0.001*

Table 6 Predicting Post-Manipulation RT by Condition

	Model 1		Model 2		Model 3		Model 4b		Model 5b		Model 6b	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	362.34 ***	8.31	359.88 ***	10.49	87.02 ***	18.89	70.40 ***	21.15	75.83 ***	21.02	71.79 ***	21.10
timepoint	-1.77	1.08	0.34	5.59	-1.77	1.08	-1.77	1.08	-1.77	1.09	-1.77	1.09
$timepoint^2$			-0.35	0.91								
Baseline RT					0.75 ***	0.05	0.76 ***	0.05	0.75 ***	0.05	0.77 ***	0.05
Neutral Internal							4.50	14.56	1.97	14.41	1.23	14.52
Negative External							10.83	13.63	5.81	13.65	8.27	13.75
Neutral External							36.78 **	13.60	33.57 *	13.50	32.52 *	13.60
PSWQ									-0.67 *	0.31	-0.92	0.72
Neut. Int. x PSWQ											-0.25	0.93
Neg. Ext. x PSWQ											1.33	0.95
Neut. Ext. x PSWQ											-0.11	0.95
Random Effects												
σ^2	1850.17		1849.75		1850.12		1850.14		1850.15		1850.16	
τ_{00}	8901.75 Subject		8901.62 Subject		3362.81 Subject		3150.44 Subject		3050.95 Subject		2956.87 Subject	
N	159 Subject		159 Subject		159 Subject		159 Subject		159 Subject		159 Subject	

Note. PSWQ = Penn State Worry Questionnaire.

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Table 7 Predicting Post-Manipulation Skill Index by Manipulation Dimensions

	Post-Manipulation Skill Index		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.07	0.04 – 0.09	**<0.001**
Baseline Skill Index	0.61	0.49 – 0.74	**<0.001**
PSWQ	0.00	-0.00 – 0.00	0.785
Negative > Neutral	-0.01	-0.02 – 0.00	0.162
Internal > External	-0.00	-0.01 – 0.01	0.537
Negative x Internal	-0.04	-0.06 – -0.02	**<0.001**
Internal > External x PSWQ	-0.00	-0.00 – 0.00	0.943
Negative x Internal X PSWQ	-0.00	-0.00 – 0.00	0.494
R^2 / R^2 adjusted	0.446 / 0.421		

Table 8 Predicting Post-Manipulation Skill Index by Condition

	Post-Manipulation Skill Index		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.05	0.03 – 0.08	**<0.001**
Baseline Skill Index	0.61	0.49 – 0.74	**<0.001**
PSWQ	-0.00	-0.00 – 0.00	0.589
Neutral Internal	0.03	0.01 – 0.04	**0.002**
Negative External	0.02	0.01 – 0.04	**0.006**
Neutral External	0.01	-0.01 – 0.03	0.184
Neut. Int. x PSWQ	0.00	-0.00 – 0.00	0.377
Neg. Ext. x PSWQ	0.00	-0.00 – 0.00	0.557
Neut. Ext. x PSWQ	0.00	-0.00 – 0.00	0.634
R^2 / R^2 adjusted	0.448 / 0.418		

Table 9 Predicting Post-Manipulation Commission Errors by Manipulation Dimensions

	Post-Manipulation Commission Errors		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	8.68	6.34 – 11.02	**<0.001**
Baseline Commission Errors	3.28	2.74 – 3.82	**<0.001**
PSWQ	0.07	-0.02 – 0.16	0.143
Negative > Neutral	2.39	-0.36 – 5.15	0.088
Internal > External	2.69	-0.06 – 5.44	0.055
Negative x Internal	3.97	-1.48 – 9.42	0.153
Internal > External x PSWQ	0.05	-0.13 – 0.24	0.566
Negative x Internal X PSWQ	0.20	-0.16 – 0.56	0.281
R^2 / R^2 adjusted	0.514 / 0.492		

Table 10 Predicting Post-Manipulation Commission Errors by Condition

	Post-Manipulation Commission Errors		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	12.32	8.75 – 15.90	**<0.001**
Baseline Commission Errors	3.29	2.74 – 3.83	**<0.001**
PSWQ	0.11	-0.10 – 0.32	0.286
Neutral Internal	-4.51	-8.74 – -0.28	**0.037**
Negative External	-4.87	-8.87 – -0.87	**0.017**
Neutral External	-5.21	-9.17 – -1.24	**0.010**
Neut. Int. x PSWQ	-0.05	-0.32 – 0.22	0.723
Neg. Ext. x PSWQ	-0.14	-0.41 – 0.13	0.302
Neut. Ext. x PSWQ	-0.00	-0.27 – 0.27	0.980
R^2 / R^2 adjusted	0.515 / 0.489		

Table 11 Predicting Post-Manipulation RT by Manipulation Dimensions

	Post-Manipulation RT		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	76.56	39.59 – 113.53	**<0.001**
Baseline RT	0.77	0.67 – 0.87	**<0.001**
PSWQ	-0.73	-1.36 – -0.10	**0.024**
Negative > Neutral	-12.12	-31.34 – 7.11	0.215
Internal > External	-18.21	-37.36 – 0.95	0.062
Negative x Internal	26.77	-11.29 – 64.83	0.167
Internal > External x PSWQ	-0.83	-2.13 – 0.47	0.211
Negative x Internal X PSWQ	-1.38	-3.89 – 1.14	0.282
R^2 / R^2 adjusted	0.637 / 0.620		

Table 12 Predicting Post-Manipulation RT by Manipulation Condition

	Post-Manipulation RT		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	66.42	24.28 – 108.57	**0.002**
Baseline RT	0.77	0.67 – 0.86	**<0.001**
PSWQ	-0.92	-2.39 – 0.54	0.214
Neutral Internal	1.30	-28.04 – 30.64	0.930
Negative External	8.29	-19.51 – 36.09	0.557
Neutral External	32.52	5.03 – 60.01	**0.021**
Neut. Int. x PSWQ	-0.25	-2.13 – 1.64	0.797
Neg. Ext. x PSWQ	1.33	-0.59 – 3.25	0.173
Neut. Ext. x PSWQ	-0.11	-2.02 – 1.81	0.911
R^2 / R^2 adjusted	0.641 / 0.622		

Table 13 Skill Index by Manipulation Dimensions, Separated by Gender

	Model 4a		**Model 4a - Women**		**Model4a - Men**	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	10.42 ***	1.39	11.29 ***	1.93	9.33 ***	2.03
timepoint	-2.69 ***	0.54	-3.81 ***	0.77	-1.41	0.74
$timepoint^2$	0.38 ***	0.09	0.56 ***	0.13	0.16	0.12
Baseline Skill Index	0.63 ***	0.06	0.66 ***	0.08	0.60 ***	0.09
Internal > External	-0.41	0.53	-0.44	0.79	-0.25	0.71
Negative > Neutral	-0.84	0.53	-1.28	0.79	-0.45	0.71
Negative x Internal	-3.85 ***	1.07	-4.79 **	1.58	-2.92 *	1.42
Random Effects						
σ^2	17.02		18.52		15.00	
τ_{00}	7.53 $_{Subject}$		8.77 $_{Subject}$		5.92 $_{Subject}$	
N	159 $_{Subject}$		85 $_{Subject}$		74 $_{Subject}$	

* *p<0.05* ** *p<0.01* *** *p<0.001*

Table 14 Skill Index by Condition, Separated by Gender

	Model 4b		Model 4b - Women		Model4b - Men	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	8.84 ***	1.47	9.24 ***	2.08	8.25 ***	2.10
timepoint	-2.69 ***	0.54	-3.81 ***	0.77	-1.41	0.74
$timepoint^2$	0.38 ***	0.09	0.56 ***	0.13	0.16	0.12
Baseline Skill Index	0.63 ***	0.06	0.66 ***	0.08	0.60 ***	0.09
Neutral Internal	2.76 ***	0.81	3.67 **	1.23	1.92	1.07
Negative External	2.33 **	0.76	2.83 *	1.09	1.72	1.03
Neutral External	1.24	0.76	1.72	1.10	0.71	1.02
Random Effects						
σ^2	17.02		18.52		15.00	
τ_{00}	7.53 $_{Subject}$		8.77 $_{Subject}$		5.92 $_{Subject}$	
N	159 $_{Subject}$		85 $_{Subject}$		74 $_{Subject}$	

Table 15 Commission Errors by Manipulation Dimensions, Separated by Gender

	Model 4a		Model 4a - Women		Model4a - Men	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	0.36	0.35	0.05	0.51	0.72	0.50
timepoint	0.86 ***	0.21	1.17 ***	0.28	0.51	0.31
timepoint^2	-0.11 **	0.03	-0.16 ***	0.05	-0.05	0.05
Baseline Commission Errors	0.66 ***	0.05	0.65 ***	0.08	0.66 ***	0.08
Internal > External	0.61 *	0.27	0.75	0.40	0.40	0.37
Negative > Neutral	0.54 *	0.27	0.64	0.39	0.44	0.37
Negative x Internal	0.89	0.54	1.62 *	0.78	0.03	0.74
Random Effects						
σ^2	2.57		2.48		2.65	
τ_{00}	2.30 Subject		2.55 Subject		1.92 Subject	
N	159 Subject		85 Subject		74 Subject	

Table 16 Commission Errors by Condition, Separated by Gender

	Model 4b		Model 4b - Women		Model4b - Men	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	1.15 **	0.44	1.16	0.61	1.15	0.62
timepoint	0.86 ***	0.21	1.17 ***	0.28	0.51	0.31
timepoint^2	-0.11 **	0.03	-0.16 ***	0.05	-0.05	0.05
Baseline Commission Errors	0.66 ***	0.05	0.65 ***	0.08	0.66 ***	0.08
Neutral Internal	-0.98 *	0.41	-1.45 *	0.61	-0.45	0.55
Negative External	-1.05 **	0.39	-1.56 **	0.54	-0.42	0.54
Neutral External	-1.15 **	0.38	-1.40 *	0.55	-0.84	0.54
Random Effects						
σ^2	2.57		2.48		2.65	
τ_{00}	2.30 Subject		2.55 Subject		1.92 Subject	
N	159 Subject		85 Subject		74 Subject	

Table 17 RT by Manipulation Dimensions, Separated by Gender

	Model 5a		**Model 5a - Women**		**Model5a - Men**	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	86.17 ***	18.33	84.63 ***	25.40	88.00 **	28.59
timepoint	-1.77	1.09	-1.85	1.51	-1.68	1.57
Baseline RT	0.75 ***	0.05	0.75 ***	0.07	0.75 ***	0.07
Internal > External	-18.70	9.56	-21.48	13.29	-16.29	14.40
Negative > Neutral	-14.86	9.44	-12.32	12.62	-17.96	14.33
Negative x Internal	25.79	19.00	14.43	25.43	39.18	28.79
PSWQ	-0.67 *	0.31	-0.54	0.45	-0.74	0.47
Random Effects						
σ^2	1850.15		1897.75		1795.61	
τ_{00}	3050.95 $_{Subject}$		2800.20 $_{Subject}$		3304.44 $_{Subject}$	
N	159 $_{Subject}$		85 $_{Subject}$		74 $_{Subject}$	

Table 18 RT by Condition, Separated by Gender

	Model 5b		**Model 5b - Women**		**Model5b - Men**	
Predictors	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Intercept	75.83 ***	21.02	71.33 *	29.35	80.67 *	31.97
timepoint	-1.77	1.09	-1.85	1.51	-1.68	1.57
Baseline RT	0.75 ***	0.05	0.75 ***	0.07	0.75 ***	0.07
Neutral Internal	1.97	14.41	5.11	19.63	-1.63	21.44
Negative External	5.81	13.65	14.26	18.29	-3.30	20.94
Neutral External	33.57 *	13.50	33.80	18.02	34.25	20.69
PSWQ	-0.67 *	0.31	-0.54	0.45	-0.74	0.47
Random Effects						
σ^2	1850.15		1897.75		1795.61	
τ_{00}	3050.95 $_{Subject}$		2800.20 $_{Subject}$		3304.44 $_{Subject}$	
N	159 $_{Subject}$		85 $_{Subject}$		74 $_{Subject}$	

Table 19 Predicting Follow-up DASS from Skill Index and Manipulation Dimensions

	DASS-21 Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	3.30	-5.03 – 11.62	0.435
Baseline Skill Index	-34.45	-103.91 – 35.01	0.329
Post-Manipulation Skill Index	11.51	-60.17 – 83.19	0.751
Baseline DASS	0.67	0.51 – 0.83	**<0.001**
Baseline PSWQ	0.13	-0.06 – 0.32	0.176
Negative > Neutral	-4.48	-9.44 – 0.47	0.076
Internal > External	-3.76	-8.52 – 1.00	0.121
Negative x Internal	7.10	-2.91 – 17.11	0.163
Int. > Ext. x P-M Skill Index	-16.94	-127.42 – 93.54	0.762
Neg. x Int. x P-M Skill Index	-35.91	-259.42 – 187.61	0.751
R^2 / R^2 adjusted	0.511 / 0.481		

Table 20 Predicting Follow-up DASS from Commission Errors and Manipulation Dimensions

	DASS-21 Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	3.52	-4.80 – 11.84	0.404
Baseline Commission Errors	-0.18	-1.48 – 1.11	0.779
Post-Manipulation Commission Errors	-0.07	-0.36 – 0.21	0.617
Baseline DASS	0.67	0.52 – 0.82	**<0.001**
Baseline PSWQ	0.13	-0.05 – 0.32	0.161
Negative > Neutral	-3.63	-8.41 – 1.15	0.136
Internal > External	-3.58	-8.40 – 1.25	0.145
Negative x Internal	8.41	-1.28 – 18.10	0.088
Int. > Ext. x P-M Commission Errors	-0.27	-0.67 – 0.14	0.196
Neg. x Int. x P-M Commission Errors	-0.19	-0.99 – 0.61	0.636
R^2 / R^2 adjusted	0.517 / 0.487		

Table 21 Predicting Follow-up DASS from RT and Manipulation Dimensions

	DASS-21 Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	3.77	-4.52 – 12.06	0.370
Baseline RT	0.03	-0.01 – 0.07	0.157
Post-Manipulation RT	-0.00	-0.05 – 0.04	0.807
Baseline DASS	0.65	0.51 – 0.80	**<0.001**
Baseline PSWQ	0.13	-0.05 – 0.32	0.164
Negative > Neutral	-4.54	-9.21 – 0.13	0.057
Internal > External	-4.07	-8.80 – 0.66	0.091
Negative x Internal	7.84	-1.58 – 17.27	0.102
Int. > Ext. x P-M RT	0.04	-0.01 – 0.09	0.112
Neg. x Int. x P-M RT	0.04	-0.05 – 0.14	0.369
R^2 / R^2 adjusted	0.532 / 0.503		

Table 22 Predicting Follow-up DASS from Skill Index and Conditions

	DASS-21 Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	1.07	-8.99 – 11.13	0.834
Baseline Skill Index	-32.45	-103.04 – 38.13	0.365
Post-Manipulation Skill Index	8.74	-134.67 – 152.15	0.904
Baseline DASS	0.67	0.51 – 0.83	**<0.001**
Baseline PSWQ	0.13	-0.06 – 0.33	0.170
Neutral Internal	0.83	-6.97 – 8.62	0.834
Negative External	-0.08	-7.27 – 7.11	0.982
Neutral External	7.94	0.77 – 15.11	**0.030**
Neut. Int. x P-M Skill Index	-6.50	-184.82 – 171.82	0.943
Neg. Ext. x P-M Skill Index	26.41	-147.18 – 200.00	0.764
Neut. Ext. x P-M Skill Index	-7.35	-184.13 – 169.44	0.935
R^2 / R^2 adjusted	0.512 / 0.478		

Table 23 Predicting Follow-up DASS from Commission Errors and Condition

	DASS-21 Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	2.06	-7.90 – 12.02	0.683
Baseline Commission Errors	-0.19	-1.50 – 1.12	0.772
Post-Manipulation Commission Errors	-0.26	-0.70 – 0.17	0.230
Baseline DASS	0.67	0.51 – 0.82	**<0.001**
Baseline PSWQ	0.13	-0.05 – 0.32	0.160
Neutral Internal	-0.59	-8.01 – 6.84	0.876
Negative External	-0.67	-7.62 – 6.29	0.850
Neutral External	7.18	0.21 – 14.14	**0.043**
Neut. Int. x P-M Commission Errors	0.13	-0.51 – 0.77	0.692
Neg. Ext. x P-M Commission Errors	0.36	-0.17 – 0.90	0.182
Neut. Ext. x P-M Commission Errors	0.29	-0.24 – 0.82	0.287
R^2 / R^2 adjusted	0.517 / 0.484		

Table 24 Predicting Follow-up DASS from RT and Conditions

	DASS-21 Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	1.22	-8.62 – 11.06	0.807
Baseline RT	0.03	-0.01 – 0.07	0.155
Post-Manipulation RT	0.02	-0.04 – 0.08	0.496
Baseline DASS	0.66	0.51 – 0.81	**<0.001**
Baseline PSWQ	0.13	-0.05 – 0.32	0.165
Neutral Internal	0.74	-6.33 – 7.81	0.836
Negative External	0.11	-6.57 – 6.80	0.973
Neutral External	8.57	1.81 – 15.34	**0.013**
Neut. Int. x P-M RT	-0.01	-0.08 – 0.06	0.792
Neg. Ext. x P-M RT	-0.06	-0.13 – 0.01	0.075
Neut. Ext. x P-M RT	-0.03	-0.10 – 0.04	0.383
R^2 / R^2 adjusted	0.533 / 0.500		

Table 25 Predicting Follow-up PSWQ from Skill Index and Manipulation Dimensions

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	11.98	6.95 – 17.01	**<0.001**
Baseline Skill Index	-0.03	-42.20 – 42.14	0.999
Post-Manipulation Skill Index	-8.27	-51.02 – 34.47	0.703
Baseline PSWQ	0.75	0.66 – 0.85	**<0.001**
Negative > Neutral	-2.89	-5.88 – 0.10	0.058
Internal > External	-1.59	-4.47 – 1.30	0.278
Negative x Internal	5.86	-0.20 – 11.91	0.058
Int. > Ext. x P-M Skill Index	-13.72	-80.39 – 52.95	0.685
Neg. x Int. x P-M Skill Index	50.02	-85.80 – 185.83	0.468
R^2 / R^2 adjusted	0.645 / 0.625		

Table 26 Predicting Follow-up PSWQ from Commission Errors and Manipulation Dimensions

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	12.07	7.00 – 17.14	**<0.001**
Baseline Commission Errors	0.31	-0.48 – 1.11	0.437
Post-Manipulation Commission Errors	-0.06	-0.24 – 0.11	0.466
Baseline PSWQ	0.75	0.65 – 0.84	**<0.001**
Negative > Neutral	-2.41	-5.32 – 0.50	0.104
Internal > External	-1.47	-4.41 – 1.47	0.325
Negative x Internal	7.06	1.21 – 12.91	**0.018**
Int. > Ext. x P-M Commission Errors	-0.11	-0.35 – 0.14	0.397
Neg. x Int. x P-M Commission Errors	0.05	-0.44 – 0.54	0.835
R^2 / R^2 adjusted	0.645 / 0.626		

Table 27 Predicting Follow-up PSWQ from RT and Manipulation Dimensions

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	12.26	7.16 – 17.36	**<0.001**
Baseline RT	-0.01	-0.03 – 0.02	0.530
Post-Manipulation RT	0.01	-0.01 – 0.04	0.339
Baseline PSWQ	0.75	0.65 – 0.84	**<0.001**
Negative > Neutral	-2.68	-5.55 – 0.19	0.067
Internal > External	-1.53	-4.45 – 1.38	0.300
Negative x Internal	6.41	0.64 – 12.18	**0.030**
Int. > Ext. x P-M RT	0.02	-0.01 – 0.05	0.221
Neg. x Int. x P-M RT	-0.03	-0.09 – 0.03	0.398
R^2 / R^2 adjusted	0.649 / 0.630		

Table 28 Predicting Follow-up PSWQ from Skill Index and Condition

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	11.35	5.25 – 17.45	**<0.001**
Baseline RT	2.41	-40.39 – 45.21	0.912
Post-Manipulation RT	15.32	-71.59 – 102.23	0.728
Baseline PSWQ	0.75	0.66 – 0.85	**<0.001**
Neutral Internal	-0.17	-4.86 – 4.52	0.944
Negative External	-1.70	-6.06 – 2.67	0.443
Neutral External	4.11	-0.24 – 8.46	0.064
Neut. Int. x P-M RT	-54.91	-163.14 – 53.31	0.318
Neg. Ext. x P-M RT	-21.65	-126.77 – 83.47	0.685
Neut. Ext. x P-M RT	-15.97	-122.95 – 91.01	0.768
R^2 / R^2 adjusted	0.646 / 0.624		

Table 29 Predicting Follow-up PSWQ from Commission Errors and Condition

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	11.91	5.83 – 18.00	**<0.001**
Baseline Commission Errors	0.31	-0.49 – 1.11	0.443
Post-Manipulation Commission Errors	-0.11	-0.37 – 0.16	0.418
Baseline PSWQ	0.75	0.65 – 0.84	**<0.001**
Neutral Internal	-1.12	-5.60 – 3.35	0.621
Negative External	-2.07	-6.32 – 2.17	0.336
Neutral External	3.87	-0.39 – 8.12	0.074
Neut. Int. x P-M Commission Errors	-0.01	-0.40 – 0.37	0.945
Neg. Ext. x P-M Commission Errors	0.08	-0.24 – 0.40	0.627
Neut. Ext. x P-M Commission Errors	0.11	-0.21 – 0.43	0.483
R^2 / R^2 adjusted	0.645 / 0.623		

Table 30 Predicting Follow-up PSWQ from RT and Condition

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	11.58	5.51 – 17.65	**<0.001**
Baseline Skill Index	-0.01	-0.03 – 0.02	0.537
Post-Manipulation Skill Index	0.01	-0.03 – 0.05	0.561
Baseline PSWQ	0.75	0.65 – 0.84	**<0.001**
Neutral Internal	-0.46	-4.76 – 3.84	0.832
Negative External	-1.71	-5.83 – 2.42	0.415
Neutral External	4.18	0.01 – 8.36	**0.050**
Neut. Int. x P-M Skill Index	0.02	-0.02 – 0.07	0.318
Neg. Ext. x P-M Skill Index	-0.01	-0.05 – 0.04	0.776
Neut. Ext. x P-M Skill Index	-0.01	-0.05 – 0.03	0.597
R^2 / R^2 adjusted	0.650 / 0.628		

Table 31 Predicting Followup DASS from Skill Index in the Worry Group Only

	DASS Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	-3.62	-27.67 – 20.43	0.760
Baseline Skill Index	-117.40	-277.83 – 43.03	0.145
Post-Manipulation Skill Index	56.41	-118.27 – 231.09	0.514
Baseline DASS	0.79	0.39 – 1.18	**<0.001**
Baseline PSWQ	0.16	-0.38 – 0.69	0.550
R^2 / R^2 adjusted	0.559 / 0.496		

Table 32 Predicting Followup DASS from Commission Errors in the Worry Group Only

	DASS Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	-8.40	-31.70 – 14.90	0.466
Baseline Commission Errors	1.77	-1.99 – 5.52	0.343
Post-Manipulation Commission Errors	-0.57	-1.29 – 0.15	0.117
Baseline DASS	0.72	0.32 – 1.13	**0.001**
Baseline PSWQ	0.32	-0.22 – 0.85	0.234
R^2 / R^2 adjusted	0.567 / 0.505		

Table 33 Predicting Followup DASS from RT in the Worry Group Only

	DASS Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	-3.71	-28.00 – 20.58	0.757
Baseline Skill Index	0.05	-0.06 – 0.16	0.390
Post-Manipulation Skill Index	0.00	-0.12 – 0.12	0.996
Baseline DASS	0.68	0.25 – 1.12	**0.003**
Baseline PSWQ	0.20	-0.38 – 0.78	0.481
R^2 / R^2 adjusted	0.570 / 0.509		

Table 34 Predicting Followup PSWQ from Skill Index in the Worry Group Only

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	3.45	-9.43 – 16.33	0.588
Baseline Skill Index	-27.58	-114.51 – 59.35	0.522
Post-Manipulation Skill Index	41.14	-52.90 – 135.19	0.378
Baseline PSWQ	0.91	0.67 – 1.14	**<0.001**
R^2 / R^2 adjusted	0.704 / 0.673		

Table 35 Predicting Followup PSWQ from Commission Errors in the Worry Group Only

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	2.65	-9.70 – 14.99	0.664
Baseline Commission Errors	1.22	-0.78 – 3.23	0.222
Post-Manipulation Commission Errors	-0.27	-0.65 – 0.12	0.171
Baseline PSWQ	0.93	0.71 – 1.16	**<0.001**
R^2 / R^2 adjusted	0.714 / 0.684		

Table 36 Predicting Followup PSWQ from RT in the Worry Group Only

	PSWQ Score at Follow-up		
Predictors	*Estimates*	*CI*	*p*
Intercept	2.93	-10.32 – 16.18	0.654
Baseline Skill Index	-0.01	-0.07 – 0.06	0.837
Post-Manipulation Skill Index	0.01	-0.05 – 0.07	0.783
Baseline PSWQ	0.91	0.66 – 1.15	**<0.001**
R^2 / R^2 adjusted	0.695 / 0.663		

Table 37 Lexical Decision Task Stimuli

Neutral Word	Valence Rating	Negative Word	Valence Rating	Psuedoword
Nursery	5.73	Scorn	2.84	Spheam
Salad	5.74	Scared	2.78	Blouthe
Diver	6.45	Slime	2.68	Browthe
Trumpet	5.75	Coward	2.74	Cliethe
Item	5.26	Offend	2.76	Creatch
Black	5.39	Quarrel	2.93	Flairch
Event	6.21	Deceit	2.9	Fleathe
Finger	5.29	Garbage	2.98	Flouthe
Building	5.29	Trouble	3.03	Choushe
Fabric	5.3	Dreary	3.05	Frouthe
Table	5.22	Crude	3.12	Kneave
Ankle	5.27	Impair	3.18	Knouthe
Theory	5.3	Fungus	3.06	Phylche
Journal	5.14	Manure	3.1	Spheane
Poster	5.34	Nuisance	3.27	Spleight
Statue	5.17	Fatigued	3.28	Splought
Thought	6.39	Bullet	3.29	Spootch
Jelly	5.66	Urine	3.25	Spouve
Detail	5.55	Feeble	3.26	Steache
Limber	5.68	Mildew	3.17	Streaff
Engine	5.2	Fault	3.43	Strought
Bottle	6.15	Greed	3.51	Strouse
Hotel	6	Rigid	3.66	Wrouve
Whistle	5.81	Disdainful	3.68	Eclodio
Activate	5.46	Scapegoat	3.67	Akidian
Avenue	5.5	Overcast	3.65	Alabato
Lottery	6.57	Alimony	3.95	Alidisy
Quality	6.25	Haphazard	4.02	Aramico
Vehicle	6.27	Darelict	4.28	Aritepa
Identity	6.57	Vanity	4.3	Balaria
Cabinet	5.05	Neurotic	4.45	Colinio
Curious	6.08	Skeptical	4.52	Olipeta
Poetry	5.86	Handicap	3.29	Epizity
Elevator	5.44	Inferior	3.07	Exominy
Muscular	6.82	Criminal	2.93	Exorion
Beverage	6.83	Impotent	2.81	Fevetia
Natural	6.59	Disappoint	2.39	Impenia

Agility	6.46	Cemetary	2.63	Jelario
Opinion	6.28	Obesity	2.73	Melidio
History	5.24	Mosquito	2.8	Opatomy
Memory	6.62	Ignorance	3.07	Oripio
Reunion	6.48	Tobacco	3.28	Ripatio
Patriot	6.71	Obnoxious	3.5	Regidio
Casino	6.81	Immoral	3.5	Semioro
Headlight	5.24	Blubber	3.52	Ubicolo
Umbrella	5.16	Blasphemy	3.75	Utology
Utensil	5.14	Maniac	3.76	Uzonia
Context	5.2	Weary	3.79	Impetia
Radio	6.73	Rusty	3.86	Icantio
Passage	5.28	Pungent	3.95	Pitanio
Name	5.55	Cane	4	Phie
Unit	5.59	Dump	3.21	Phic
Dawn	6.16	Scar	3.38	Spee
Lion	5.57	Cell	3.82	Spou
Body	5.55	Slow	3.93	Sove
City	6.03	Timid	3.86	Stug
Bake	6.17	Fall	4.09	Sust
Idol	6.12	Bland	4.1	Clie
Hawk	5.88	Habit	4.11	Cret
Boxer	5.51	Lump	4.16	Drut
Banner	5.4	Dirt	4.17	Flah
Fish	2.42	Kick	4.31	Feth
Foam	6.07	Cold	4.02	Foth
Coin	6.02	Sour	3.93	Cosh
Cat	5.72	Rat	3.02	Gug
Writer	5.52	Stink	3	Wruv
Wine	5.95	Bored	2.95	Wrus
Astonished	6.56	Decompose	3.2	Altosentie
Athletics	6.61	Immature	3.39	Feveticcoe
Computer	6.24	Mutation	3.91	Bendestery
Employment	6.47	Insolent	4.35	Colonetta
Medicine	5.67	Embattled	4.39	Deckobetic
Inhabitant	5.05	Bereavement	4.57	Exlorione
Hamburger	6.27	Indifferent	4.61	Fillacolio
Easygoing	7.2	Radiator	4.67	Hendritote
Hairdryer	4.84	Kerosene	4.8	Trilalattio
Astronaut	6.66	Corridor	4.88	Hinnerlato

Concentrate	5.2	Nonchalant	4.74	Ladication
Lighthouse	5.89	Defiant	4.26	Malegetron
Mobility	6.83	Stagnant	4.15	Marometer
Agreement	7.08	Overwhelmed	4.19	Malimatie
Politeness	7.18	Vampire	4.26	Neckilodio
Intellect	6.82	Revolver	4.02	Paratrezza
Orchestra	6.02	Controlling	3.8	Peekrology
Industry	5.3	Suspicious	3.76	Quadritogo
Restaurant	6.76	Arrogant	3.69	Redditomy
Respectful	7.22	Hurricane	3.34	Refinistan
Material	5.26	Avalanche	3.29	Reggipetto
Sentiment	5.98	Destruction	3.16	Rentorious
Thermometer	4.73	Ridicule	3.13	Semigennoe
Education	6.69	Allergy	3.07	Terremotoe
Skyscraper	5.88	Invader	3.05	Exominight
Decorate	6.93	Discouraged	3	Seminiffio
Salute	5.92	Neglect	2.63	Stipinorio
Abundance	6.59			

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